ELECTRONICS

and Beyond

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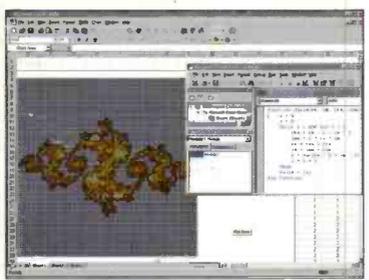
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Digital Broadcasting is coming soon

Terrestrial & satellite radio & TV

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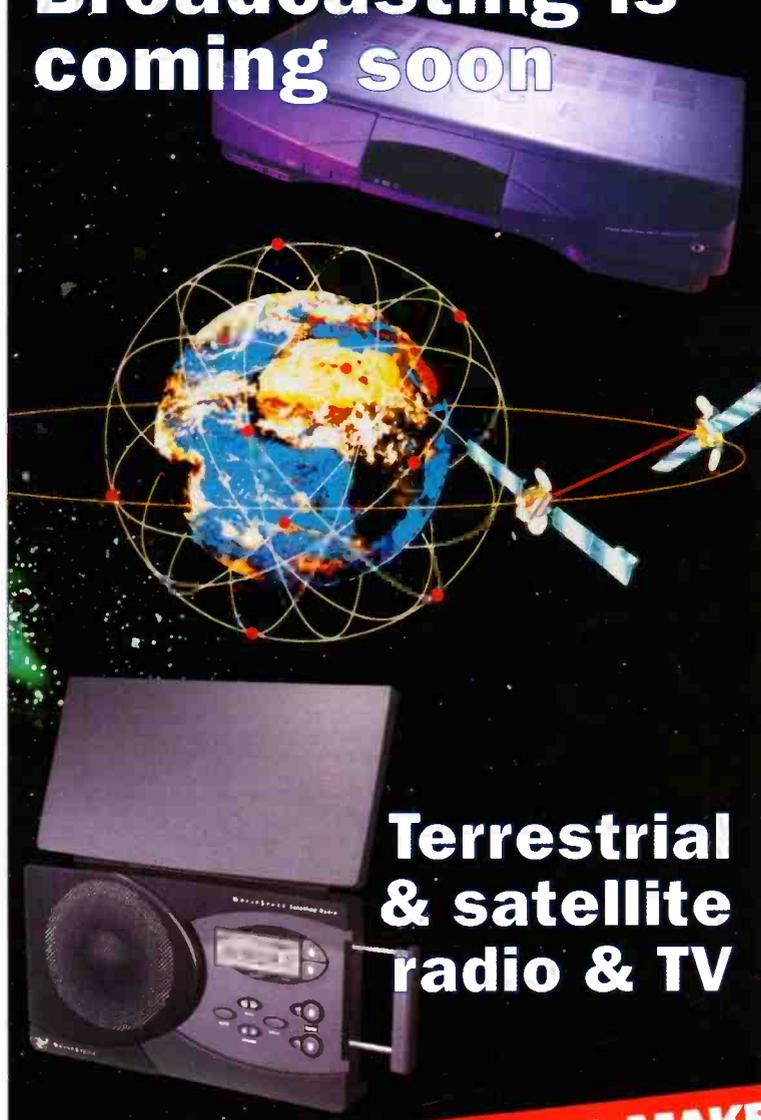
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by Mike Tooley
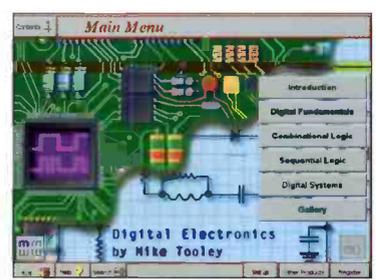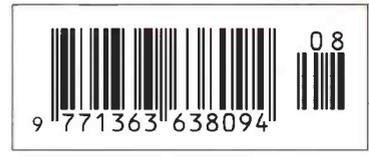
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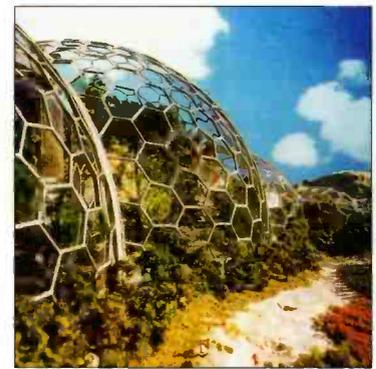
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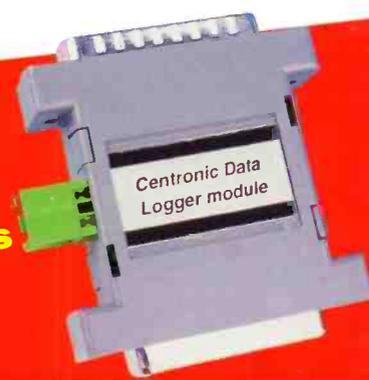
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Later this year digital broadcasting will not only be coming to the UK, but to four billion inhabitants of earth. In June, Sky digital service should be up and running, and in the Autumn we should see the start of the much publicised terrestrial service from the BBC and British Digital Broadcasting. One can only hope that the quality of the programmes will match the quantity that will eventually be offered, if not it will be a pointless exercise. However, the digital audio broadcasting service being offered by WorldSpace does appear to promise a great deal for vast areas of the world where short wave radio transmissions are often all that is available, let alone television. We have two articles this month previewing these latest developments.

This bumper edition sees the re-introduction of our top 30 best selling books, and as a bonus we have included a discount voucher offering 15% off any book in the list. Maplin stock several hundred books covering a diverse range of electronics and computer related topics.

Congratulations go to W. C. M. Lutchman of Salisbury for winning the Quickroute 4.0 competition featured in the May edition. The Full Access Version will be despatched to the lucky winner in the very near future.

Paul Freeman-Sear, Publishing Manager

ELECTRONICS and Beyond

http://www.maplin.co.uk

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NEWS REPORT
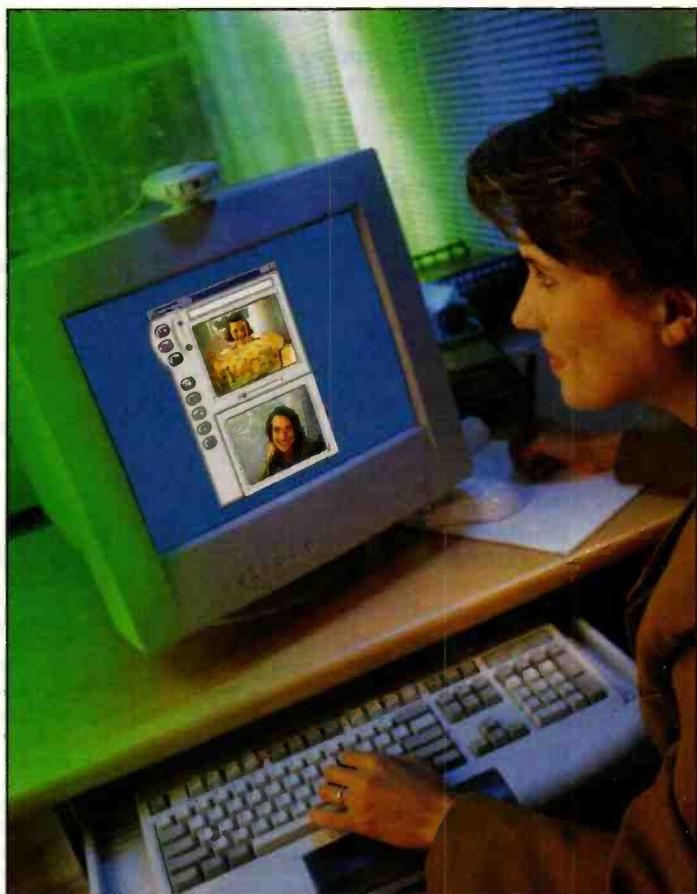
Kodak Teams With Intel for Digital Imaging

Kodak has cut a deal with Intel to jointly develop and market digital imaging products, sharing patent licenses on products and splitting the cost of updating Kodak photo-finishing labs with Intel equipment. The move expands an alliance begun in March 1997, when the two companies agreed to use each other's technology in digital imaging. Kodak and Intel plan to spend as much as £95 million over the next three years building the consumer market for digital imaging products.

For further information, check: **www.kodak.co.uk.**
Contact: Kodak, Tel: (01442) 261122.

Apple Consumer Mac

In an attempt to position itself as the Sony of the PC market, Apple has unveiled a new machine, called iMac which features a striking design, easy Internet access and PowerPC G3 performance. The only downside is the pricing which has yet to be published for the UK. In the US the iMac hits the streets at £810 ($1,299).

iMac is a complete Internet-age PC which Apple claims will work straight out of the box. It features a PowerPC G3 microprocessor running at 233MHz with a high speed 512k backside L2 memory cache, 15-inch display with 1,024 by 7,68 resolution, Internet access, internal 33.6Kbps modem, 10/100Base-Tx Ethernet, 12Mbps Universal Serial Bus (USB), and a 4Mbps infrared port (IrDA).

For further details, check: www.apple.com. Contact: Apple, Tel: (0181) 569 1199.

Dupont and CDT Target Flexible Displays

Flexible displays have made a step closer to reality following an announcement by DuPont and Cambridge Display Technology (CDT) that they have entered into a two-year joint development to bring light-emitting polymer (LEP) technology into commercial use in flexible displays.

Through the alliance, the companies expect to supply plastic substrates coated with LEP material to electronics manufacturers in large volumes within three years. Customers will be able to build displays to incorporate into products such as VCR's, CD players, mobile phones, lighted signs and alarm clocks.

"This alliance enables CDT to deliver on its promise of bringing LEP technology to market across high and low information content products. Over the next 18 months, a major goal will be achieving large volume, flexible, low information products. Ultimately, we anticipate large scale manufacture of flexible substrates developed with DuPont and leading electronics companies to create high information content products
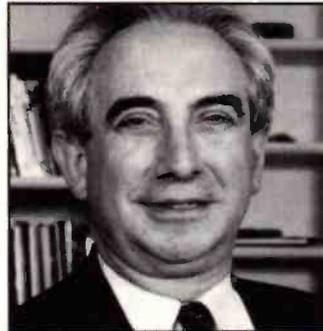
such as the flexible electronic newspaper," said CDT CEO Danny Chapchal.

For further details, check: www.cdtltd.co.uk. Contact: CDT, Tel: (01223) 276351.
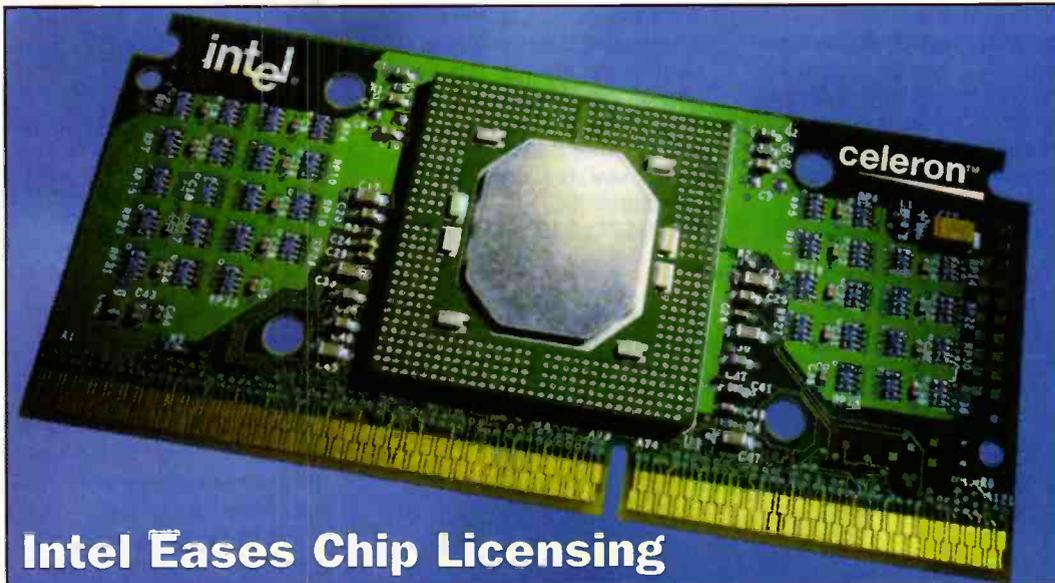
Intel Eases Chip Licensing

With its eye surely on Microsoft's anti-trust difficulties in the US, Intel is planning to license its P6 chip-set technology, making life easier for companies like Advanced Micro Devices that make competing products. Intel says it's reached a licensing agreement with one chip-set maker and is in discussions with other potential licensees.

Contact: Intel, Tel: (01793) 403000.

For further information, check: www.intel.com.

Dr Solomon's Launches Deluxe Anti-Virus Technology

Dr Solomon's Software has announced the availability of its Anti-Virus Deluxe, a brand new retail title in its award-winning family of anti-virus software.

Dr Solomon's Anti-Virus Deluxe includes a full year of free continuous updates with an all-new, intuitive online update process; exclusive proxy-based NetGuard technology to protect against viruses transmitted through the Internet; superior ease of use with a streamlined interface and a multimedia virus tutorial; compatibility for both Windows 95 and Windows NT; plus free technical support and 24-hour virus emergency support.

For further details, check: **www.drsolomon.com.** Contact: Dr Solomon, Tel: (01296) 318700.

Epson Shows True Colours

Regular quarterly tracking by Woking-based Inteco reveals that printer manufacturer Epson has slowly, but surely, stolen the lead from HP and Canon in sales to new home-PC buyers in the UK and France.

"We've seen both Epson (6% to 34%) and Canon (16% to 27%) gradually take share from HP (47% to 21%) over the past two years of research, but it is clearly Epson that has gained the most. In the most recent wave they have gone into the lead for the first time," said Pete Day, manager of Inteco's PCs in the Home tracking service.

For further information, check: www.inteco.com. Contact: Inteco, Tel: (01483) 751777.

Growth to Slow in 1998 Global Semiconductor Market

The global semiconductor market is experiencing its third consecutive year of lacklustre performance, as the semiconductor industry is forecast to grow 8% in 1998 with revenue projected to reach £100 billion, according to Dataquest, a subsidiary of Gartner Group.

In 1997, the market grew 3.5% with revenue reaching £90 billion, and in 1996 the market declined 6.3%.

The worldwide semiconductor industry will return to strong growth in 1999 when the market is forecast to grow 18% with revenue surpassing £120 billion.

Even with single-digit growth in 1998, the semiconductor industry will nearly double by 2002 with revenue approaching £180 billion. Dataquest analysts said DRAM pricing will dictate the growth in the industry along with developments in Asia.

For further details, check: **www.dataquest.com.** Contact: Dataquest, Tel: (0800) 716089.

Intel Announces Digital Day Project

What do bar-coded dairy cows, Australian aborigines, Thai monks and Andy Grove have in common? They are all part of a new book produced by Against All Odds Productions and underwritten by Intel.

"One Digital Day: How The Microchip Is Changing Our World" documents the effects of the microprocessor and modern computing technology around the world in the course of a single day. Published by Times Books/Random House, the book will be in stores from June 1.

Against All Odds (AAO) specialises in the design and execution of large-scale photographic projects that combine compelling story-telling with state-of-the-art technology. AAO was founded by Rick Smolan, who created the prize-winning "Day in the Life" book series.

In his foreword, Intel Chairman Andy Grove says the photos and accompanying text show how microprocessors "change how existing products function and allow the creation of new ones. In the aggregate, they change how we live, how we work, how we entertain ourselves and how we are able to imagine – and thus create – the world our children will inherit."

For further information, check: **www.intel.com.** Contact: Intel, Tel: (01793) 403000.

Dr Williams Receives 1998 Engineering Council President's Award

Dr John Williams OBE, Secretary and Chief Executive of the IEE, has been awarded the 1998 Engineering Council President's Award in recognition of his conspicuous service to the engineering profession. Dr Williams received his award from HRH The Duke of Kent at the Engineering Council Annual Conference. He was presented with an inscribed crystal rosebowl and a Certificate.

For further information, check: **www.iee.org.uk.** Contact: IEE, Tel: (0171) 240 1871.

Hand Holding from NEC

NEC has launched a handheld PC called the MobilePro 750C H/PC which it claims weighs in at less than two pounds, and features a large, touch-typeable keyboard, an eight-inch colour touch-screen display, and eight-hour battery life.

The Windows CE 2.0 machine is available immediately price £560 ($899) at **www.necnow.com** and will appear in the shops in the UK in a couple of months. For further details, check: **www.nec.com.** Contact: NEC, Tel: (0181) 993 8111.
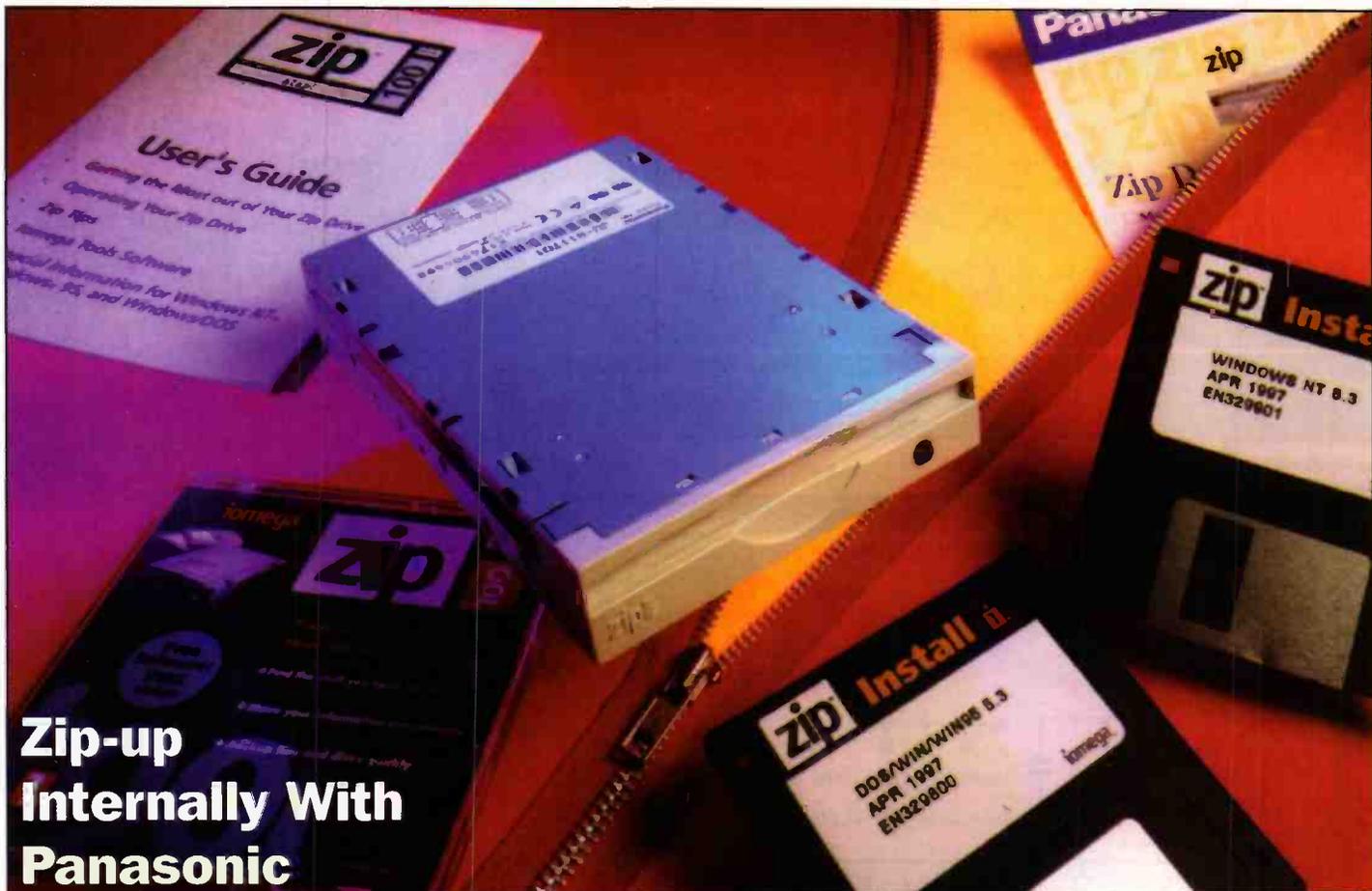
Zip-up Internally With Panasonic

Following its manufacturing license agreement with Iomega, Panasonic has announced the availability of its own internal Zip drive that will provide PC users with a low-cost solution for built-in 100Mbyte disk storage. The price of the new drive is expected to be approximately £80.

For further details, check: **www.panasonic.co.uk.** Contact: Panasonic, Tel: (0500) 404041.

ARM Licenses Core to Matsushita
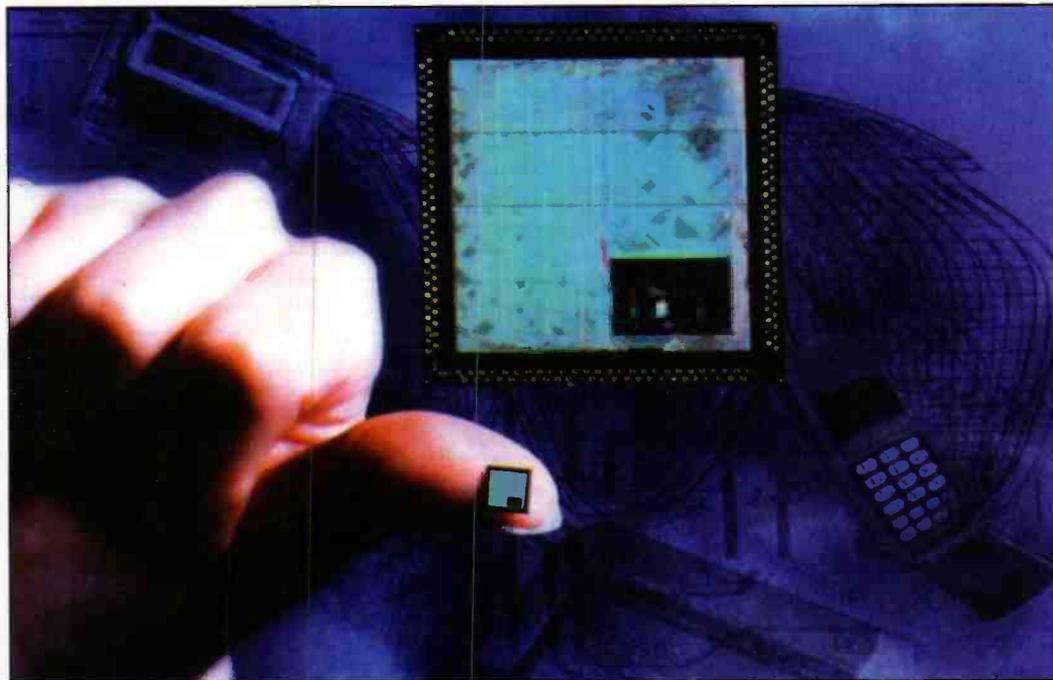
Matsushita has licensed from ARM the ARM7TDMI high-performance, low-power 32-bit RISC processor core, which will be used as a core for the mobile communication market, and in intelligent appliances for the multimedia market.

Matsushita has adopted the advanced 0.25μm CMOS process for the first implementation of the ARM7TDMI core. This will provide a microprocessor core with small-size, high-performance and low-power consumption, ideal for a system-on-a-chip large scale integrated solution.

For further details, check: **www.arm.com.**
Contact: ARM, Tel: (01223) 400400.

Computer Industry Backs Microsoft

Twenty-six computer industry executives, including the chairmen of Intel, Dell, Compaq and Hewlett-Packard, have lined up behind Microsoft CEO Bill Gates, in a joint letter urging the US Department of Justice not to block the planned release of Microsoft's Windows 98 operating system. Interfering with the release of Windows 98 would drag down the entire industry's efforts to deliver value to customers and returns to shareholders said the letter.

For further information, check: www.microsoft.com.
Contact: Microsoft, Tel: (0345) 002000.

WorldSpace-

DIGITAL SOUND BROADCASTING SYSTEM

● ●

Information supplied by WorldSpace and Alcatel Espace

A revolution is in the air.

Digital Radio is about to take off in a big way. The plan for mass coverage of the three continents of Africa, Asia and South America via 3 geostationary satellites is underway and is planned to be fully operational within 2 years. The company responsible for such a large project as this is WorldSpace.

Right now, WorldSpace, based in Washington, D.C., and founded in 1990 as a privately-held corporation is poised to satisfy humanity's appetite for information and entertainment by bringing a varied diet of digital sound broadcasting to more than four billion people. The WorldSpace System has been planned to enable 80% of the earths' population to listen to music, news, sports and drama, educational and all types of informational programming. Using satellite technology, this digital broadcasting system will expose the bulk of humanity to a whole new plethora of audio entertainment.

The proposal is that listeners will have access to a huge variety of music from every corner of the globe. Individuals in countries where airplay is minimal for certain types of music will now find stations dedicated exclusively to these tastes. It is hoped that listeners will be able to hear their favourite music at all hours and explore a wide world of new sounds as well.

The plan is for international and local stations to be on air with an all news format with continuous access to world breaking news and in-depth coverage.

The worldwide audience for sports is immense and ever-growing, so the aim is to provide fans with coverage of popular mainstream events like soccer and basketball as well as regional games, such as badminton and baseball. Listeners should also be able to find live coverage of events, interviews with athletes, in-depth commentary and the latest scores and stories.

It is hoped that talk radio will find a massive new audience - much of it in places that have never been exposed to this broadcast format. The 'talk' will include discussions on everything from health, to the humour of some of the most amusing radio personalities in the world.

The power of a mass medium to educate is well known and WorldSpace intends to offer its listeners a rich and varied menu of educational programming, formal and informal. People in many parts of the world will now have the opportunity to learn things over the airwaves that they might never be exposed to anywhere else.

Diversity

International broadcasters should be able to tap into huge new audiences in areas that were essentially inaccessible to them until now. Local broadcasters could establish a regional presence and reach a vast and lucrative new audience. For the first time ever, local stations of every size, in even the most remote reaches of the planet, will be able to reach an audience throughout the continent. The smallest stations of today could possibly become superstations of tomorrow. Plus, today's international broadcasters like the BBC will have a whole new audience available to them in regions that could never receive their signals before.

Quality & Portability

Prior to WorldSpace, listeners had to settle for low-powered local stations and poor reception or they had to fumble with shortwave to try and find distant stations. Now, high-quality sound should be available at any time, anywhere, using portable digital receivers. In many parts of the world, people have to settle for poor-quality sound from large receivers that were clearly not designed for mobility. Digital broadcasting will deliver the highest quality sound to every listener in its continent-wide broadcast areas, from portable digital receivers small enough to fit in the palm of your hand.

To achieve superior sound qualities, WorldSpace is using advanced MPEG Layer 3 compression techniques pioneered by Fraunhofer Gesellshaft. This technique achieves compression by increasing the amount of information in a single broadcast band. When compared to compact discs, MPEG technology increases compression by tenfold. Efficient compression gives the WorldSpace satellites greater broadcasting flexibility, while recreating superior mono and stereo sound qualities. The receivers are fitted with a Starman® chipset to demodulate the broadcasts. The system will broadcast in a

range of sound qualities, compared to current technologies, the quality will range from 'telephone sound' to the same qualities you expect from a compact disc.

System Overview

The digital sound broadcasting receiver system is based on a simple concept. The system routes a signal from a ground control station through a small satellite dish. The dish antenna transmits the signal to a geostationary satellite, which then sends the signal directly to millions of portable digital sound broadcasting receivers worldwide.

WorldSpace will be launching three satellites which will provide broadcast coverage in Africa, the Middle East, Asia, the Mediterranean Basin, Latin America, and the Caribbean. Each satellite will carry a payload that will implement baseband processing- appearing for the first time in a commercial programme- and a more conventional 'transparent' payload.

The three geostationary satellites will be at the following orbital locations:
◆ AfriStar at 21° east for Africa and the Middle East.
◆ AsiaStar at 105° east for Asia
◆ AmeriStar at 95° west for Central and South America
Each satellite covers a zone defined by three spot beams, with system configuration identical for each region. (See Figure 1)

◆ **The Space Segment** includes the satellite and associated ground control segment which provides continuous control of satellite operation. The ground control segment is composed of two TCR (telemetry, command and ranging) stations, and a satellite control centre.

◆ **The Mission Segment** includes the mission centre which is in constant contact with the ground control segment and the business segment, primarily manages broadcaster access to the satellite

and frequency band allocation. The communication system monitoring centre controls the quality of the downlink signals.

◆ **The Broadcast Segment** includes studio and uplink station equipment via which broadcasters access the satellites - individual VSAT-type terminals and hub stations which are shared by several broadcasters.

◆ **The Radio Segment** will include millions of receivers that will enable listeners to pick up the programmes of their choice. These receivers are equipped with electronic chip sets capable of decoding digital radio signals, as well as receiving conventional radio broadcasts.

◆ **The Business Segment** takes care of channel reservations and billing

◆ **The Infrastructure Segment** provides the network communications links for all these different segments which are spread over five continents. (See Figure 2)
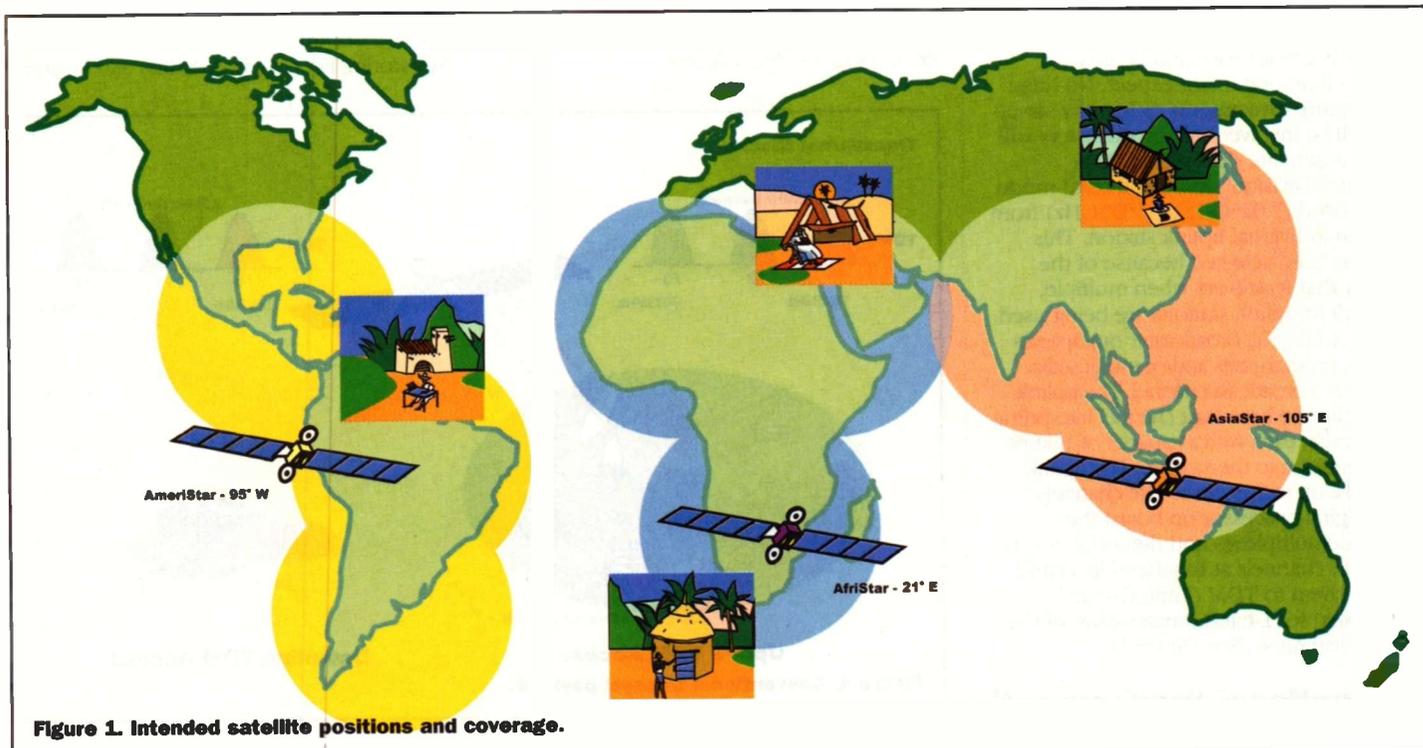
Figure 1. Intended satellite positions and coverage.
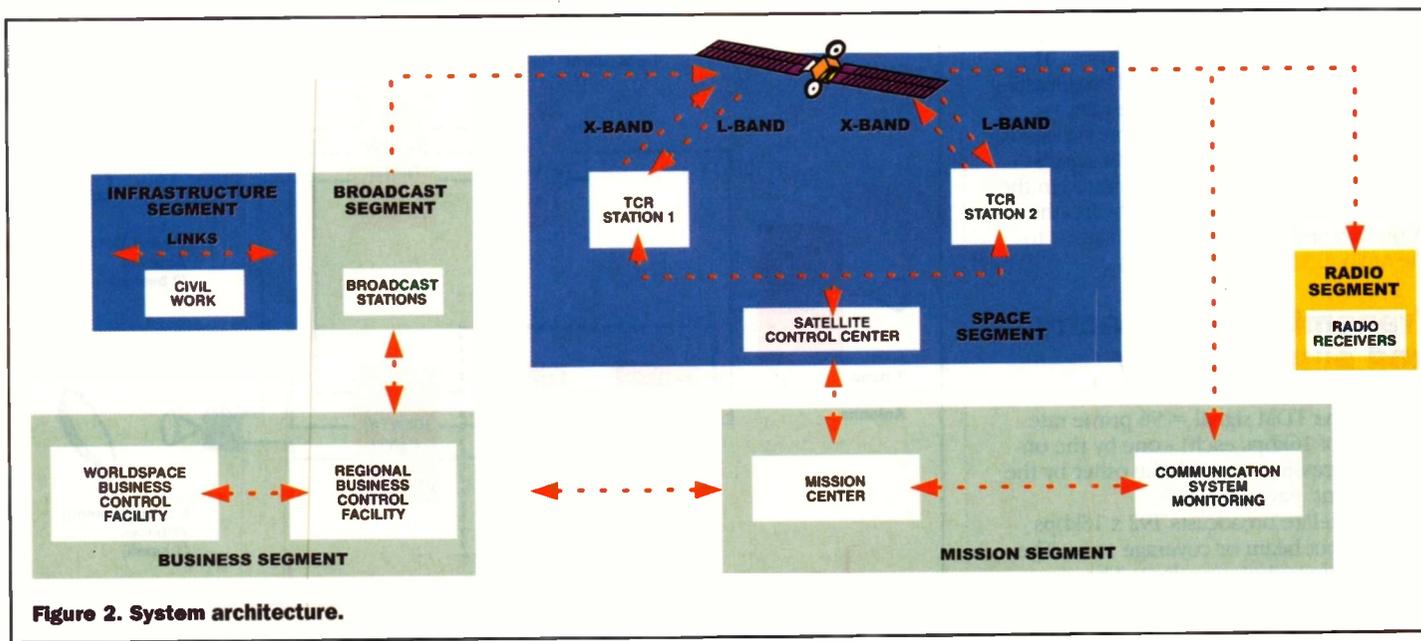
Figure 2. System architecture.

Figure 3. Baseband processing payload.

Within figure 3:
- Processed Mission
- 27kHz Bandwidth
- Prime Rate Channels
- F1 F2 F288
- 7025MHz 7075MHz
- 2.5MHz Bandwidth
- TDM
- Fa 1467MHz Fb Fc 1492MHz
- Individual Station, Hub, Studio, Studio, Studio, Studio
- Prime Rate Channels
- Broadcast Channels
- Users Fa Fb Fc
- Uplink FDM Access
- Downlink TDM Access
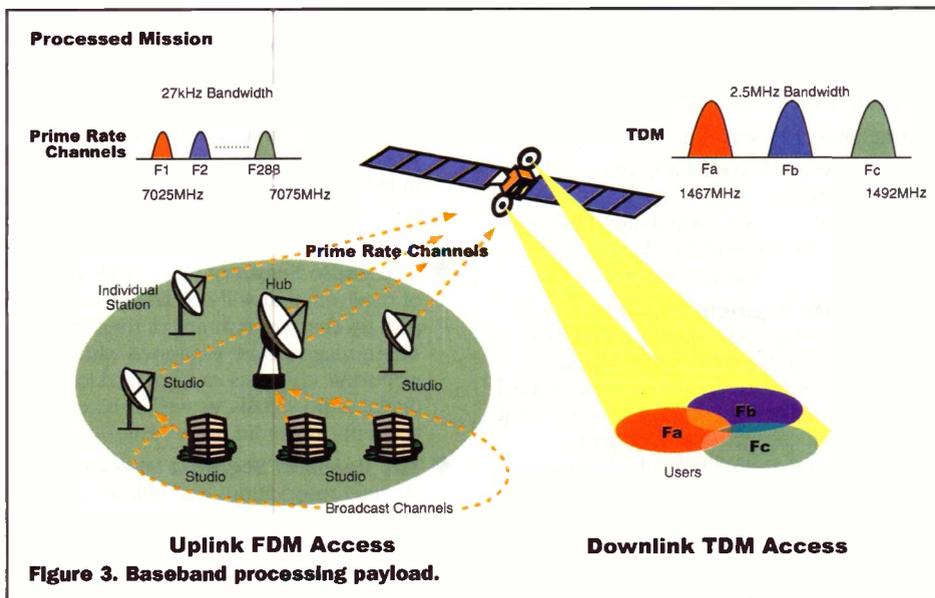
Baseband processing

Broadcasters will be able to link to systems with much greater ease and far less retooling than one might expect. No huge infrastructure investments or lengthy set-up times will be involved. All broadcasters will access the satellite directly in FDMA (Frequency Division Multiple Access) mode in the X-band (7.025GHz to 7.075GHz) from their own individual uplink station. This mode has been selected because of the flexibility that it delivers when multiple, independent uplink stations are being used.

In the studio, the broadcaster multiplexes the audio programmes and/or multimedia services on a broadcast channel. The uplink station splits the broadcast channel into prime rate channels, each with a capacity of 16kbps, for transmission to the satellite. The uplink can handle up to 288 prime rate channels.

The digital processor on-board the satellite demultiplexes and demodulates the prime rate channels at baseband level and converts them to TDM (Time Division Multiplexes) for L-band transmission of the signal to listeners. (See Figure 3)

Conventional 'transparent' communication

This method enables several broadcasters to access a hub station, which is capable of broadcasting bundles of programmes. The hub station receives multiplexed broadcasting channels, splits them into prime rate channels, then performs the same processing as the digital processor. The TDM signals (a maximum of three) are transmitted in the X-band to the satellite which converts the frequency and sends the L-band signals to the radio receiver. (See figure 4)

Transmission capacity and sound quality

Each of the three beams transmits two TDM signals (one TDM signal = 96 prime rate channels of 16kbps each) - one by the on-board processing payload, the other by the 'transparent' payload.

Each satellite broadcasts 192 x 16kbps channels per beam or coverage zone. The multiplexing technique adopted by Worldspace will support combinations of radio programmes. In this way each user in

a coverage zone will be able to receive:
- 96 mono radio stations
- or 48 stereo FM stations
- or 24 CD quality programmes
- or a combination of the above
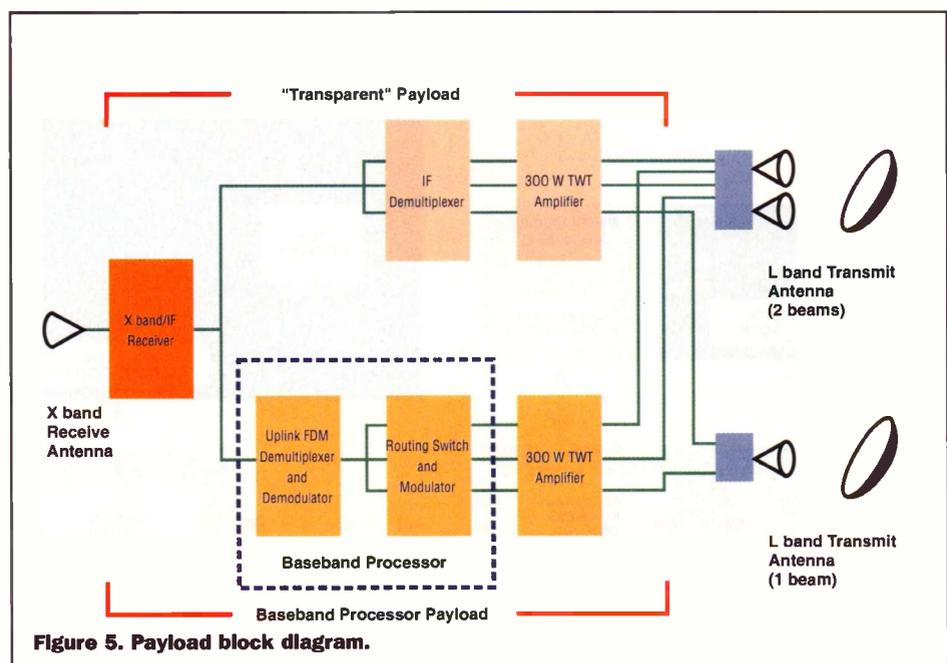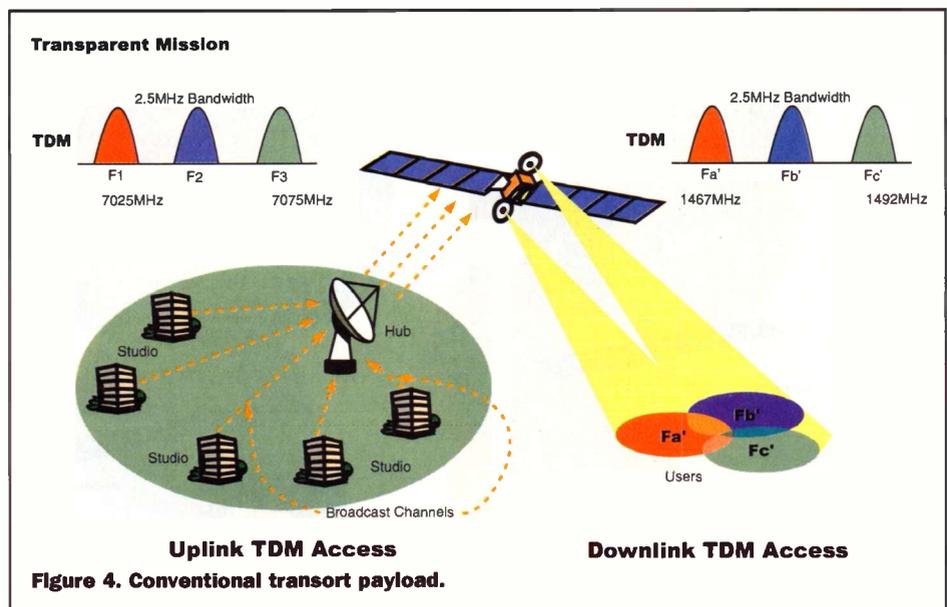
For down links, the system uses the L-band frequency (1.467GHz to 1.492GHz) allocated by the International Telecommunications Union (ITU) for digital satellite broadcasting services.

The high L-band power is achieved by a pair of 150W travelling wave tube amplifiers (TWTA) operating in parallel. (See Figure 5)

Once the listener has selected a frequency, the receiver's ICs will extract the required TDM signal (identical in all access modes) and decode it to restore the original sound. The programmes are digitally coded using the MPEG $\frac{1}{2}$ layer III compression standard. The resulting sound quality and the number of programmes received will depend on the digital bit-rate chosen by the broadcaster - from 16kbps to 128kbps. In the future, the system may support digital bit-rates of up to 1.5Mbps for data distribution.

The ground control system features Telemetry Command and Ranging stations (TCRs), Communications Systems Monitoring Equipment (CSMEs) and Regional

Figure 4. Conventional transort payload.

Within figure 4:
- Transparent Mission
- 2.5MHz Bandwidth
- TDM
- F1 F2 F3
- 7025MHz 7075MHz
- 2.5MHz Bandwidth
- TDM
- Fa' Fb' Fc'
- 1467MHz 1492MHz
- Studio, Hub, Studio, Studio
- Broadcast Channels
- Users Fa' Fb' Fc'
- Uplink TDM Access
- Downlink TDM Access

Figure 5. Payload block diagram.

Within figure 5:
- "Transparent" Payload
- IF Demultiplexer
- 300 W TWT Amplifier
- L band Transmit Antenna (2 beams)
- X band/IF Receiver
- X band Receive Antenna
- Uplink FDM Demultiplexer and Demodulator
- Routing Switch and Modulator
- 300 W TWT Amplifier
- Baseband Processor
- Baseband Processor Payload
- L band Transmit Antenna (1 beam)

Integration rooms in Toulouse.

been contracted to provide the three satellites. Alcatel has sub-contracted to Matra Marconi, also of Toulouse, to provide the satellite bus, while Alcatel Espace will provide the satellite payload and the Telemetry Command and Ranging (TCR) subsystem, an integral part of Ground Control Operations.

Receivers

The key component of the receiver is a special Starman® chipset which will demodulate and decompress the transmissions. SGS Thomson and Micronas Intermetall are producing Starman® chipsets which will go into the first generation of satellite receivers. Each company will manufacture at least one million units. In addition to satellite programming, it will be possible to receive shortwave, AM and FM

Operations Control Centres (ROCCs). The TCR and CSME Stations provide commands and controls to facilitate broadcasting in conjunction with the Regional Operations Control Centres. The Feeder Link Stations are used by the broadcaster or content provider to feed the satellites with the programming they need to entertain and inform those parts of the world. The ROCCs control the broadcast operations.

Each satellite will have an extensive network of ground control stations employed to obtain feedback, send maneuvering commands, conduct system checks and maintain a constant link to the satellite vehicles.

The network will allow for 'quality control' over all aspects of the broadcasting chain. When a broadcaster sends its signal to the satellite, feedback is available to ensure proper allocation of system resources and to block unwanted transmissions.

Satellites

The solar-powered satellites will be parked in a geostationary orbit some 24,000 miles above the earth, and are extremely reliable with many automatic back-up systems. Each satellite will consist of two parts, a 'bus' and a 'payload'. The bus is the part of the satellite that makes flight and manoeuvring
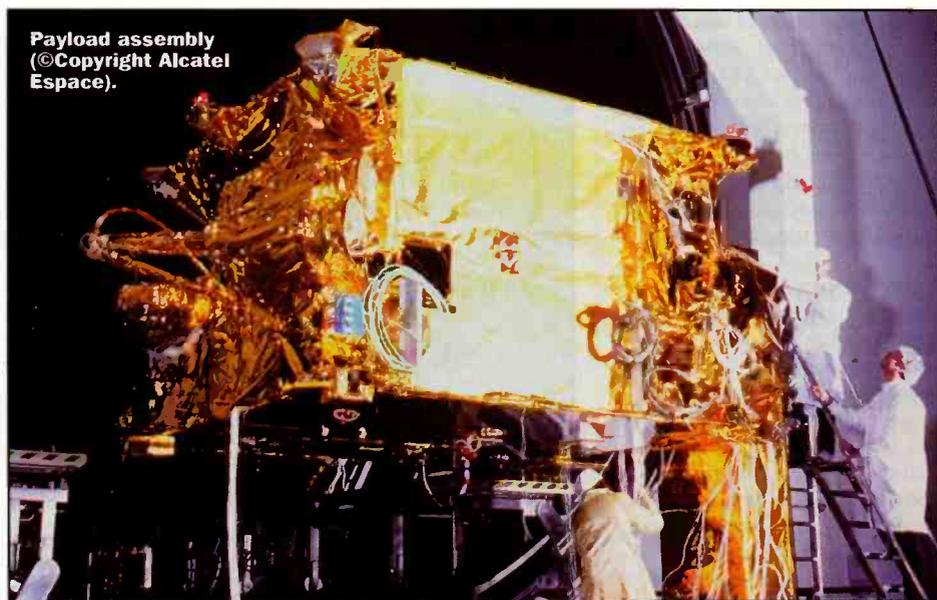
Payload assembly (©Copyright Alcatel Espace).

possible. The payload comprises the 'brains' of the satellite. The bus onboard the satellites is part of the venerable Eurostar family of flight-proven machinery. Each satellite will have its own onboard base band processor. This provides efficient bundling and routing of broadcast transmissions.

Alcatel Espace of Toulouse, France has

broadcasts with the portable receiver.

The receivers will be available in 1998 in Africa, the Middle East and Asia, corresponding to the start of service of the AfriStar 1 and AsiaStar 1 satellites. In 1999 receivers will be available throughout Latin America and the Caribbean as service begins on AmeriStar 1. Additionally, satellite receivers will be available through select retail outlets in Europe and North America for people who travel through the WorldSpace Coverage Area.

On-air dates

The system's first satellite, AfriStar, is schedule for launch in October 1998. The second satellite of the system, AsiaStar, is set to be launched in January of 1999, with the third satellite, AmeriStar, scheduled for launch in May of 1999. Broadcast operations are scheduled to commence in December of 1998, ushering in the 21st Century and a new era of communications. ELECTRONICS

Technical Characteristic of Each Satellite

Design:	3-axsis stabilised EUROSTAR platform
Launch mass:	2,750kg
Span:	28m solar panels deployed
EIRP*:	53dBW ma.
Power consumption:	6kW
In-orbit lifetime:	15 years
Launcher:	Arianne IV/V

* equivalent isotropic radiated power

Ariane V launcher and WorldSPace Satellite.
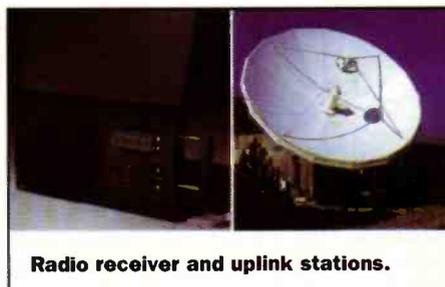
Radio receiver and uplink stations.

PROJECT
Centronic
DATA LOGGER

Dr Pei An describes a dangle-type data logger designed for the Centronic port of PCs.

Construction of this data logger is very simple as it contains an A/D converter, a precision voltage reference source, and several passive components all built on to a single-sided PCB board which is housed in a dangle-type enclosure. In use, it is plugged directly into the Centronic port of a desktop or a laptop computer. The basic design of the logger has 8-bit A/D conversion accuracy, which can be readily increased to 10-bit conversion accuracy by changing to a 10-bit converter. Another feature is that the data logger does not need an external power supply as it 'steals' power from the Centronic port!

It measures a voltage in the range from 0V to 2.55V, and by using different sensors, various physical parameters such as temperature, pressure, bio-electro signals, etc., can be measured and recorded by a PC. Signal amplification circuits may be required in some cases to convert the emf produced by a sensor to the right voltage range.

The data logger has a serial interface which allows other modules to be connected to it. These modules may be analogue multiplexers, D/A converters, digital output expanders or signal generators. By connecting various modules together, a sophisticated digital control system can be constructed.

A demonstration control program written in Turbo Pascal 6 programming language has been developed for use with the module.

Figure 1 shows how the data logger can be connected to a desktop computer and Photo 1 shows the data logger.

The Centronic port

The pin-layout and functions for a Centronic port on PCs is shown in Figure 2. The details of the Centronic port have been described in the article entitled 'Programmable Centronics 24-line I/O card' which appeared in issues 111 and 112 of Electronics and Beyond. More details of the Centronic port and its applications can be found in Reference 1. In brief, a standard Centronic port contains three I/O ports which can be accessed by the CPU. One port is the DATA port, another is the CONTROL port and the third is the STATUS port. The first two are output ports and the third one is an
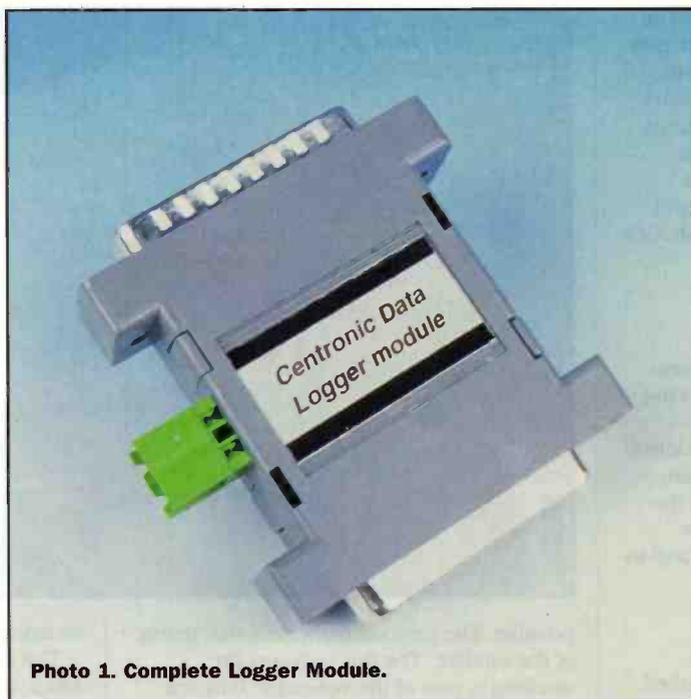
Photo 1. Complete Logger Module.
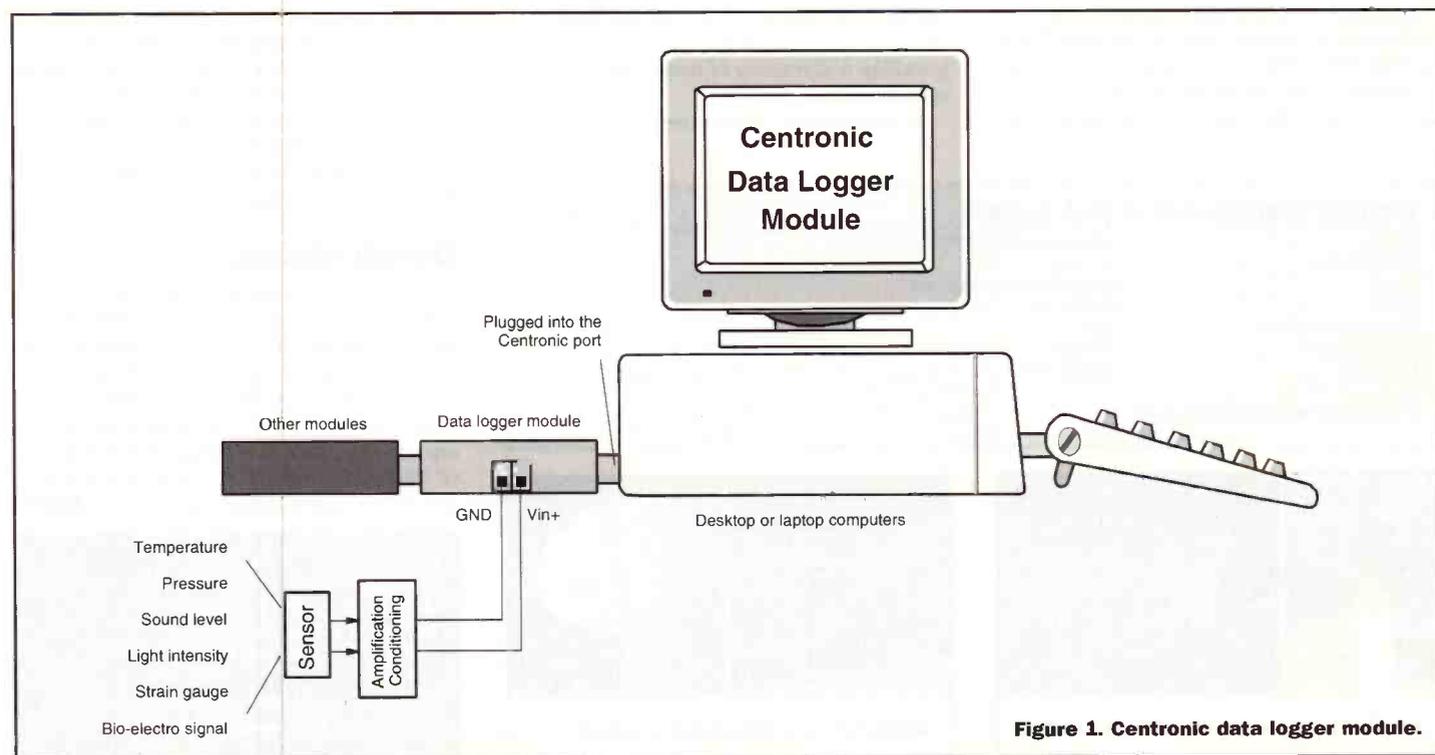
Figure 1. Centronic data logger module.
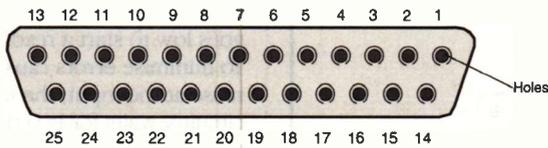
Centronic connector on a pc viewed from the back of the pc
Connector type: 25 pin female D-type

Pin functions of the Centronic port connectors

Connectors on pcs	Direction (for pc)	Name	Explanations
1	OUTPUT	STROBE	lot to strobe data into printer
2	OUTPUT	DB0	data bit 0
3	OUTPUT	DB1	data bit 1
4	OUTPUT	DB2	data bit 2
5	OUTPUT	DB3	data bit 3
6	OUTPUT	DB4	data bit 4
7	OUTPUT	DB5	data bit 5
8	OUTPUT	DB6	data bit 6
9	OUTPUT	DB7	data bit 7
10	INPUT	ACK	low to indicate data received, printer ready
11	INPUT	BUSY	high to indicate printer busy
12	INPUT	PE	high to indicate printer paper empty
13	INPUT	SLCT	high to indicate printer on line
14	OUTPUT	LF/CR	auto linefeed after carriage return
15	INPUT	ERROR	low to indicating printer error
16	OUTPUT	INITIALIZE	low to initialize printer
17	OUTPUT	SLIN	low to select printer
18-25			
		GND	twisted-pair return Ground
		Unused	
		Logic GND	logic ground
		Chasis GND	chasis ground

Figure 2. Centronic port on computers.

input port. A computer uses the DATA and CONTROL ports to output data and the STATUS port to input data. In this application, the DATA port (8 lines) and STATUS port (2 lines) are used.

Serial interface bus for connecting ICs

The serial interface bus is a data bus for connecting ICs together. Typically, such a bus contains three data lines: Serial Clock, Serial Data Input to ICs and Serial Data Output from the ICs. Data is transferred on the bus serially. An IC in the bus can be selected to either output data or input data using the Chip Select pin. Serial data transfer reduces the rate of data transfer, but the bus reduces the number of hardware links amongst ICs. It is a useful bus for low to medium speed data transfer applications.

The Serial Peripheral Interface (SPI) is a type of serial bus that has been adopted as an industrial standard. An SPI compatible IC contains a serial clock (SCLK), a serial data input to an IC (SDI), a serial data output from the IC (SDO) and a chip select input (-CS). Some ICs may only output data without receiving it. In this case, the SDI line does not exist. One example of these ICs is an A/D converter which only outputs A/D conversion results. If an IC only receives data, the SDO line does not exist. An example is the D/A converter which only receives data from a host micro-controller.

There are a huge number of ICs having the serial interface bus, typical examples are:

◆ The AD7715 (Analog Devices, order code NP33L) is a low-power single-channel 16-bit A/D converter with a programmable amplifier and programmable filter. The amplification can be programmed from 1 to 127 and the filter can be programmed as well. It has a serial data input for configuring the device and a serial data output for sending out A/D conversion results. The pin-out of the IC is shown in Figure 3(a).

◆ The AD7858LAN (Analog Devices, order code NP35Q) is a high speed, low power, 12-bit A/D converter with eight analogue input channels which operates from a single 3V power supply. The SPI bus contains all four lines (i.e. SCLK, SDI, SDO and -CS) for two-way data communication. The serial data input is used to write data into the IC, for instance, to select a particular analogue input channel. The serial data outputs the resulting data bits from an A/D conversion. The pin-out of the IC is given in Figure 3(b).

◆ The MAX533 (Maxim) is an 8-channel analogue multiplexer IC. It contains eight independent analogue switches. Each analogue switch can be selected by writing a control word into the IC via a serial data input (SDI). It can be used with an A/D converter to enable the latter to measure a number of analogue inputs. The pin-out is given in Figure 3(c).

◆ The AD8300AN (Analog Devices, order code NP29G) is a low power, 12-bit digital to analogue converter. The serial data is written into the IC via the SDI line. The pin-out is shown in Figure 3(d).

The ML 2506 (Micro Linear) is a programmable sine wave generator (for pin-out see Figure 4a) which generates a sine wave signal with its frequency controlled digitally. The frequency is determined by a time constant which is written into the IC's internal register. This data is written into the IC through a serial data bus.

For expanding I/O output lines, the UCN5810 and UCN5832 (Allego Microelectronics) serially-loaded and latched drivers can be used. They are able to expand 10- and 32-digital output lines, respectively. The status of each output is controlled by writing a 10-bit or 32-bit control data into the ICs through their serial interface. The pin-out of UCN5810 is shown in Figures 4(b).

The Data Logger Internals

The circuit diagram of the data logger is shown in Figure 5. The TLC548 A/D converter is a

(a) AD7715 (b) AD7858LAN (c) MAX335 (d) AD8300AN
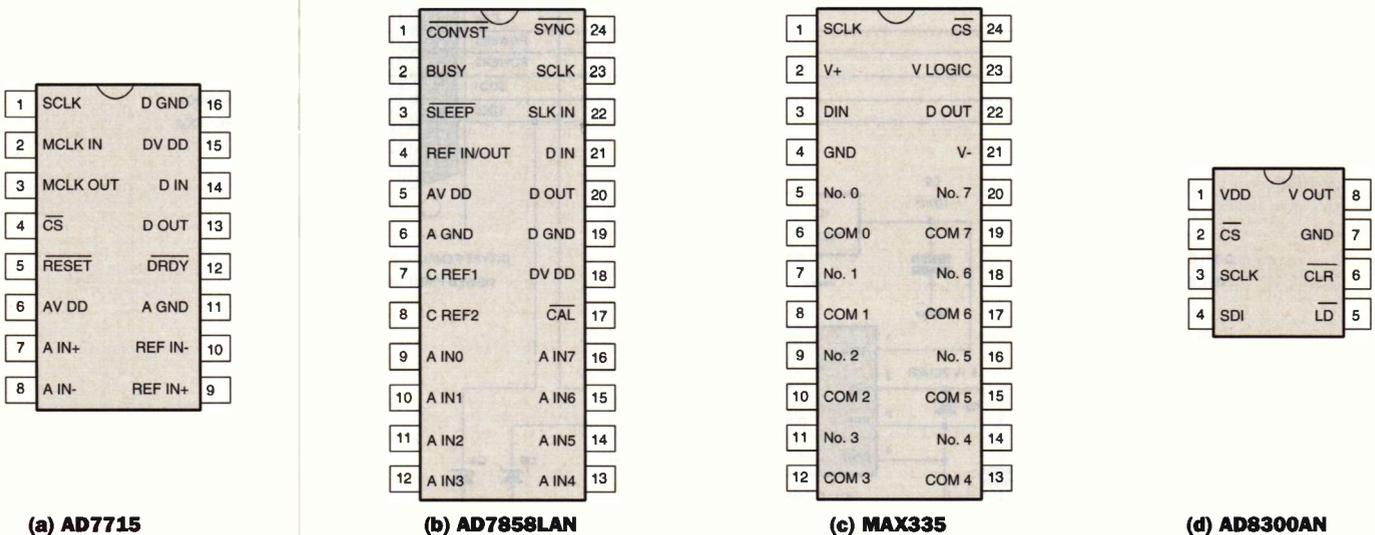
Figure 3. Pin-out of some ICs using serial bus.

1	SCLK	-CS	24
2	V+	V LOGIC	23
3	DIN	D OUT	22
4	GND	V-	21
5	No. 0	No. 7	20
6	COM 0	COM 7	19
7	No. 1	No. 6	18
8	COM 1	COM 6	17

(a) ML2506

1	OUT8	OUT9	18
2	OUT7	OUT10	17
3	OUT6	SERIAL DATA OUT	16
4	CLOCK	LOAD SUPPLY	15
5	GROUND	SERIAL DATA IN	14
6	LOGIC SUPPLY	BLANKING	13
7	STROBE	OUT1	12
8	OUT5	OUT2	11
9	OUT4	OUT3	10
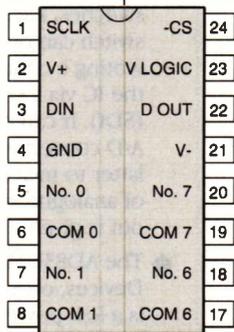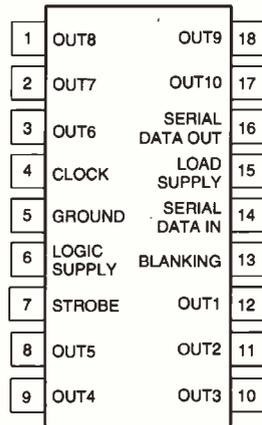
(b) UCN5810

Figure 4. Pin-out of more ICs using serial bus.

LinCMOS 8-bit switched-capacitor successive-approximation A/D converter. It has an on-board sample-and-hold circuit, a 4MHz system clock generator and a serial interface. The TLC548 is able to sample 45,500 times per second. The pin-out and the internal block diagram are shown in Figure 6. Pin 8 (VCC) and Pin 4 (GND) are connected to the positive and negative rails of the power supply. The range of the power supply voltage is between 3V to 6V with a typical current assumption of 1.9mA. Pins 1 and 3 (REF+ and REF-) are connected to an external band-gap voltage reference. REF- and GND are normally wired together.

The serial interface of the converter consists of two TTL-compatible control lines, the I/O clock input (I/O CLK, Pin 7) and chip select input (-CS, Pin 5) and one 3-state data output line (SDO, Pin 6). The system clock and the I/O clock operate independently and do not require any special speed or phase relationships between them. This simplifies the interfacing with other circuits. The interfacing hardware and software are only concerned with initiating the conversion and reading the data by using the I/O CLK and -CS. The operational sequence is explained below and is shown in Figure 7.

1. When -CS is high, the data output line is at a high impedance state. It also disables the clock input, I/O CLK. -CS goes low to start a read cycle. To minimise errors caused by noise at the input, the internal circuitry waits for two rising edges and then a falling edge of the internal system clock after a high-to-low transition is detected on the -CS pin, before it is accepted. The MSB of the previous conversion result (DB7) automatically appears on the DATA OUT pin.

2. The falling edges of the first four I/O CLK shift out DB6, DB5, DB4 and DB3 of the previous conversion result on the DATA OUT pin. The on-chip sample-and-hold begins sampling an analogue input after the 4th falling edge of the I/O CLK.

3. Three more clock cycles are applied to the I/O CLK, DB2, DB1 and DB0 of the previous conversion result are shifted out at each falling edge of the I/O CLK.

4. The final (8th) clock cycle is applied to the I/O CLK. The falling edge of this clock terminates the sample process and initiates the hold function which continues for the next four internal system clock cycles. After that the hold function terminates and an A/D conversion is performed during the next 32 system clock cycles. A complete A/D conversion takes 36 internal system clock cycles. During conversion,
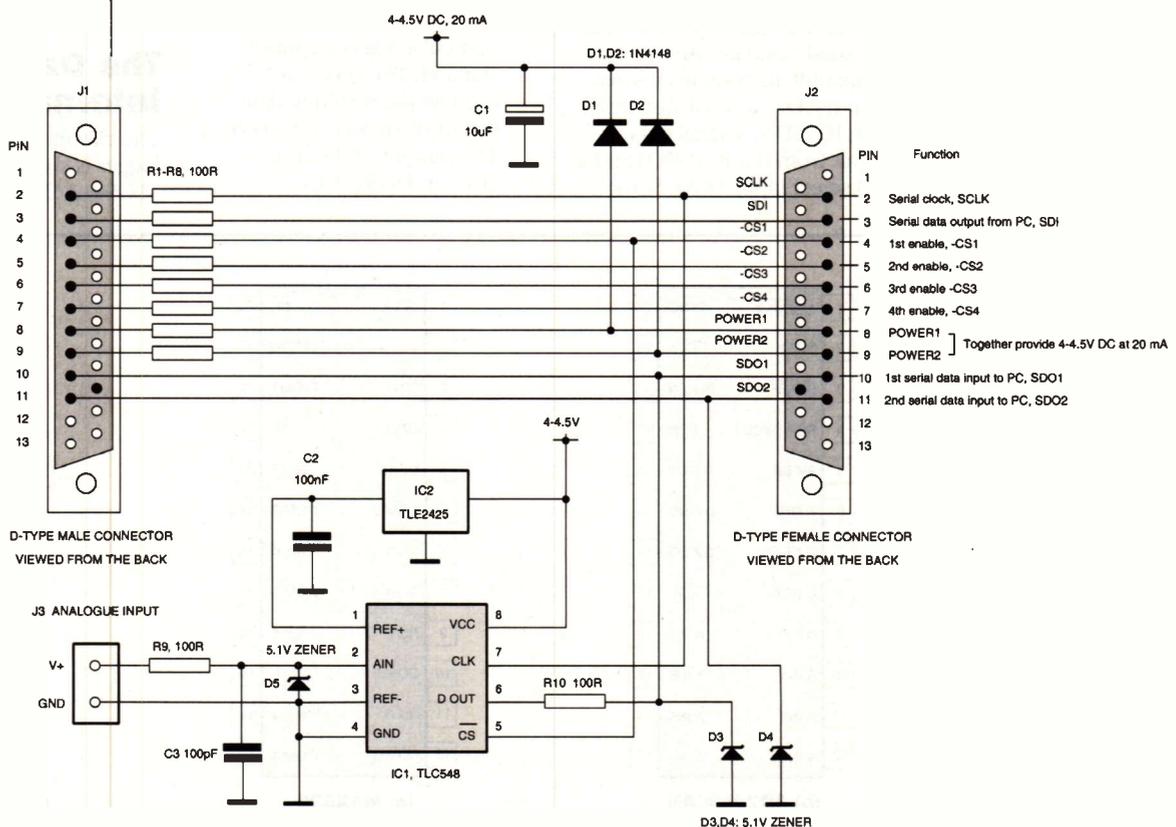
Figure 5. Circuit diagram of Centronic data logger.

either -CS must go high or the I/O CLK remains low for at least 36 system clock cycles. -CS can be kept low during multiple conversion, however, special care must be taken to prevent noise from getting into the I/O CLK, which otherwise causes the device and the external interface circuit to lose synchronisation. If -CS is taken high, it must remain high until the end of the conversion. A valid falling edge of -CS will cause the device to reset and to abort the conversion in progress.

Centronic Port Connections

For the present data logger, only 8-output lines of the DATA port and 2-input lines of the STATUS port of the Centronic port are used. The lines are assigned as shown in Table 1.

The Circuit

The circuit diagram is shown in Figure 5. R1 to R8 are resistors which limit the current drawn from the output lines of the DATA port. DB6 and DB7 of the DATA port are used to supply power to the data logger, and are set to logic high all the time. The current from each line flows through D1 and D2 (1N4148) and charges the capacitor C1. The voltage across C1 could reach as high as 4.2V, so 5.1V Zener diodes D3, D4 and D5 provide protecting for each line from over-voltage.

J1 (male D-type connection) is plugged into the Centronic port of the computer and J2 (female D-type connector) provides a connection with other modules. J2 has a serial bus containing a serial clock, a serial data output and two serial data inputs. The connector also has four chip selects.

'Stealing' Power from the Centronic Port

The power supply to the module comes from two output lines of the DATA port (Bits 6 and 7). For a standard Centronic port on a PC, two lines in the DATA port could together supply up to 20mA at a voltage of about 4V. The A/D converter only consumes 1.9mA at a supply voltage of 3V. The 2.5V voltage reference has a quiescent current consumption of 170μA. Therefore, the two lines in the DATA port could supply enough current to the data logger.

Programming

In order to control the data logger, a PC must be able to output data and read data via the printer port. If the base address of the Centronic port to be used is P_address, then the addresses for the DATA port and the STATUS port are P_address and P_address + 1, respectively. For most PCs, P_address is 378H for LPT1 and 278H for LPT2 (888 and 632 decimal). A Turbo Pascal procedure to automatically find the base address for LPTs installed is given in the progam list.

To output a byte (in decimal) from the DATA port, the

following commands are used:
```
QBASIC    OUT
P_address, byte
TP6
PORT[P_address]:=byte;
```

To input data via the STATUS port, the following commands are used:
```
QBASIC x=INP[P_address]
TP6   x:=PORT(P_address);
```

After issuing the command, the data input from the STATUS port is assigned to a variable x (in decimal).

The demonstration program is written in TP6 programming languages and is listed in Table 2.

Figure 6. Pin-out and internal block diagram of TLC548.

Construction and testing

The artwork of the PCB board and the component layout is given in Figure 8a,8b. In constructing the PCB board, resistors, diodes, capacitors and connectors are soldered to the PCB board first, then the two ICs are soldered directly onto the board. As they are CMOS devices, the soldering iron should be properly earthed. Space inside the enclosure is limited so C1 and IC2 are soldered to the PCB board from

```
DATA port, output port
BIT 0:    Serial clock for the SPI bus (SCLK)
BIT 1:    Serial data output from the PC (SDI, ICs receive data )
BIT 2:    First chip selection line (-CS1)
BIT 3:    Second chip selection line  (-CS2)
BIT 4:    Third chip selection line (-CS3)
BIT 5:    Fourth chip selection line (-CS4)
BIT 6:    Power supply line 1, Together with DATA 7 to supply power to the modules
BIT 7:    Power supply line 2. Together with DATA 6 to supply power to the modules

STATUS port, input data into PC.
BIT 2:    First serial data input line to PC (SDO1, ICs output data)
BIT 3:    Second serial data input line to PC (SDO2, ICs output data)
```

Table 1. Input/Output lines assignment.
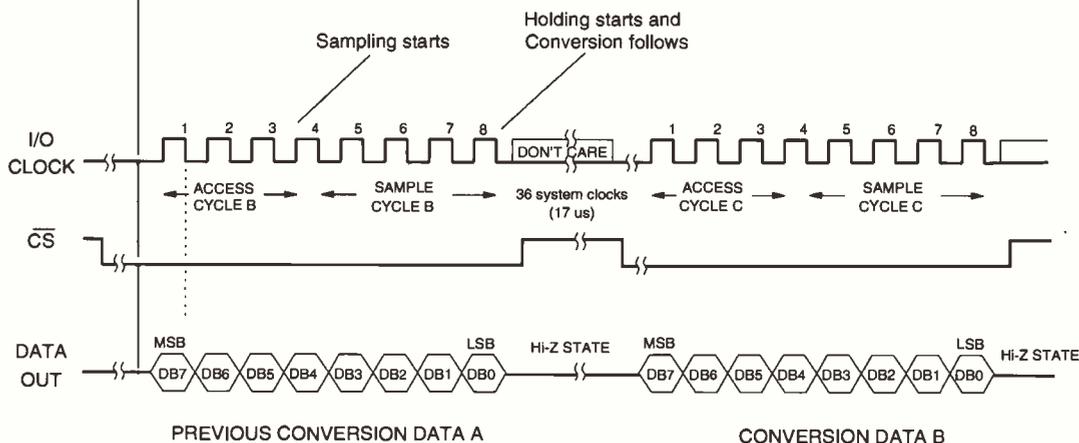
Figure 7. Operation sequence of the TLC548 serial A/D converter.
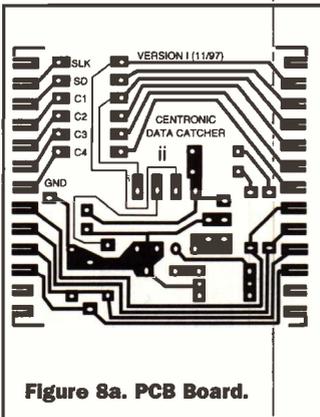
Figure 8a. PCB Board.

the track side. All other components are soldered to the board from the component side.

Once the construction of the PCB board is completed, the board is fixed in a dangle-type ABS box (see Figure 9). J3 is a detachable screw-type terminal. The header of the terminal is glued to the side of the box as shown in Figure 9. At this stage, the logger can be plugged into a computer's LPT port and the demonstration program is activated. A precision voltage reference can be used for checking the functioning of the data logger.

The data logger can be plugged into the PCs LPT1 port, but it is recommended that a second LPT port is installed on your PC so that LPT1 can be left connected to a printer. Multi-purpose I/O cards normally have a second LPT port and are available in many computer shops and cost approximately £10.

Build a voltage reference

Variable voltage references are useful tools for testing A/D converters. Such devices can be easily made using precision voltage reference ICs and a precision resistor network, or alternatively, using a variable resistor with a precision voltmeter. Figure 10 shows several possible circuits that can be constructed on a small piece of strip board and housed in a suitable box. They can be used for testing future projects involving A/D or D/A converters.

Technical support

The kit is available from the author. It consists of all the hardware for readers to construct a Centronic data logger. Source code and EXE file in Turbo Pascal 6 are provided on a 3½in floppy

```pascal
Program Centronic_Port_Data_Logger;
{Software driver for the printer port data
logger for Maplin}
{Hardware and software designed by Dr. Pei
An. All right preserved, 1/98}

{DATA PORT ( output port )
  DB0:      SCK of the SPI bus (used by the
logger and available    for   xpansion)
DB1:  SDA of the SPI bus (used by the logger
and available      for    expansion)
  DB2-DB5: -CS1, -CS2, -CS3 and -CS4 of the
SPI Bus
              (-CS1 used by the logger and -CS2
to -CS4 available      for    expansion)
  DB6, DB7: power supplies, 20mA at 4 Volts
  STATUS PORT ( input port )
  DB6:       Data input to PC, bit weight: 64
(used by TLC548)
  DB7:       Data input to PC, bit weight: 128
(available for    expansion)
 CONTROL PORT (output port), not used}

uses
    Dos, Crt;
var
  i,ii,j,k,l,m,n,P_address,command: inte-
ger;
  h1,m1,s1,s1001,h2,m2,s2,s1002,totalnum-
ber,ix:word;
  dummy,voltage:real;

Procedure Input_printer_address;
{Universal auto detection of printer base
address}
{ $000:$0408 holds the printer base address
for LPT1
  $000:$040A holds the printer base address
for LPT2
  $000:$040C holds the printer base address
for LPT3
  $000:$040e holds the printer base address
for LPT4
  $000:$0411 number of parallel interfaces
in binary format}
var
  lpt:array[1..4] of integer;
  number_of_lpt,LPT_number,code:integer;
  kbchar:char;
begin
    clrscr;
    LPT_number:=1; {defaut printer}
  number_of_lpt:=mem[$0000:$0411]; {read
number of parallel ports}
    number_of_lpt:=(number_of_lpt and
(128+64)) shr 6;
    lpt[1]:=memw[$0000:$0408];
{Memory read procedure}
    lpt[2]:=memw[$0000:$040A];
    lpt[3]:=memw[$0000:$040C];
    lpt[4]:=memw[$0000:$040E];
    textbackground(blue); clrscr;
    textcolor(yellow);
textbackground(red);   window(10,22,70,24);
clrscr;
    writeln('Number of LPT installed    :
',number_of_lpt:2);
    writeln('Addresses for LPT1 to LPT 4:
',lpt[1]:3,'    ',      lpt[2]:3,'    ',
lpt[3]:3,'    ', lpt[4]:3);
    write('Select LPT to be used (1,2,3,4)
: ');
    delay(1000);
  if number_of_lpt>1 then begin    {select
LPT1 through LPT4      if more than 1 LPT
installed}
    repeat
    kbchar:=readkey;
{read input key}
    val(kbchar, LPT_number, code);
{change character to value}
    until (LPT_number>=1) and (LPT_num-
ber<=4) and      (lpt[LPT_number]<>0);
                              end;
    clrscr;
    P_address:=lpt[LPT_number];
    writeln('Your selected printer inter-
face:      LPT',LPT_number:1);
    write('LPT  Address
: ',P_address:3);
    delay(1000);
    textbackground(black); win-
dow(1,1,80,25); clrscr;
end;

Procedure Out(data:byte);
{output command via the data port of the
centronic port}
begin
```

Table 2. Demonstation programme.

```pascal
    port[P_address]:=data;
end;

Function Input_AD:byte;
{input the serial data from the A/D convert-
er}
{input data connected to DB6 of the STATUS
port, bit manipulation is required}
begin
    Input_AD:=(Port[P_address+1] and 64)
shr 6; {read data and manipulate the data}
end;

Function AD_converter:real;
{read previous data from the A/D converter
and start another A/D conversion}
{to find the instaneous A/D conversion
result, this function must be called twice
with time delay}
var
    add,data: array [1..8] of byte;
    ii,addx:byte;
begin
    out(command+4);                  {-CS1 =1
}
    out(command+0);                  {-CS1 =0
to start A/D
       converter }
    for ii:=1 to 8 do begin          {start
A/D conversion and      read the previous
result}
      data[ii]:=input_AD;            {read
digit}
      out(1+command);                {SCK
high, -CS1=0}
      out(command);                  {SCK low
again, -CS1=0}
                   end;
    AD_converter:=(128*data[1] + 64*data[2] +
32*data[3] + 16*data[4] + 8*data[5] +
4*data[6] + 2*data[7]+1*data[8])*2.49/255;
end;

Procedure init;
begin
    highvideo;
    textbackground(blue);
    clrscr;
    out(4+8+16+32+64+128); {SCK=0, SDA=0, -
CS1..-CS4=1,       POWER LINE=1}
    command:=64+128;
    for l:=1 to 10 do dummy:=AD_converter;
end;

Procedure check_AD_speed;
{to find out the fastest data logging rate}
var
    time1,time2,dt:real;
    t,speed:longint;
begin
    clrscr;
    gotoxy(30,24); write('Checking A/D
speed');
    gettime(h1,m1,s1,s1001);
    for t:=1 to 20000 do dummy:=AD_convert-
er;
    gettime(h2,m2,s2,s1002);
    time1:=3600*h1+60*m1+s1+s1001/100;
    time2:=3600*h2+60*m2+s2+s1002/100;
    dt:=time2-time1;
    speed:=round(20000/dt);
    clrscr;
    gotoxy(10,24); write('MAXIMUM A/D con-
version speed [1/s]: ',speed:6,'Press any
key');
end;

{*************Main program*************}
begin
    input_printer_address;
    clrscr;
    check_AD_speed;
    readln;
    clrscr;
    init;
    writeln('          Centronic Miniture
Data Logger');
    repeat
    gotoxy(20,10);writeln('Voltage read
from Logger:        ',AD_converter:6:3,'
[V]');
    until keypressed
end.
```

diskette. The price for a kit is £25 including postage and packing. The assembled and tested units are £35 each. Please direct your enquiry to Dr. Pei An, 11 Sandpiper Drive, Stockport, Manchester SK3 8UL. U.K. Tel/Fax/Answer: +44-(0)161-477-9583. E-mail: PAN@ FS1. ENG. MAN. AC. UK.

References

PC Interfacing - Using Centronic, RS232 and Game Ports,
by Pei An, published by Newnes, Butterworth-Heinemann, 1998, ISBN0240514483.
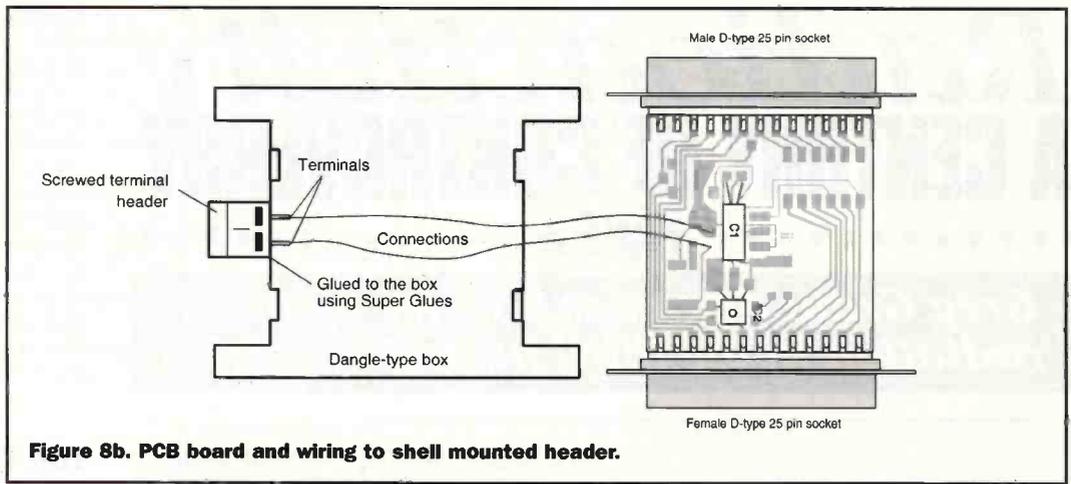
Figure 8b. PCB board and wiring to shell mounted header.
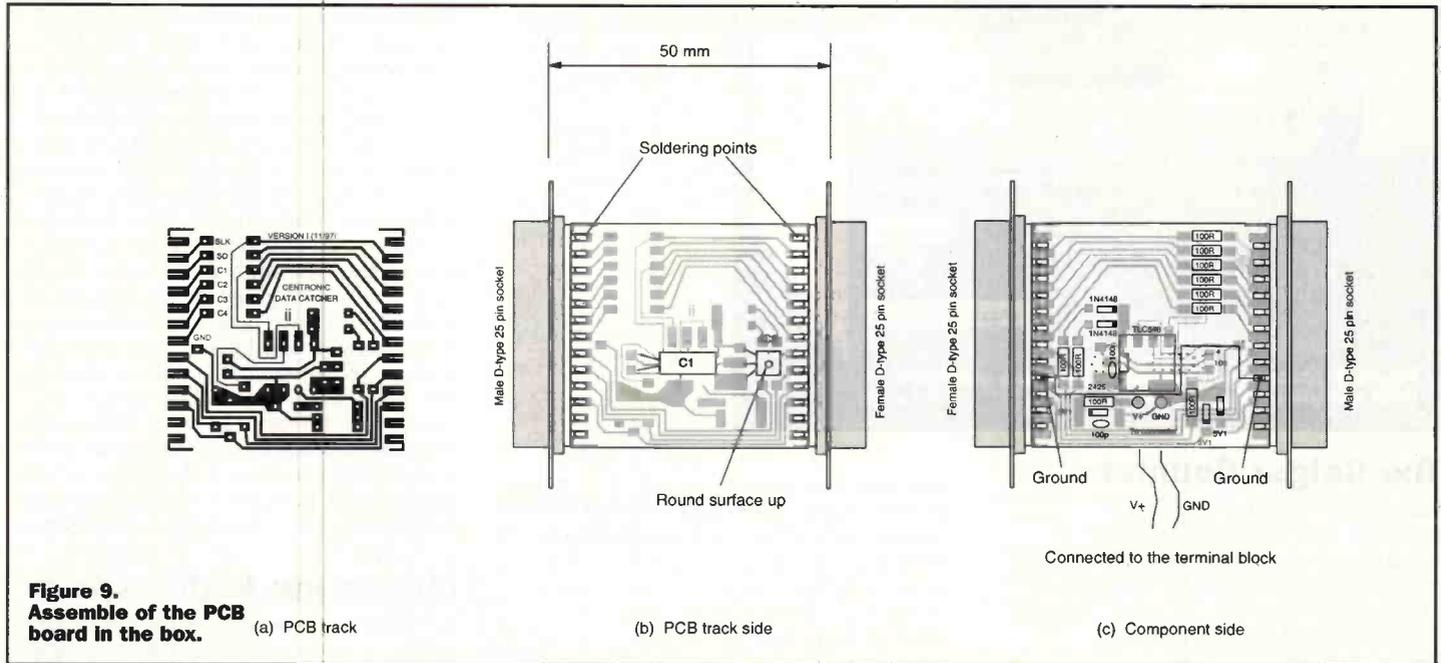
Figure 9.
Assemble of the PCB
board in the box.   (a) PCB track   (b) PCB track side   (c) Component side
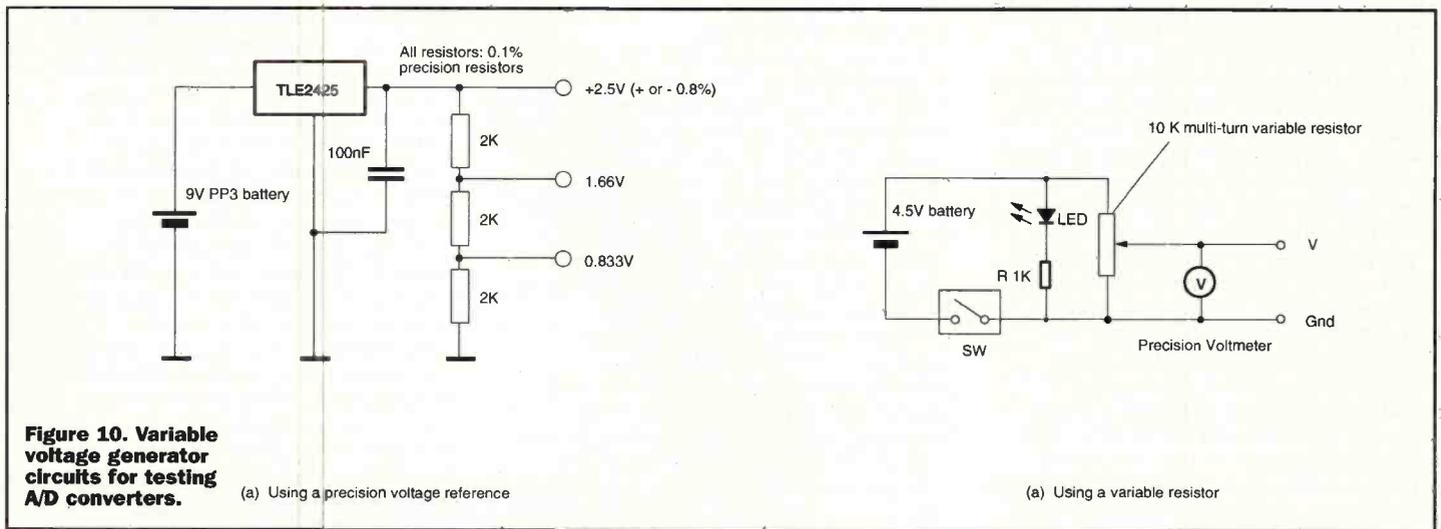
Figure 10. Variable
voltage generator
circuits for testing
A/D converters.   (a) Using a precision voltage reference   (a) Using a variable resistor

PROJECT PARTS LIST

SEMICONDUCTORS

IC1	TLC548 A/D converter	(GX06G)
IC2	TLE2425 2.5V 0.8% voltage reference	(CR12N)
D1,D2	1N4148 Diode	(QL80B)
D3-5	5V1 Zener diode	(QH07H)

RESISTORS All resistors: metal film 1% 0.6W resistors

R1-R10	Min Res 100R	(M100R)

CAPACITORS

C1	Gen Electrolytic 10uF 16V	(AT98G)
C2	Ceramic Disc 100nF	(RA49D)
C3	Ceramic Disc 100pF	(WX56L)

CONNECTORS

J1	25-W D-type male	(YQ48C)
J2	25-W D-type female	(YQ49D)
J3	PCB Conn 2-way Plug & Skt	(KC30H and KC22Y)

MISCELLANEOUS

Dangle-type 25 pin D-type housing	(JB03D)
PCB board	

Radioactivity
A CENTURY OF CONTROVERSY
● ● ● ● ● ● ● ● ● ● ● PART 3 ● ● ● ● ● ● ● ● ● ● ●

Greg Grant discusses how we measure radiation in the third part of his series
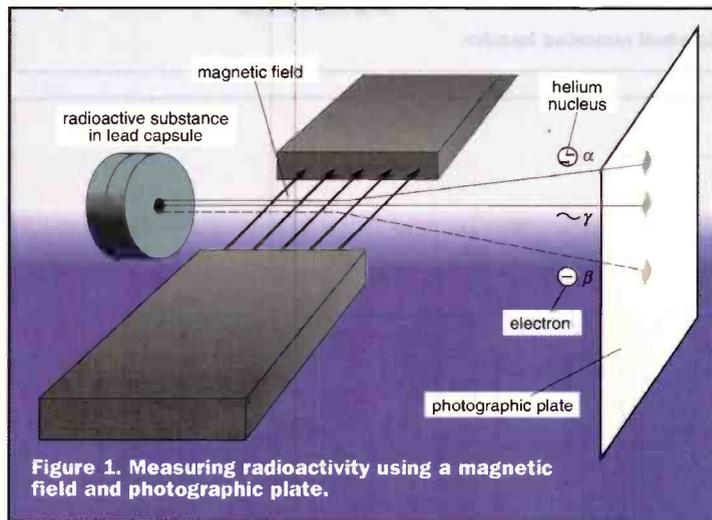
Figure 1. Measuring radioactivity using a magnetic field and photographic plate.

The Geiger Counter

Radioactivity is – as has been shown previously – the spontaneous collapse of certain heavy elements accompanied by high energy radiation consisting of alpha rays, or helium nuclei, beta rays which are composed of electrons, and finally gamma rays. Radioactivity can be split into these three constituent components by passing it through a magnetic field, as shown in Figure 1.

The alpha particles, having a positive charge, and the negatively-charged electrons are deflected in opposite directions whilst the gamma rays – in effect high energy photons – remain unaltered. Since all three types of radiation will fog a photographic plate, or ionise a gas, they can be detected either electronically or photographically.

The problem of measuring radioactivity electrically was first addressed around 1906, by two of the great names in the field, Ernest Rutherford and his assistant, the German research physicist Hans Geiger. They were investigating alpha and beta particles which, being extremely energetic, were very difficult to detect. However, two years later Geiger developed the earliest particle detector when he revealed the first crude version of what the world now knows as the Geiger Counter. The device was, in essence, a cylinder of soda glass containing a gas under a high electrical potential, yet one not high enough to overcome the resistance of the gas itself, thereby setting up a discharge spark. When a high energy particle entered the cylinder it stripped some electrons from a gas molecule, leaving a positive ion. This last, in turn, would be attracted to the negatively-charged cathode – with considerable force – creating more ions, each of which repeated the process. In short, an ionisation avalanche occurred,

producing an electric discharge which could be electronically amplified and then counted by either an electro-mechanical register, or as 'clicks' in a loudspeaker.

The modern Geiger Counter, illustrated in Figure 2, consists of a gas between two electrodes one of which, the cathode, is a hollow cylinder. The other, a fine wire stretched along the cylinder's axis, is the anode which carries a potential of around one kilovolt (kV). When an atom of the enclosed gas is ionised by a charged particle passing through it, an electron is produced by the collision and attracted to the central wire, in the course of which it collides with gas atoms. As a result of the intense electric field near the central wire, the electron can acquire enough energy between collisions to enable it to ionise another atom.

A second electron is set free and, through successive collisions, an avalanche of electrons collect as a charge on the central wire, producing an electrical impulse which, typically, can be some 50V. This pulse is independent of both the energy and nature of the particle that liberated the electrons within the gas and the counter operation depends critically on the voltage on the central wire. If this is too high, additional electrons produced by the positive ions begin additional discharges and the counter discharges continuously. If the voltage is too low however, an electron avalanche never takes place and the counter simply acts as an ionisation chamber, or a proportional counter, in which the output pulses are far smaller.

To prevent multiple pulsing, a quenching vapour such as methane is mixed with the counter's gas, which is usually Argon or Neon, at a pressure of around 14 kilopascals. Naturally some of the vapour is used up during each pulse, and so such tubes have a somewhat limited life, typically of about 10^8 to 10^9 counts. Halogen gas is also used as a quenching agent, giving tubes with a much greater lifespan. The central wire is usually tungsten, some 75 to 125

micrometres (mm) in diameter, whilst the other electrode can be made from aluminium, copper or brass.

The modern form of the device was produced in 1928 by Geiger, in co-operation with Walther Muller, the Professor of Physics at Kiel University. They improved the sensitivity, durability and hence overall performance of the original model. Presently Geiger-Muller Counters are used in industry to measure the thickness of sheet metal, by geologists in mineral exploration and by doctors to detect radioactive sources used in surgical procedures. They are also widely used in physical, biomedical and chemical research.

The Co-Incidence Counter

In 1929 another German physicist, Walther Bothe, came up with a new method for studying and measuring cosmic rays. He arranged two Geiger Counters in a circuit which would record a strike only if *both* counters recorded it simultaneously. Since the counters were placed one on top of the other, the only way a strike would register would be via a vertical cosmic ray passing through the whole arrangement. Moreover, particles other than cosmic rays – even if arriving from the correct direction – would have insufficient energy to pass through both devices. This Co-Incidence Counter, as Bothe termed his origination, proved most useful in measuring the brief time intervals between the passage of a ray through one counter and the other below it. Bothe used his device to demonstrate that the laws of both the Conservation of Momentum and of Energy applied equally as well at the atomic level as they did – for example – for marbles.

Measuring Radioactivity

Radioactivity has been measured in a wide variety of units since Rontgen's time, some of which have changed as a result of international conferences to determine universally acceptable – and therefore meaningful – units. Presently, the most widely accepted units are those of the Système International d'Unités, or SI system, created by the 11th General Conference on Weights and Measures.* Some of the units of radioactivity – past and present – are given in Table One.

To begin with, let's look at Ionising Radiation. The oldest unit is the Rontgen, symbol R, which indicated the quantity of radiation needed to generate one electrostatic unit of charge in a cubic centimetre of air at standard temperature, pressure and humidity. However, when it comes to measuring the effect of radioactivity on human tissue matters become somewhat convoluted. The original unit was the rad – derived from the expression 'radiation abosrbed dose' – the unit of 'Absorbed
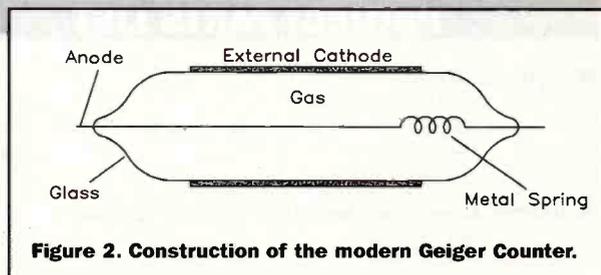
Figure 2. Construction of the modern Geiger Counter.

Unit	Description	Relationship to other units
rem [Abbreviation for Rontgen Equivalent Man]	Equal to the amount of radiation that produces the same damage to humans as **1 Rontgen** of high voltage X-rays.	The unit of Radiation Dose. Poorly defined originally, it was redefined in 1962 to clarify the usage of the term RBE, in both radiobiology and radiation protection.
rep [Abbreviation for Rontgen Equivalent Physical]	Equal to **93 ergs/gram** or **0.93 rads.**	This is the obsolete unit of Absorbed Radiation Dose.
rad [Shortened version of Radiation]	Equal to **0.01 joules/ Kilogram** or **100 ergs/gram.**	Superseded the Rontgen.
Rontgen (R)	Approximately equal to positive and negative charges of **2.58 x 10⁻⁴ coulombs/kilogram** of air.	The earliest unit of radiation measurement.
Sievert (Sv)	Approximately equal to **8.38 Rontgen** or **1 mCurie of Intensity per hour.**	The unit of Radiation Dose. The Sievert is an SI-coherent unit.
Gray (Gy)	Equal to **1 joule of radiation energy absorbed/kilogram** of tissue.	Superseded the **rad. 1 Gray =100 rad** and 1 Sv is approximately equal to **8.4 x 10⁻² Gy.** The Gray is an SI-coherent unit.

Table 1. Units of Radioactivity.

Ionising Radiation Dose' or 'Kerma.'

This last is the quotient of the sum of the initial kinetic energies of all the charged particles liberated through indirect ionising radiation in a volume element of a material, divided by the *mass* of the volume element, which was equal to 100ergs per gram of tissue. It was defined by the International Commission on Radiological Units and Measurements in 1962, as equal to the amount of radiation that releases an energy of 100ergs/gram of matter. One 'rad' in other words was approximately equal to the absorbed dose delivered when soft tissue was exposed to one 'Rontgen' of medium-voltage radiation. The unit however was not coherent with the SI system and so, in the 1980s, the rad was replaced by the 'Gray,' symbol 'Gy,' defined by the International Commission on Radiation Units and Measurements. It is called after the British physicist and radiobiologist Louis H. Gray.

Particulate radiation tends to cause greater injury per absorbed dose than, say, gamma or X-rays. Therefore, there are units which enable the normalisation of doses of different types of radiation in terms of what is called the Relative Biologic Effectiveness, or RBE. These units are the 'rem' – that dose in 'rads' that will cause the same amount of biological damage as one 'rad' of X- or Gamma rays – and the 'Sievert,' the latter abbreviated to 'Sv,' and called after the Swedish physicist Rolf Sievert. These are the units of Radiation Dose.

What this means is that the dose equivalent of a given type of radiation in 'Sieverts,' is the same dose in Grays multiplied by a quality factor based on the radiation's RBE. Generally speaking therefore one 'Sv', or 100rem – is the amount of radiation broadly equal in biologic effectiveness to 1Gy of gamma rays. However, both the rem and the Sievert are too large for some applications and so the milliSievert, or mSv, is frequently used, as indeed is the microSv, abbreviated to mSv, or one millionth of a Sievert.

One millionth of a Sievert for example is about 1/10th of the dose one would receive through flying from the United Kingdom to Spain, or around one 1/20th of the dose one would expect to get from a chest X-ray. One mSv, the equivalent of 1,000mSv, amounts to 50 times the dose one would get from a chest X-ray or, put another way, less than half the average annual dose one would receive from the natural radiation that occurs in the UK.

If gamma and cosmic rays are displayed on a map, bar graph or pie chart the quantity shown is usually the 'Absorbed Dose Rate in Air,' expressed in nanograys/hour. Where radon gas is concerned, the definition is of 'Activity

Unit	Description	Relationship to other units
Becquerel (Bq)	Equal to **1 atomic disintegration/second**	This unit also equals **2.7 x 10⁻¹¹ Ci.**
Curie (Ci)	Equal to **3.7 x 10¹⁰ atomic disintegrations/second.**	This is the unit of the Quantity of Radioactivity.

Table 2. Radioactivity in Materials.

Concentration in Air' and is expressed in 'becquerels/cubic metre.' Therefore to get an overall picture of the total amount of radiation to which humans are exposed, the above must be converted to a quantity termed the 'Effective Dose Equivalent,' which is expressed in millisieverts.

When it comes to whole populations, dosage is measured in 'person-rems' and 'person-Svs,' which express the product of the *average* dose per individual times the number of people exposed to the radiation. For example, a dose of 1Sv to each of 100 individuals would be the same as 100 person-Sv or 10,000 (10⁴) person-rems.

Radioactivity in Materials

Table two highlights the units used to measure the radioactivity present in a specific sample of material or substance, for example an archaeological specimen. These, the Becquerel and the Curie, are both named after two of the foremost early investigators in this field.

One Becquerel is equal to one atomic disintegration per second and we can look at this fact in a very personal way. Each one of us contains 60Bqs-worth of natural potassium-40/ Kg, which means that, on average, some 60 potassium atoms disintegrate every second within each Kg of material. And in this case 'material' means you and me!

The Curie on the other hand is the unit of radioactivity, established as such by the 1910 Radiology Congress, held in Brussels. It was based on the work of Hess who ". . determined the rate of emission of alpha particles from a gram of radium." [1] Indeed Hess himself suffered a thumb amputation in 1934, brought about by an accident with a radioactive substance.

High Energy Particle Measurement

The 'Electron-volt,' abbreviated to 'eV,' is the unit used to express energy at the atomic level. Visible light for example, has a quantum energy of around 2eV. An eV is the energy acquired by a particle that has a charge of the same magnitude as that of the electron when it passes between electrodes that differ in potential by one volt.

Cosmic rays of course are among ". . the most energetic particles we know of." [2] Indeed gamma ray photons are between

10,000 and 10,000,000 times more energetic than those of visible light, when they originate from atomic nuclei. The eV therefore is an ideal unit in which to measure such huge energies. It is the equivalent of 1.602 x 10⁻¹⁹ joules.

Man first began to tentatively approach the particle energies found in nature in 1929, when the British physicist John Cockcroft and his Irish colleague Ernest Walton " . . devised a voltage multiplier that would build up high electrical voltages capable of accelerating protons to the point where they contained more energy than the alpha particles occurring in nature." This was the beginning of what would later become a huge, and expensive, effort to discover not simply the energies behind cosmic rays, but the makeup of the fundamental building blocks of matter itself. Cockcroft and Walton began the era of particle acceleration techniques, giving ". . . impetus to the development of the cyclotron and other methods of accelerating particles to high energies." [4]

In time, this would lead to such centres as the Bevatron Particle Accelerator at the Lawerence Berkeley laboratory in the United States and the Super Proton Synchrotron at the Centre Européen de Recherche Nucléaire, or CERN, in Europe. These devices – more commonly referred to as 'atom smashers' by the press – use hitherto undreamed of energies to advance our understanding of the world we inhabit.

The increasing use of radioactive devices however, raised further concerns about health, both that of the staff involved in such work and of the general public. In the fourth article in this series, we'll look at the question of radiation and health.

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1. *Weber, Robert L. (1988): Pioneers of Science. Adam Hilger, Bristol, England. Page 104.*
2. *Asimov, Isaac (1975): Please Explain. Abelard-Schuman, London. Page 122.*
3. *Asimov, Isaac (1989): Asimov's Chronology of Science & Discovery. Grafton Books, London. Page 503.*
4. *Ibid (1), Page 138.*
* See 'SI Units for Current Technology' article in 'ELECTROTECHNOLOGY,' the journal of the Institution of Electronic & Electrical Incorporated Engineers, April/May, 1997.

Removable MEDIA

PART 1

Photo 1. The SuperDisk LS120.

Martin Pipe examines alternatives to the floppy disk.

Photo 2. LS120 disk.

One thing's for sure. Whatever the size of your hard disk, it's never big enough. Applications are, after all, becoming more and more bloated. A word processor that consumes 100Mb, I ask you? Goodness knows how much a full installation of Windows 98 will consume. Let us not forget the temptations of the Internet. It's difficult to resist downloading those sound files, video clips, shareware programs, e-mail and FAQ documents. Not to mention stuff like your browser's cache that you, as the user, aren't always aware of. OK, you could upgrade your hard disk or even add a second one. Technically, it's possible provided that there's space in that there case; IDE supports up to four devices. SCSI, which is more supportive of external peripherals, will support up to fifteen in its 16-bit guise.

But what about removable media? That way, you could get organised and reserve a disk for each specific purpose. Removable media has other uses, too. Essential files and irreplaceable work can be backed-up so that they're not lost in the event of virus infection, hardware theft or a hard disk crash. The back-up disks can be retained in a separate location, possibly in a fireproof safe. Through the flexibility of removable media, complete work projects and multimedia presentations can be posted to colleagues and friends around the world. Finally, less-used data and programs can be shifted (temporarily, if need be) off your hard disk.

You could use a floppy disk for this kind of job but, to be quite frank, 1.44Mb is a joke in today's multimedia-enriched PC world. One of the drives we shall be examining in next month's article is the SuperDisk/LS120 (see Photo 1), a 120Mb drive that is read/write/format backwards-compatible with older 3.5in. floppy media (see Photo 2). The drive's manufacturer hopes that, primarily through this feature, it will become the high-capacity removable medium of choice. If only things were that simple. Unfortunately, the SuperDisk's closest competitor – Iomega's Zip, which has similarly-priced, albeit less-capacious flexible media – beat it to the market by two years, and has built up a formidable customer base. What's more, the 100Mb Zip is somewhat faster than the SuperDisk. Various computer manufacturers, including Apple, are now building Zip drives into their machines (see Photo 3).

Interestingly SuperDisk's inventor, Imation, isn't planning a Macintosh version of the SuperDisk, at least for the time being. In the PC world, however, various PC hot-shots including Compaq and Viglen are now offering the SuperDisk as an option. The additional cost of incorporating a SuperDisk isn't that great, since the existing floppy can be dispensed with. Notebook manufacturers are warming to SuperDisk, and an increasing number of new models are being equipped with the device. The drives can be made quite thin – certainly thinner than Zip hardware – and the backwards-compatibility is seen as another significant advantage. SuperDisk interfaces to a PC via the IDE bus. If it's to be used as a boot drive in the same way as a 3.5in. floppy can, the motherboard's BIOS needs to support the device. Most motherboards produced over the last year can.

If your PC is an older type, a 16-bit ISA IDE controller – the Promise SuperMax – will support the SuperDrive as a bootable device. If you don't want to buy one of these, replace the BIOS chip or

Photo 3. Zip drive and disk. See Maplin Catalogue.
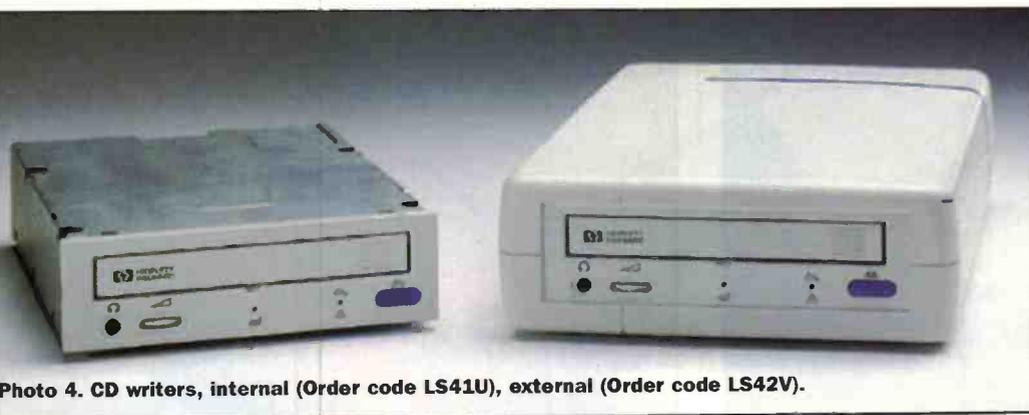
Photo 4. CD writers, internal (Order code LS41U), external (Order code LS42V).

upgrade the motherboard then you might need to retain your existing floppy if the ability to boot from a removable disk is required – as it might be in the event of a hard disk crash. The Zip drive is available in internal (SCSI, IDE) and external (parallel port, SCSI) versions. Maplin sell all except the internal SCSI version for a common price of £109.99; the respective order codes are JS34M (parallel port external), JS32K (SCSI external) and CK04E (IDE internal). The new Zip Plus drive (LS84F, £149.99) has both parallel-port and SCSI interfaces, and is thus worthy of consideration by those who have both Mac and PC platforms. Blank disks are also available from Maplin, as are a range of Zip-related accessories.

Other removable media options include CD-Recordable (CD-R) and CD-Rewritable (CD-RW), which were examined in some depth by articles published previously in *Electronics and Beyond*. Because it's a WORM (write-once, read many times) medium, CD-R is perhaps better suited to the archiving of data. CD-R's biggest advantages are backwards-compatibility with CD-ROM drives (well, how many PCs do you know without one of these?) fast data transfer speeds (limited by the CD-ROM reader) and incredibly cheap media (unbranded CD-Rs can now be acquired for 80p each, in bulk quantities). CD-RW disks can't be read by the majority of installed CD-ROM drives, although the newer readers are said to be compatible. CD-RW's main advantage is that the disks can be re-formatted and used again. Interestingly, the latest drives and software support replacement of files (commonplace enough if a piece of work is being updated) without the need to re-format. Blank CD-RWs are now priced at around the same level as Zip and SuperDisk media, but hold more data – up to 650Mb.

There are other bigger-capacity alternatives to Zip and SuperDisk. We will be examining two of them next month. The SCSI-interfaced Jaz, which is made by Zip's creator Iomega, is effectively a removable hard disk drive see Photo 5. This will store up to 1Gb per disk, although a 2Gb version that – surprise, surprise

Photo 5. Iomega Jaz drive and disk.
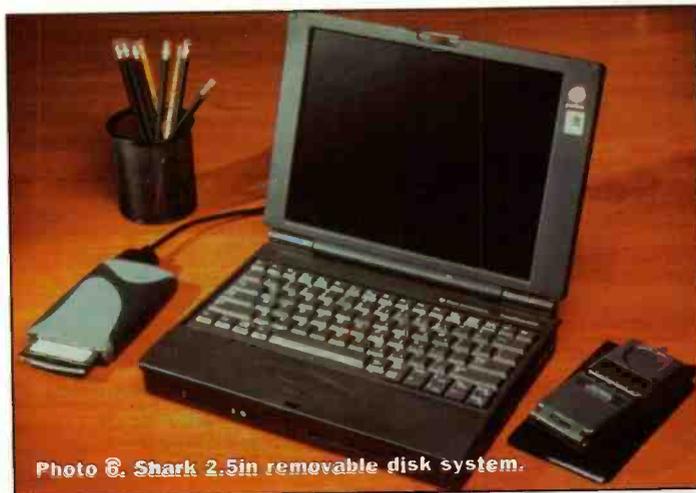
Photo 6. Shark 2.5in removable disk system.

– needs different (and more expensive) media. The 1Gb drive is quite expensive; Maplin's prices are £299.99 and £234.99 for the external (order code CD02C) and internal (CD01B) versions respectively. Even the 1Gb media isn't cheap at £79.99 (Maplin order code CD03D) each. It must be remembered, however, that the

system does work at hard disk-type speeds; SuperDisk and Zip are much slower. The other system, which has just started appearing over here, is Avatar's 177 Shark (see Photo 6). Like Jaz, Shark is based around a removable hard disk – albeit one only capable of storing 250Mb of data. At £33 each, the 2.5in. disks are somewhat cheaper than those associated with Jaz – although the cost per megabyte is more. Already a success story in the States, Shark is intended primarily for use with notebook PCs. Indeed, the review sample shipped with a PCMCIA interface card; with this, it's claimed that Shark can deliver levels of performance not dissimilar to those associated with IDE drives.

For the ultimate in performance, however, you can't beat a proper hard disk. These can be made removable. Indeed, Maplin sell lockable pull-out caddies suitable for both IDE (40-pin) and SCSI (50-pin) disk subsystems see Photo 7. Both are designed for modern half-height 3.5in. drives, fit into a vacant 5.25in. drive bay, are easy to fit, and are inexpensive. Both SCSI (CD49D) and IDE (ZE79L) sell for £19.99. Bearing in mind the current low cost of hard disk drives, this approach could be quite attractive under some circumstances. Your existing drive could be used to boot the machine, and perhaps store applications. The removable one could then be dedicated to user-specific (and perhaps sensitive) data. At the end of the day, the machine can be switched off and the drive caddy removed. Thanks to the IDE auto-detect systems of modern PC motherboards, that second drive doesn't have to be in the machine for it to boot. The same would also be true of SCSI systems, provided that the caddied drive isn't the terminated one.

Another application that lends itself to the caddy approach is where multiple operating systems are required. You could partition your hard disk and install various operating systems (e.g., Linux, OS/2, Windows) on each. As an alternative, individual hard disks pre-loaded with each operating system (plus any relevant application software) could be fitted into a dedicated caddy. As long as the caddies are interchangeable, booting from different operating systems is very much a plug-and-play affair (although the PC must be powered down first!). This is a much better

Photo 7. Caddy system for removable hard drives. Order code ZE79L (IDE), CD49D (SCSI).
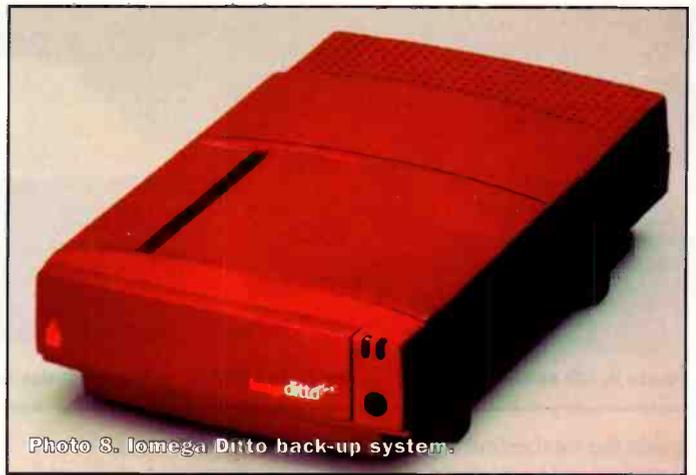
Photo 8. Iomega Ditto back-up system.

Photo 9. The Backer system uses conventional VHS tapes.

approach than partitioning. Not only is the capacity juggling-act dispensed with, but performance could be better since each drive can be optimised for that particular operating system and any filing system peculiar to it. I myself use this approach, and have boot-caddies dedicated for Windows 95 (FAT file system) and NT4.0 (NTFS). Although most of the proper removable media can be organised as boot devices, their performance isn't as good as a pukka hard disk. Unless you're prepared to slow down your system – after all, we're talking about the operating system here – it's not worth considering booting from removable media unless it's an emergency.

The final removable media option is the tape streamer. These have traditionally been used for back-up, although superfloppies have eroded their market share recently. The big problem with tape is that it doesn't have the random accessibility of disk. As a result, restoring, or transferring a particular file (or group of files) back to your hard disk, can be a very time-consuming activity. This is simply because the drive may have to spool through the tape to find the files of interest. In addition, data transfer rates are somewhat slow. Backing up a complete hard disk can take several hours, even with comparatively fast SCSI-connected systems like DAT. Tape does have one major advantage, however, the media is inexpensive, and modern systems can store several gigabytes. Modern back-up software is easy to use, although the manner in which they compress (and write data to) the tape varies widely.

As a result, it may be impossible to read a tape on another machine – even if the hardware is identical or media-compatible – unless the same back-up software is used. If you want to read a tape that was written to some years ago, you might run into problems – not least because the back-up software used to create the archive (if you can remember what it was) might not run under your current operating system... We'll be looking at the Iomega Ditto Max (Maplin order code LS86T, £149.99), which is capable of storing up to 7.5Gb of data on a single Ditto-type tape (the product is, however, compatible with other standard but lower-capacity media including the Travan TR-3 and QIC3020) see Photo 8. The Ditto Max is designed to connect to a PCs (ECP) printer port, and is hence happy with both desktop and notebook PCs.

It has an interesting feature, whereby the first 125Mb of the tape are treated separately. The Ditto Max is supplied with the Seagate Software-sourced FlashFile, which treats this 125Mb partition as a removable medium complete with drive letter. It's nowhere near as fast as a disk, particularly in terms of access times, but it's quicker than the rest of the tape. In any case, it can be useful to have. As a cheaper alternative, there's the Windows-specific Danmere Backer, which is capable of storing up to four gigabytes on a standard videotape (see Photo 9). The latter is inexpensive simply because you already own the tape transport, in the form of your VCR. If you're prepared to rummage around inside your machine, then the ISA version of Backer, complete with software, can be yours for a mere £34.99 (Maplin order code LS64U). As an alternative, the (ECP) parallel-port version sells for £59.99 (order code LS65V).

Next month, we benchmark the various products. Plus an in-depth discussion of their operation.

L ast month we looked at some ideas and applications for the 418MHz transmitter/receiver pair (Maplin Order code NW43W). This month we take a look at some specific circuits that can be constructed using the modules, some of which can form the basis of a remote control or telemetry system. Constructors not requiring all the functions can modify the circuits accordingly if necessary.

In order to avoid unnecessary repetition and to allow flexibility, several different functions have been incorporated into two basic circuits, one incorporating the transmitter module and the other using the receiver. Constructors not requiring all the functions can modify the circuits accordingly if necessary.

Transmitter

Referring to Figure 1, it can be seen that the transmitter circuit is based around the M145026B-1 encoder IC. Regulator RG1 provides a stable 5V supply and capacitors C1 – C3 serve as general supply rail de-coupling. C4 and C7 provide specific high frequency de-coupling for the ICs. IC1 is a hex Schmitt inverter and is used to perform a series of different functions in the circuit. The main purpose of this section of the circuit is to control the amount of time that the transmitter is

418MHz
LOW POWER
TX & RX MODULES
• • • • • • • • • PART 2 • • • • • • • • •

by Gavin Cheeseman

operating, thereby reducing the overall power consumption of the unit. The details of the operation of this section of the circuit are as follows: IC1a, C6 and R6 form a low frequency oscillator. The output of IC1a is fed to C5 and R5 which effectively act as a differentiator. When IC1 pin 2 goes high, IC1 pin 3 is momentarily pulled high until C5 charges, which results in IC1 pin 4 momentarily pulsing low. When in 'power saving' and during this short pulse the transmitter is enabled, so drawing current.

Terminal P14 operates as a transmit inhibit line if taken low and conversely P3 forces permanent transmission. This part of the circuit functions in the following way: IC1c and IC1f together with R3 and D2 effectively allow the pulse train from IC1b to be gated out if a logic low is applied to terminal P14. IC1d, IC1e, R4 and D3 repeat this function. R1 and R2 are pull-up resistors and ensure that the IC inputs remain in a logic high state when no input is connected. The output of IC1d on pin 8 is fed to IC2 pin 14 (the Transmit Enable line).

In all cases, while IC2 pin 14 remains high, the output from the IC is disabled and transistor TR1 is switched off. If IC2 pin 14 is taken low, serial data is produced on pin 15. The actual data that appears on pin 15 is determined by the state of the 9 address/data lines; we will cover this in more detail later. The data output is fed to the base of transistor TR1 via R7 which ensures that the current is limited to an acceptable value. TR1 in turn drives the transmitter module.

In power saving mode, the output from IC1 pin 8 momentarily pulses low at regular intervals resulting in the transmitter sending a series of short data bursts. In between bursts the transmitter is off thereby saving power. Applying a logic low condition to terminal P14, disables the output of the transmitter, whereas applying a logic low to terminal P3 results in the output being permanently enabled. Capacitor C9 de-couples the transmitter module. R11 is set to allow the transmitter to operate at 5V. VC1 tunes the antenna to resonance. R8, R9 and C8 are timing components relating to IC2. The values of these have been selected to ensure that the maximum data rate
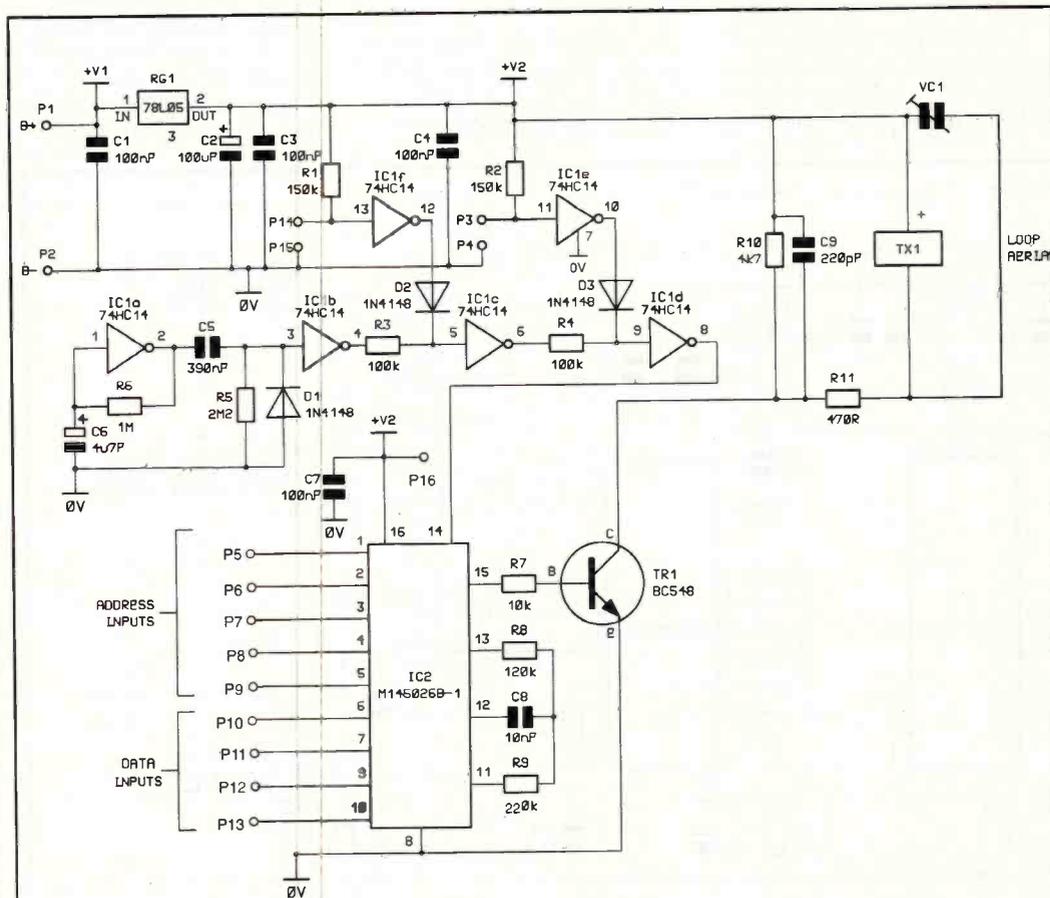
Figure 1. Transmitter Circuit Diagram

requirement for the transmitter module is not exceeded. If you intend to modify these values, it is important to ensure that you stay within the data rate specification mentioned in the transmitter leaflet.

Legal Requirements

To ensure compliance with mandatory DTI regulations, it is necessary to adhere to the License Exemption requirements printed in the leaflet supplied with the transmitter and receiver modules. The requirements include limitations regarding maximum antenna dimensions and mandatory labelling. Specific legal requirements apply to the use of the 418MHz band. Readers who are unsure of the legality of a particular application are advised to seek further advice before proceeding.

Transmitter construction

The circuit can be built on a variety of materials including printed circuit board and matrix board. The antenna can be formed from single strand copper wire or alternatively etched onto PCB material. Care should be taken to remove any unused copper from the area of the antenna as this may adversely affect performance. Take time to work out your layout as this will avoid problems later.
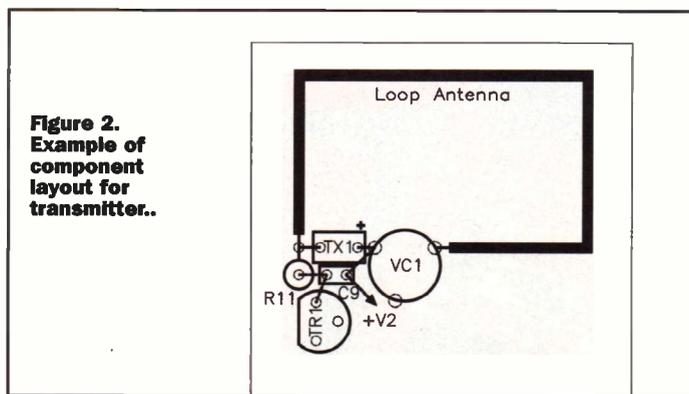
Figure 2. Example of component layout for transmitter..
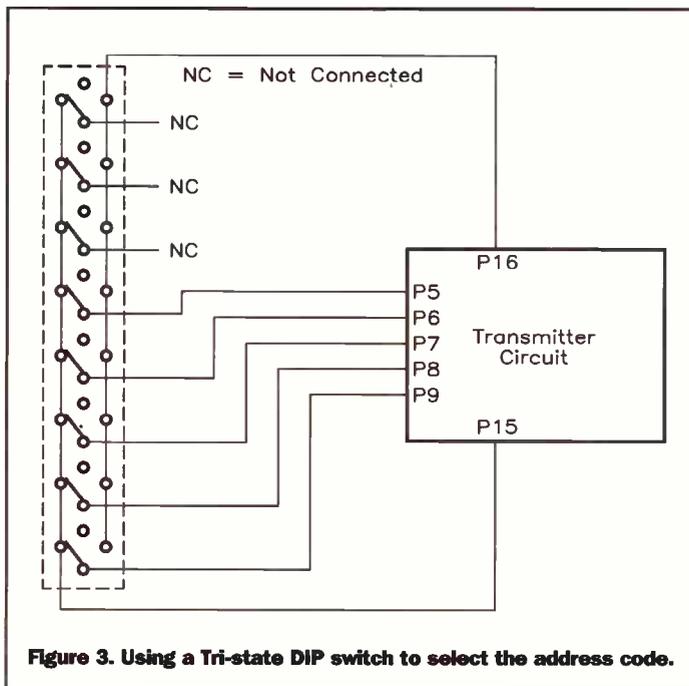
Figure 3. Using a Tri-state DIP switch to select the address code.

As always, take care to ensure that polarised components are inserted observing the correct polarity. This is particularly important not only for the correct operation of the circuit but also for safety, as some components such as ICs and electrolytic/tantalum capacitors can explode if incorrectly connected. The positive terminal of the transmitter is indicated by a black band, marked on one side of the package.

As with all high frequency devices, component layout is critical. This is particularly the case with the radio frequency part of the circuit. C9, R11, TX1 and VC1 must be grouped together as closely as possible. An example of how to layout the most critical components is shown in Figure 2. The dimensions and shape of the loop antenna are important and detailed information regarding this is given in the leaflet supplied with the transmitter module. The layout of the remaining components, relating to IC1 and IC2 is not so critical but there are still important considerations. High frequency de-coupling capacitors should be kept as close to the associated IC as possible. Therefore C4 should be close to IC1 and C7 should be kept as near as possible to IC2. The arrangement of power supply rails is important and the RF and digital supply rails should be kept separate as far is practical. The RF and digital 0V tracks should join only at terminal P2 and the +V2 tracks should join as close to the output of RG1 as possible. It should be noted that the +V2 supply rail feeding the transmitter module is effectively the RF ground in this circuit.

Figure 4. Receiver Circuit Diagram
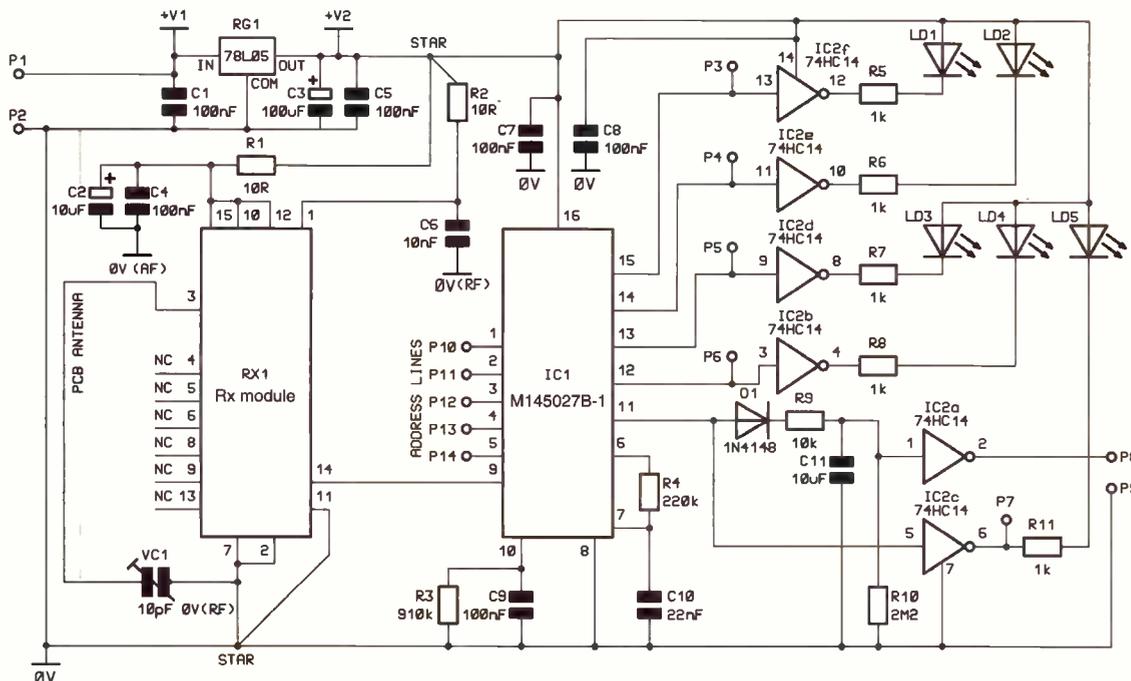
Consideration must be given to the arrangement of the data and address lines depending on application. For general purpose use, these are probably best brought out on PCB pins. Alternatively DIP switches can be used as shown in Figure 3. If you wish to fix the address inputs permanently at one value then the pins can be hard wired.

Receiver

Figure 4 shows the circuit diagram for the receiver unit. Once again, this has been designed to allow for a variety of different uses. As with the transmitter, RG1 provides a regulated 5V to power the circuit. Capacitors C1, C3 and C5 provide general supply de-coupling. The radio frequency, audio frequency and digital parts of the circuit each have their own de-coupling to prevent unwanted signals feeding back onto the supply line. C2 and C4 de-couple the receiver module's AF power rails, C6 is used for the RF power rails and C7 and C8 de-couple the supply to IC1 and IC2. The effect of this filtering is enhanced by resistors R1 and R2 which add a small amount of additional impedance to the AF and RF supply rails.

The demodulated output from the receiver module appears on pin 14 and this is fed to IC1 pin 9. IC1 functions
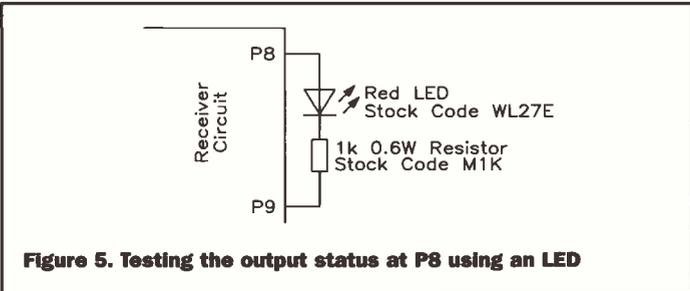
as a decoder producing a 4-bit data output on pins 12 to 15 when a valid address code is received. Under this condition, a valid transmission output is produced on IC1 pin 11. The data outputs are brought out on terminals P3 – P6. R3, R4, C9 and C10 are timing components relating to the correct operation of the decoder chip. The values of these have been chosen based on the operating parameters of the encoder.

The valid transmission output is fed to a diode pump circuit comprising D1, R9 and C11. When the valid transmission output is present, this drives the diode pump, charging C11, resulting in a logic high condition at IC2 pin 1. This results in a logic low at the output of IC2a, and this appears on terminal P8. When the valid transmission output is not present on IC1 pin 11, for example because no signal is being received or the address code is incorrect, C11 slowly discharges. R10 provides a

reliable discharge path for C11. When the voltage at IC2a falls below a predetermined threshold the IC's output switches high resulting in a high condition at terminal P8. IC2b – IC2f are used to drive light emitting diodes LD1 – LD5. The LED's provide an indication of the state of the data outputs and the valid transmission output.

Receiver construction

Similar considerations apply when building the receiver as with the transmitter and readers are recommended to apply the same rules of construction. To some extent, separation of the supply rails is forced by the inclusion of resistors R1 and R2, but don't forget to use separate runs for the 0V tracks. If possible, the AF, RF and digital 0V tracks should join only at terminal P2. Once again, keep the de-coupling capacitors close to their associated components. C2, C4 and C6 should be as

close to the supply pins of the receiver module as possible. Similarly, C7 should be next to IC1 and C8 to IC2.

Testing

Although some tests can be carried out on the circuits individually, it is best to test the transmitter and receiver together. The circuits have been designed to operate over a wide range of supply voltages and exhibit low current consumption (see specification).

In order to test the system, it is necessary to ensure that the code set on the transmitter address lines corresponds with that set up on the receiver. The address pins are tri-state, which means that the inputs can be either logic low, logic high or open circuit; this must be borne in mind if you wish to make use of the maximum number of possible code combinations. The decoder used in the receiver circuit is designed to decode the first five bits of incoming code as address and the remaining four bits as data; the arrangement on the transmitter should correspond with this. Probably the easiest way to set up the system during testing is to leave P5 – P9 on the transmitter and P10 – P14 on the receiver not connected (in tri-state mode). The data inputs on the transmitter (terminals P10 – P13) should

Figure 5. Testing the output status at P8 using an LED
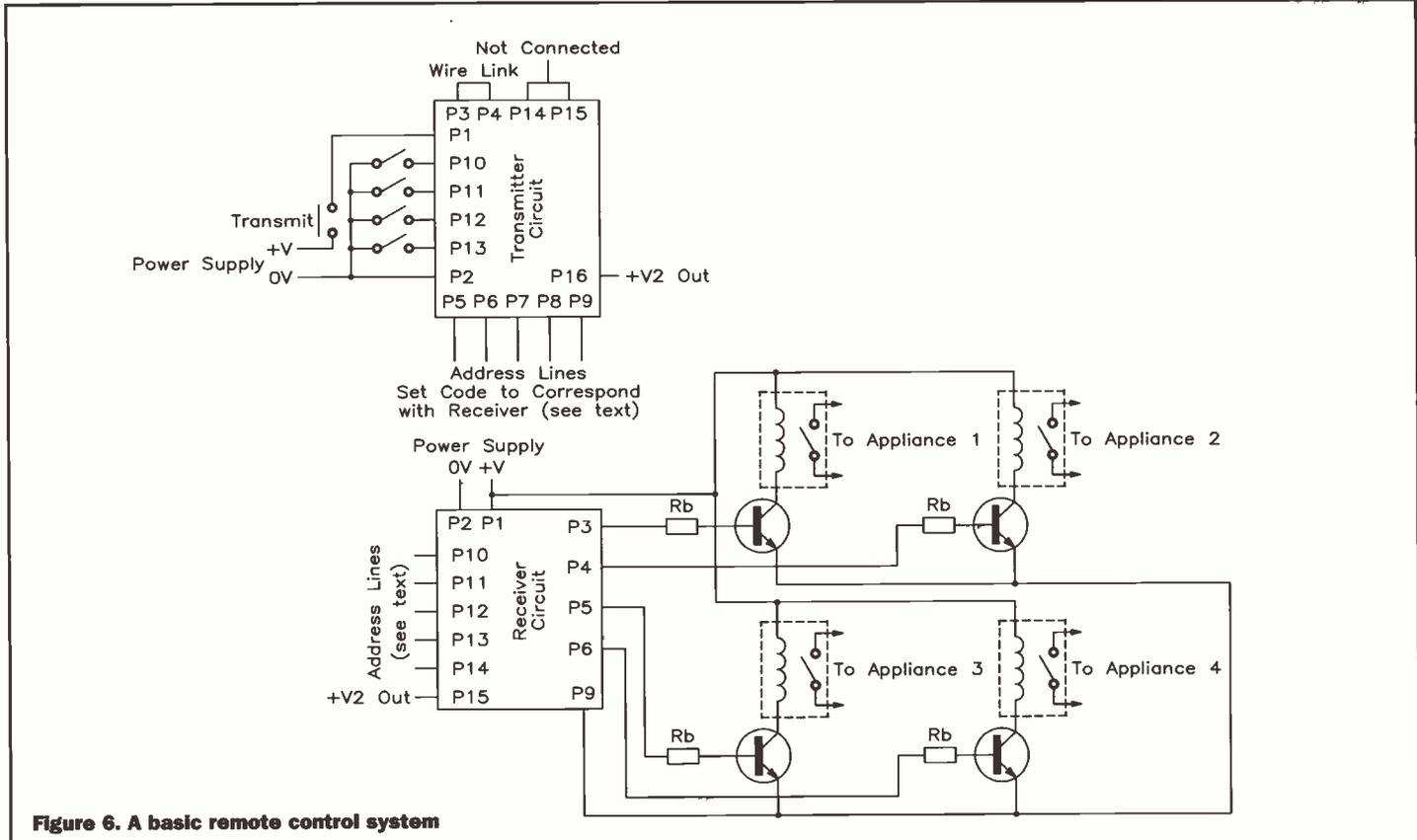
Figure 6. A basic remote control system
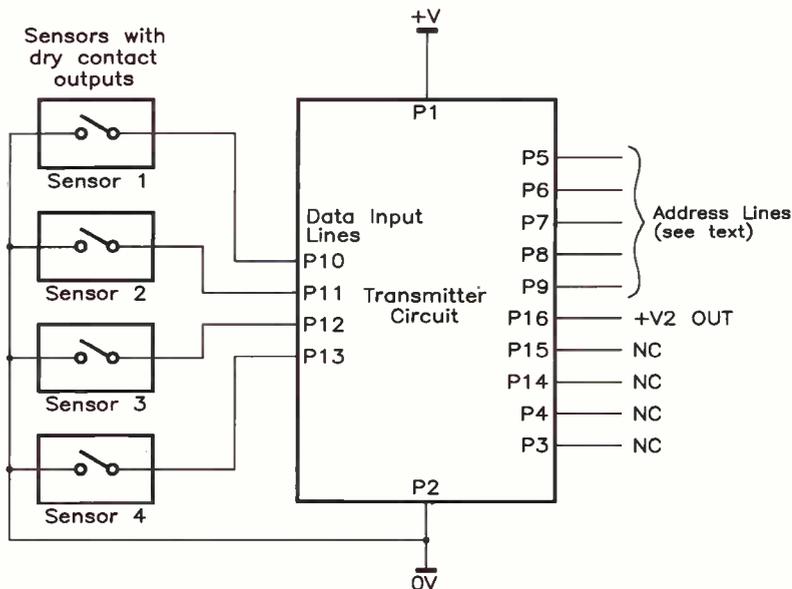
Figure 7. Example of how to interface sensors with dry contact outputs to the transmitter.

also initially remain unconnected (this is interpreted as a logic high as the receiver treats the data part of the code as binary only).

To test the operation of the system, place the transmitter and receiver side by side and apply power to both units. In both cases, the supply +V is connected to terminal P1 and the 0V connection is made to terminal P2. When power is applied, LD5 on the receiver should flash at regular intervals. LD1 – LD4 should also be illuminated. When the receiver is first powered up, P8 should initially switch to a logic high state but should return to logic low after a few seconds. This can be checked using a multimeter, logic probe or oscilloscope. If you have none of these you can temporarily connect an LED and resistor between terminals P8 and P9 to indicate the output status (see Figure 5). The LED will glow dimly when the output is logic high and will switch off in a logic low state. It is undesirable to leave to LED in place if the output at P8 is connected to other apparatus, as the combination may create an excessive load for IC2a.

If everything appears to be functioning as described, temporarily connect a wire link between terminals P14 and P15 on the transmitter ensuring that P3 and P4 remain open circuit. This should disable the transmitter output. LD5 on the receiver should stop flashing, indicating that a valid transmission is no longer being received. After a period of a few seconds terminal P8 should switch from a logic low to a

logic high state. Remove the wire link between P14 and P15 on the transmitter and after a short time, LD5 should flash and P8 should return to a logic low condition.

If all is well, sequentially apply a logic low to each of the transmitter data lines (terminals P10 – P13). After a short delay, the corresponding LED on the receiver should extinguish. If the data lines are then returned to an open circuit or logic high condition, the LED's should once again illuminate, after a short period. Do not connect the data or address lines to voltages exceeding +5V or to negative voltages as this may damage the IC.

Now connect a wire link between terminals P3 and P4 on the transmitter; this should make the unit transmit continuously. Repeat the above test, applying a logic low to each of the transmitter data lines. This time the corresponding LED on the receiver should extinguish almost immediately.

As a final test, apply a logic

low to one of the transmitter address lines (P5 – P9). This should result in all of the receiver LEDs extinguishing, as the transmitter address will then be different to that set up on the receiver.

Antenna alignment

The only alignment required for either circuit is to adjust antenna trimmer VC1. Adjustment of this capacitor is required to resonate the antenna, ensuring that the maximum range is obtained within the operating limitations. No additional test equipment is required to do this, but if you have access to a suitable field strength meter or spectrum analyser, you can save time by using it to pre-align the transmitter. To do this, adjust VC1 on the transmitter for maximum radiated power. During alignment, the transmitter can be made to operate continuously by linking terminals P3 and P4.

If you do not have any test equipment this is not a problem. Switch on the transmitter and receiver and check that LD5 is illuminated indicating that a valid code is being received. Move the receiver away from the transmitter until LD5 extinguishes. At this point adjust VC1 on the receiver until LD5 illuminates again. Move the receiver further away from the transmitter and repeat the process until maximum operating distance is achieved. Now adjust VC1 on the transmitter to increase the operating range still further until optimum performance is obtained. It can be useful to enlist someone's help when carrying out this procedure, as the line of sight range can be considerable.

Applications

As mentioned, the circuits described in this article have been designed for use in a wide range of different applications. A few examples follow:

Remote control system

The transmitter and receiver circuits can easily be used to create a simple remote control system enabling up to four different appliances to be switched on or off. An example of how to achieve this is shown in Figure 6. By applying a logic low or a logic high to the transmitter data lines, you can control the state of the corresponding data outputs on the receiver. Each of the four data output lines from the receiver is connected to a transistor switch, which in turn drives a relay. Care must be taken to ensure that the relay used is of a suitable voltage and current rating for the device being switched. When using the transmitter in remote control applications, terminals P3 and P4 should be linked so that the transmitter starts sending the code as soon as power is applied. If you do not link these pins, there will be a delay before the receiver latches the data. When the receiver detects a valid code, the four bits of data will be latched at the receiver output. The data remains latched until another valid code transmission containing different data is detected or the receiver power supply is disconnected.

SPECIFICATION

TRANSMITTER CIRCUIT

Tx frequency band:	418MHz
Operating voltage:	8 to 14V
Operating current:	7mA (P3 low)
Min modulation pulse width:	>1ms
Tx range:	up to 100m
Addresss/data inputs:	TTL compatible (5V)

RECEIVER CIRCUIT

Rx frequency band:	418MHz
Operating voltage:	8 to 14V
Operating current:	20mA all LEDs illuminated

Telemetry Applications

The system is ideal for short range telemetry and related in-building security applications. For this function, terminals P3, P4, P14 and P15 on the transmitter should normally be open circuit. Under this condition the unit operates in power saving mode, sending short pulses of code information at regular intervals. If necessary, the current consumption of the transmitter can be reduced still further by omitting regulator RG1 and linking +V1 and +V2, but only if a 5V power supply is used. Please note, this should not be attempted at any supply voltage other than 5V as damage to the circuit may result.

For the receiver a further reduction in current consumption can be obtained by not fitting LED's, LD1 – LD5. These are included purely to provide an 'at a glance' indication of the output status and may not be required in your final application.

The transmitter circuit will interface directly to any sensor providing a dry contact output. These include reed switches and PIR detectors. Up to four sensors of this type can be wired directly to the transmitter data lines. The status of the sensors will appear at the receiver data output on terminals P3 – P6. Figure 7 shows an example of how to interface sensors to the system. The data input will also

P1	+V1
P2	0V
P3	Transmit Enable
P4	0V
P5	A1 (Address line)
P6	A2 (Address line)
P7	A3 (Address line)
P8	A4 (Address line)
P9	A5 (Address line)
P10	D6 (Data line)
P11	D7 (Data line)
P12	D8 (Data line)
P13	D9 (Data line)
P14	Transmit Inhibit
P15	0V
P16	+V2

Table 1. Transmitter terminal designations.

accept up to a 4-bit binary code at TTL levels.

If the receiver fails to detect a valid transmission on several successive occasions, the output at P8 will switch to a logic high. This can be used to indicate that there is a fault with the system or that it is possibly being tampered with (for example if the transmitter power supply has been disconnected). It is also worth noting that P8 will go high if the transmitter is moved out of range of the receiver, or if the operating frequency in the 418MHz band is being jammed by another transmission. This could be an advantage in security applications.

System siting and performance

The maximum operating range of the system is based on several factors but greater

P1	+V1
P2	0V
P3	D6 (Data line)
P4	D7 (Data line)
P5	D8 (Data line)
P6	D9 (Data line)
P7	Valid Transmission (active low)
P8	Code error/Transmission lost output (see text).
P9	0V
P10	A1 (Address line)
P11	A2 (Address line)
P12	A3 (Address line)
P13	A5 (Address line)
P14	A5 (Address line)
P15	+V2

Table 2. Receiver terminal designations.

distance will generally be achieved over a line of sight path. If there are walls or other solid structures between the transmitter and receiver, this will inevitably reduce the maximum range but of course, sometimes, this cannot be easily avoided.

Use of high gain or even ¼ wave whip antennas on the transmitter unit is strictly prohibited as this would result in the effective radiated power exceeding the legal maximum. Therefore, you are confined to the designs shown in the leaflet supplied with the transmitter and receiver modules. Which type you decide to use is up to you and some experimentation may be needed to get the best performance.

Positioning is also important. Avoid mounting locations close to large metal objects etc. as these can result in unpredictable effects and if very

close could de-tune the circuit. If you can, try to mount the units as much in the clear as possible. If you find you cannot get enough range, try moving the transmitter and receiver to a different position if practical. Sometimes deep nulls can be produced when signals arrive at the receiver out of phase due to reflections, and when this happens even slight repositioning of the transmitter or receiver can produce drastic improvements.

Environmental factors should also be taken into consideration. If you intend to install the units where they are subjected to extremes of temperature or humidity, steps must be taken to ensure that adequate protection is provided. These conditions are likely to affect the operation of the circuit as well as possibly causing serious corrosion to the components. Both the transmitter and receiver can be installed in plastic boxes or tubes without seriously affecting their performance. Under no circumstances should units be allowed to come into contact with moisture.

Finally, the designs described in this article are intended as general application circuits and are not fully optimised. Readers may find that improvements can be made modifying circuit configurations and values but are reminded of the need to ensure compliance with the MPT 1340 licence exemption requirements.

ELECTRONICS

PROJECT PARTS LIST

TRANSMITTER CIRCUIT

RESISTORS
R1, 2	150k Min Res	2	M150K
R3, 4	100k Min Res	2	M100K
R5	2M2 Min Res	1	M2M2
R6	1M Min Res	1	M1M
R7	10k Min Res	1	M10K
R8	120k Min Res	1	M120K
R9	220k Min Res	1	M220K
R10	4k7 Min Res	1	M4K7
R11	470R Min Res	1	M470R

CAPACITORS
C1, 3, 4, 7	100nF Ceramic	4	BX03D
C2	100uF 10V Elect	1	AT30H
C5	390nF Poly Layer	1	WW48C
C6	4.7uF 16V Tantalum	1	WW64U
C8	10nF Poly Layer	1	WW29G
C9	220pF Monores	1	RA37S
VC1	Trimmer 10pF	1	WL69A

SEMICONDUCTORS
IC1	74HC14	1	UB10L
IC2	M145026B-1	1	UJ49D
RG1	78L05	1	QL26D
D1-D3	1N4148	1	QL80B
TR1	BC548	1	QB73Q

MISCELLANEOUS
TX1	Transmitter*	1	NW43W
P1 – P16	Pin 2145	1 pkt	FL24B
	14 pin IC socket	1	BL18U
	16 pin IC socket	1	BL19V

* Supplied with receiver module.

RECEIVER CIRCUIT

RESISTORS
R1, 2	10R Min Res	2	M10R
R3	910k Min Res	1	M910K
R4	220k Min Res	1	M220K
R5, 6, 7, 8, 11	1k Min Res	5	M1K
R9	10k Min Res	1	M10K
R10	2M2 Min Res	1	M2M2

CAPACITORS
C1, 4, 5, 7, 8	100nF Ceramic	5	BX03D
C2	10uF 63V Elect	1	AT77J
C3	100uF 10V Elect	1	AT30H
C6	10nF Ceramic	1	BX00A
C9	100nF Poly Layer	1	WW41U
C10	22nF Poly Layer	1	WW33L
C11	10uF 16V Tantalum	1	WW68Y

SEMICONDUCTORS
IC1	M145027B-1	1	UJ50E
IC2	74HC14	1	UB10L
RG1	78L05	1	QL26D
D1	1N4148	1	QL80B
LD1-5	Min LED Red	5	WL32K

MISCELLANEOUS
RX1	Receiver module*	1	NW43W
P1 – P15	Pin 2145	1 pkt	FL24B
	14 pin IC socket	1	BL18U
	16 pin IC socket	1	BL19V
	SRBP Plain Board 3962	1	JP53H

* Supplied with transmitter module.

APPROXIMATE COST £35

Imaging DEVICES

● ●

Imaging devices enable us to see things that would be difficult or impossible to see with the unaided eye. Reg Miles takes a look.
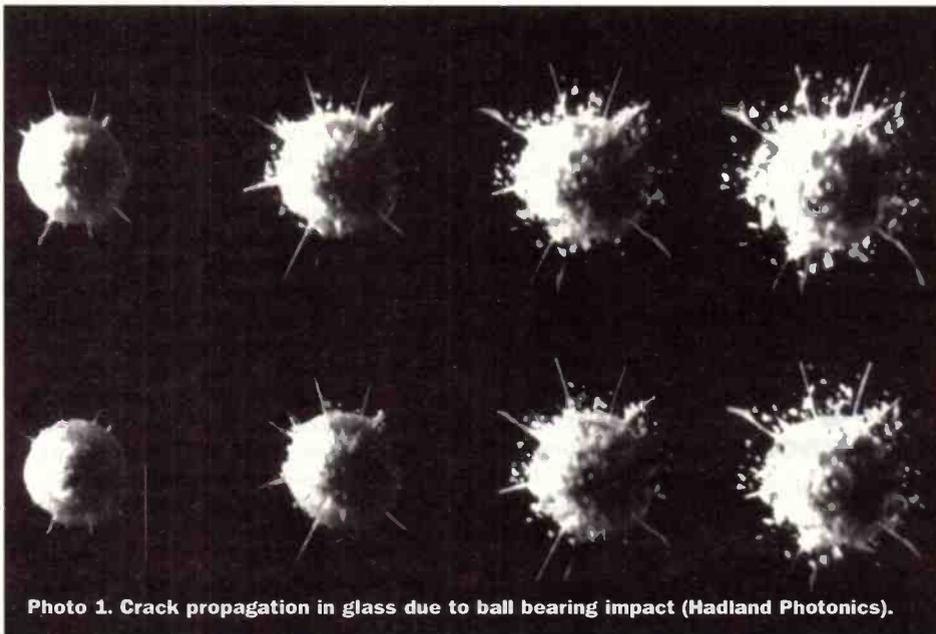
Photo 1. Crack propagation in glass due to ball bearing impact (Hadland Photonics).

There may not be enough light - or any light, the subject may emit radiation beyond the very limited visible spectrum, it may be hidden away, or be too small, or moving too quickly. But none of these things matter when specialised devices can either directly reproduce or indirectly create images from such extremes.

Film vs Video

Freezing motion is open to all thanks to electronic flash and fast shutters.

Flash has a normal duration of about 1/1000s, but can be reduced to as little as 1/10,000s in combination with through-the-lens (TTL) flash metering. However, this does depend on the distance and reflectivity of the subject, together with the film/CCD sensitivity and the lens aperture - the greater the film/CCD sensitivity and the larger the lens aperture the shorter the flash duration. In Figure 1 light from the flash is shown entering the lens and being reflected down by the film to a silicon photo diode; when the metering system determines that exposure is sufficient the flash is quenched

by a thyristor. Obviously to freeze motion the flash must be significantly brighter than the ambient light, and with such a short duration that is unlikely unless it is quite dark.

For specialised work a microflash can give a duration of a microsecond or less. Alternatively, a stroboscope will give multiple exposures of a moving event on a single frame. For extremely short exposures a laser will give nanosecond or picosecond duration - but that's really specialised. A fast shutter is far more convenient but does require bright ambient light - ideal for daylight, as well as a sensitive film/CCD and a large lens aperture. Of the cameras generally available those with electro-mechanical shutters now peak at 1/8000s whereas electronic shutters have reached 1/20,000s. The latter operate by dumping the initial charge build-up through 'sweep-out drains' on the CCD and then retaining the charge for the wanted duration (Figure 2 illustrates this for interlaced scanning, but the principle is the same for full-frame progressive scanning).

Cameras that allow a rapid sequence of still images to be taken, whether in

conjunction with flash or fast shutter, provide a halfway house between still and moving images. For the latter a video camera with a fast electronic shutter provides an inexpensive entry into the world of motion analysis. It is not high-speed imaging, because the field rate is only 50Hz, but the shutter speed will be high enough to render most action clear when the recording is played back a frame at a time (at normal playback speed it will be jerky because there is 1/50s between each truncated exposure).

True high-speed imaging has until recently been almost exclusively the preserve of electronically controlled and triggered cine cameras. Those with an intermittent film movement can manage up to 500 frames per second (fps) before stresses become too great. For framing rates up to 20,000fps the film is run continuously and the optical image is moved at the same velocity as the film by a multi-sided prism block rotating behind the lens. For still higher framing rates - up to 20,000,000fps - a short length of film is either rotated on a drum or it remains static and the images are scanned along its length by a spinning mirror.

But film has now been largely superseded by high speed video because of the cost and convenience. However, this gives poor quality, and film remains the highest quality medium available.

High speed video cameras operate over a range of 1000-40,000fps, and normally employ a CCD fibre-optically coupled to an image intensifier (ICCD) to compensate for the minimal exposure times. The equivalent of a fast shutter is achieved by gating the intensifier to give times down to a few microseconds. The images are digitally stored and can then be transferred to video. Recording times range from about one minute at 1000fps to just over a second at 40,000fps - with the image quality decreasing as the speed increases.

For even higher speeds still more specialised cameras are required. Such cameras have framing rates that give the equivalent of up to 100,000,000fps. A beamsplitter passes the image to a number of progressive scan ICCDs which are sequentially activated - thus with eight ICCDs eight frames are recorded (Figure 3). This may not sound many but with events lasting less than a microsecond it is sufficient. Exposure times are varied by gating the intensifier to give times ranging from a few nanoseconds to a millisecond or so. The camera will also have the provision for varying the interframe times - again from nanoseconds to a millisecond or so. A computer controls the operational parameters, and provides storage, virtually immediate viewing and subsequent data analysis (Figure 4 shows a typical system layout; including trigger inputs to enable the event itself to activate the camera because synchronisation is obviously critical).

Invisible Radiation

Turning to invisible radiation, Kodak has been allowing people to inexpensively explore the near infrared region from 700-900nm for many years with its 35mm High Speed Infrared black and white negative film

Figure 1. Olympus TTL camera and flash.

and 35mm Ektachrome Professional Infrared false-colour transparency film (both available from professional dealers). These record reflected infrared, and are also sensitive to visible light; they can additionally be used to record heat distribution over about 250°C to 500°C - but infrared film is not a thermal recording medium. Both films require a filter on the lens: red for B&W to remove blue and green light, or opaque for infrared recording only; and yellow for the colour film to remove blue light. Alternatively, infrared filters can be used on lights, giving near invisible lighting in the dark.

There are striking differences between infrared and normal film reproduction. With the B&W film things that reflect infrared strongly - such as chlorophyll in vegetation - reproduce almost white. In colour, infrared is reproduced as red, red as green, green as blue, and blue comes out black - with numerous other colours being formed depending on the proportions of visible and infrared radiation.

Those films will be fogged by the infrared illuminators used on some night vision devices. These operate in the range 750nm to 3μm, and can employ an IRED, a filtered incandescent lamp or a laser. As with ambient light, the infrared radiation reflected from the subject is brought to a focus on the photocathode of an image intensifier (Figure 5). Thus the image is fluorescent green (the eye being most sensitive to contrast variations in the mid frequencies). Some of these devices can be adapted to fit onto video cameras and still

cameras with interchangeable lenses. They are available from companies like Hama, Jenoptik, Moonlight and Swains.

Thermal imaging cameras operate in the 1-3, 3-5 and 8-13mm ranges, with a temperature differences of less than 0.1°C (noise equivalent temperature difference - NETD). These differences are displayed in either grey scale or false colour - usually with 256 levels.

Cameras that operate in the 8-13mm range normally employ very sensitive cadmium/mecury/tellurium (CdHgTe) detectors. However, it is difficult to produce a high-density area array device, so the conventional means is to employ a point detector and to scan this with a mirror system (Figure 6). The 8-13mm band is also more susceptible to absorption by airborne water molecules - reducing transmission in summer humidity. Cameras that operate in the 1-3 and 3-5mm ranges are less susceptible to water absorption. These generally employ a Platinum Silicide (PtSi) Schottky-Barrier IR CCD or charge sweep device (CSD). The CSD architecture allows large, sensitive, pixels (Schottky-Barrier detectors) thanks to physically small vertical CSD channels having the necessarily large charge-handling capacity (Figure 7). Frame integrated charges are read-out from the SB detectors by the transfer gate scanner and interlace circuit, swept down the CSD channel by the CSD scanner, before passing into the horizontal CCD from where they are clocked out via the floating diffusion amplifier to a VCR and/or computer. These high density arrays produce thermal noise and must therefore be cooled - usually by a Stirling closed cycle system.

Much shorter wavelengths are obviously desirable for microscopes. But despite improvements in optics and illumination over the centuries, the wavelength of visible light still limits the details that can be resolved to a few hundred nanometres, allowing a magnification of 1000 times. The light microscope remains the backbone of microscopy, but ultraviolet light and electrons have been substituted for those applications where greater magnification is necessary.

Ultraviolet light approximately doubles the resolving power, due to the resolution varying inversely with the wavelength of the radiation. One of the main uses of a UV microscope is measuring the distribution of nucleic acids (natural polymers) in cells; a task aided by their strong UV absorption which makes them stand out.

Figure 2. CCD fast shutter.

Figure 3. Pyramid beam splitter and 8 ICCDs of Imacon 468.

Electron Microscopy

The transmission electron microscope (TEM) has a resolving power of 0.1nm at a magnification of more than 1,000,000 times. An electron gun produces a broad beam which is focused by magnetic lenses (Figure 8) - most of the electrons pass through the thin (<500nm) specimen and are projected onto a fluorescent screen. Because electrons are scattered by air, a high vacuum is required in the column from gun to screen. Those electrons that do not pass directly through the specimen either contribute to the normal image or can provide additional information through accessories or peripheral equipment. Some are absorbed, others scattered over small angles or in distinct directions with crystalline specimens, some maybe reflected (backscattered), impinging electrons can cause secondary electrons to be emitted, or X-rays, or photons (cathode luminescence). Alternatively, some electrons will loose a particular amount of energy by interaction with the specimen. So the TEM is a versatile device.

However, much electron microscopy is now done using scanning microscopes. The surface scanning electron microscope (SEM) is designed to image the surface structure of usually solid specimens, and can achieve a resolution of 1nm with a magnification of up to 400,000 times. A fine beam of electrons is focused into a spot of less than 4nm and used as a probe to scan the specimen in a raster pattern; deflection being achieved by a magnetic field, usually with a double-deflection system located in the final lens (Figure 9). The beam causes secondary electrons to be emitted from the surface in amounts that are characteristic of its nature and topography; these electrons are detected and form a signal that modulates the brightness of a CRT being scanned in synchrony with the electron beam. Non-conducting specimens will build up a charge under this electron bombardment and therefore need to be
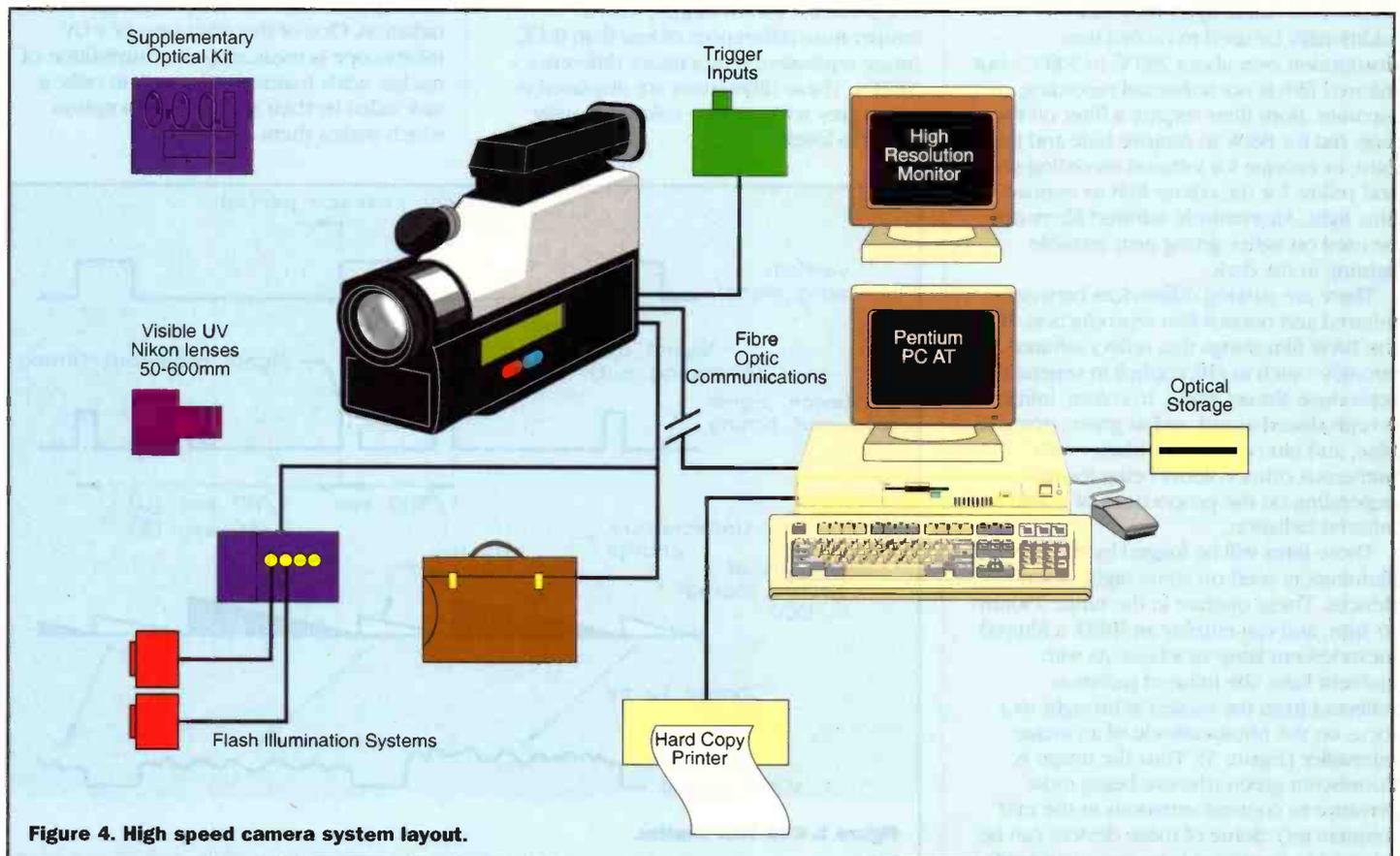
Figure 4. High speed camera system layout.
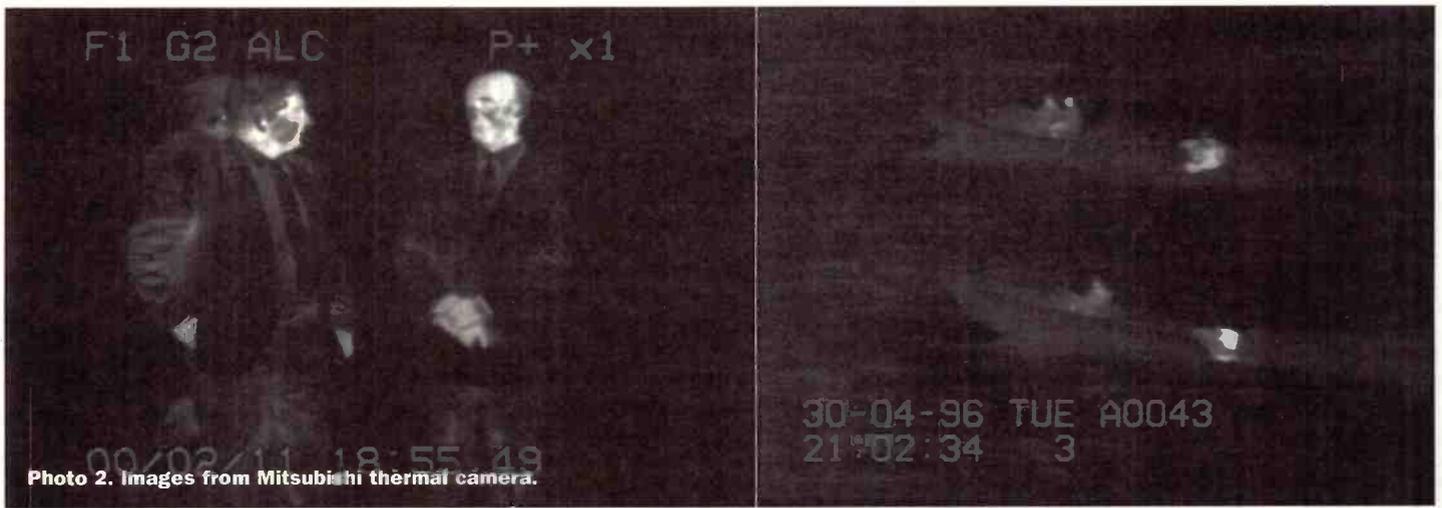
Photo 2. Images from Mitsubishi thermal camera.

given a conductive coating. As with the TEM, additional information can be gleaned from the electrons as they are scattered, etc.

Both TEMs and SEMs can be converted into a scanning transmission electron microscope (STEM) which, as the name implies, combines their functions. This offers a resolution of 1nm and a magnification of over 1,000,000 times.

The scanning tunnelling microscope (STM) is a variation on the electron microscope, which hit the headlines in 1990 when it was used by IBM to produce the company's logo out of atoms of frozen xenon gas. In conventional use the STM scans the specimen with an extremely fine probe. Both this and the specimen are electrically charged. There are two operational modes - constant current and constant height. In the former, which is normally used, the probe is magnetically lowered just far enough for electrons to begin tunnelling out of the specimen's surface atoms to the tip, the probe is then lifted and moved to the next point where it is lowered and tunnelling begins again (Figure 10). This continues line by line, enabling an image of the atomic contours to be constructed. In constant height mode the probe does not go up and down but scans quickly across, measuring current changes as the surface height varies beneath it. This requires a very flat surface, such as metal, to avoid damaging the probe. The STM does not require a vacuum because electrons travel less than a nanometre. However, some microscopes do have a vacuum to maintain exceptional specimen cleanliness. Returning to the IBM logo, this was created by turning up the probe's voltage so that, before imaging the surface atoms, it first pushed them around - an early example of nanotechnology.

The STM begat the AFM - atomic force microscope. This does not use electrons, but directly measures atomic forces. A needle-like probe is mounted on a cantilever, and as the tip is brought in toward the atomic surface there is an initial attraction force and then repulsion; this repulsive force in nano-Newtons between surface and tip is measured through the deflection of the cantilever using a laser beam (Figure 11). The AFM has two operational modes - contact and non-contact. In the former the tip-surface distance is about 0.5-1.0nm, in the latter about 2.0nm (there may be no actual contact between tip and surface in the contact mode but the forces are still sufficient to damage delicate specimens). The tip can also be pushed against the repulsive force to indent the surface and find its elastic properties. Because the specimen does not have to carry a current it does not need to be conductive, and as before, a vacuum is necessary only for exceptional cleanliness.

Ultrasound

Turning from objects that are too small to see to those that are hidden, ultrasound images of the internal parts of the body have become familiar in the past few years thanks not only to its actual use in hospitals but in numerous films and TV dramas. Pulses of ultrasound emitted from a probe are both reflected back from the surface of organs and pass through them, compressing them slightly, and are then reflected back from the next surface, and so on. As the probe receives the reflections the varying

Figure 5. Infrared night vision device.
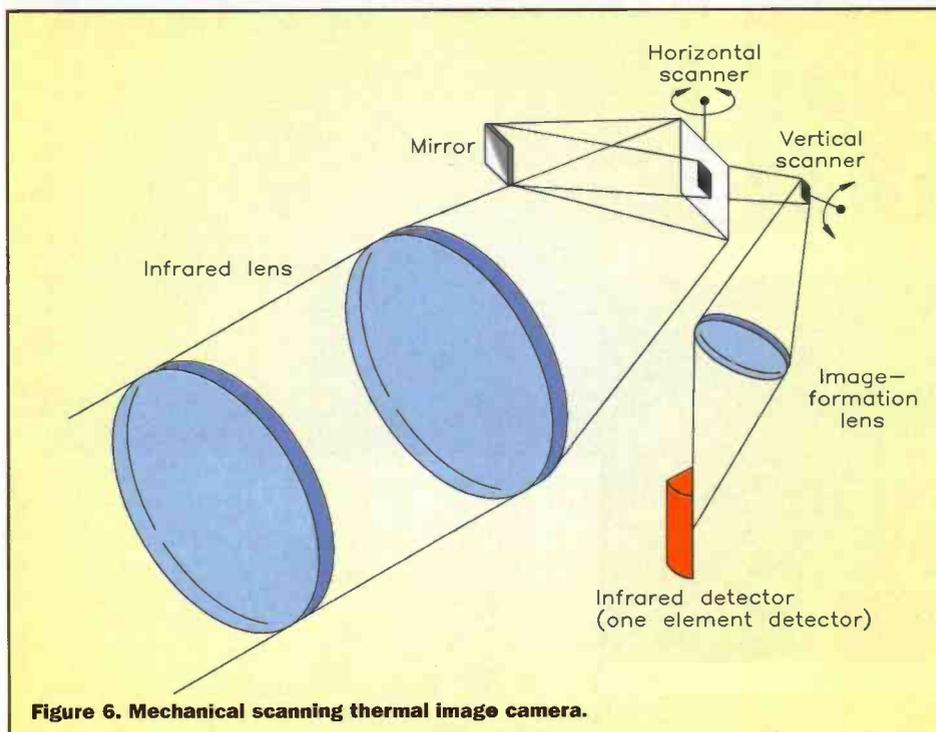
Figure 6. Mechanical scanning thermal image camera.
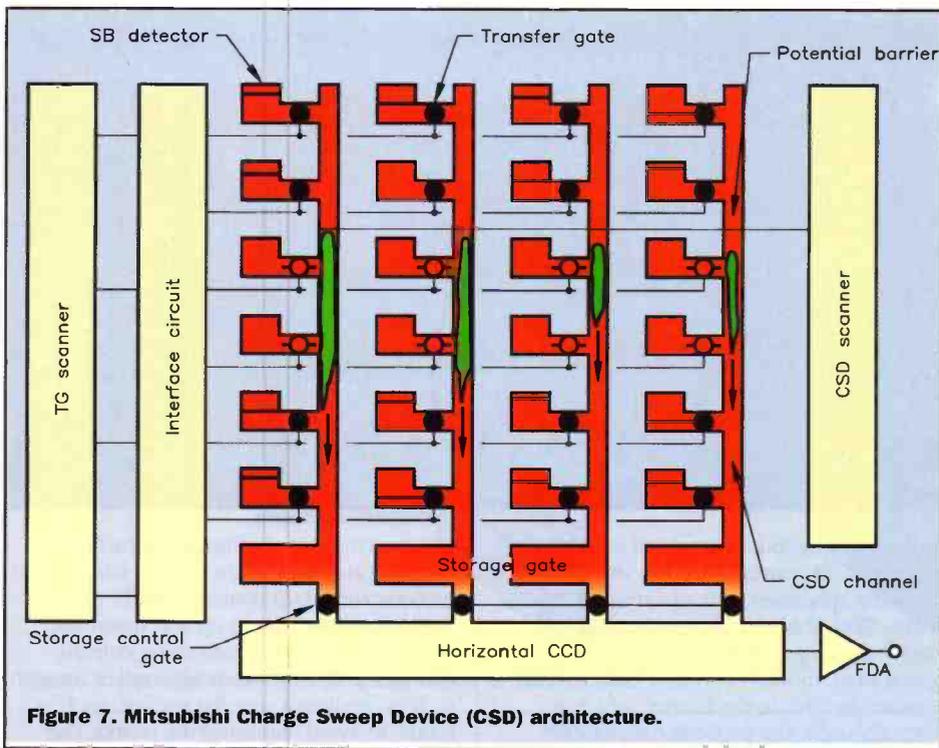
Figure 7. Mitsubishi Charge Sweep Device (CSD) architecture.

Figure 8. Block diagram Transmission Electron Microscope.

intensities represent the densities of the parts and the delays their relative positions. Computer processing offers both grey-scale and false colour imaging. In addition, a variety of probe shapes and sizes are available for different parts of the body - both external and internal. Because the penetration depth of ultrasound is limited to some extent by its frequency those organs located deep in the body are difficult to image, and in this case an ultrasound endoscope can be used (Figure 12).

Tomography

Another means of achieving body images is by tomography - scanning narrow cross-sections, or slices, through patients. Computed tomography (CT) is one such means. A gantry with a body aperture contains an X-ray tube that passes X-rays through the patient to be received by an arc of hundreds of detectors on the opposite side (Figure 13). Tube and detectors rotate 360° around the body to obtain a

multiplicity of samples that a computer fuses into a single anatomical slice. The unit can also take a series of contiguous slices, with the patient table moved fractionally
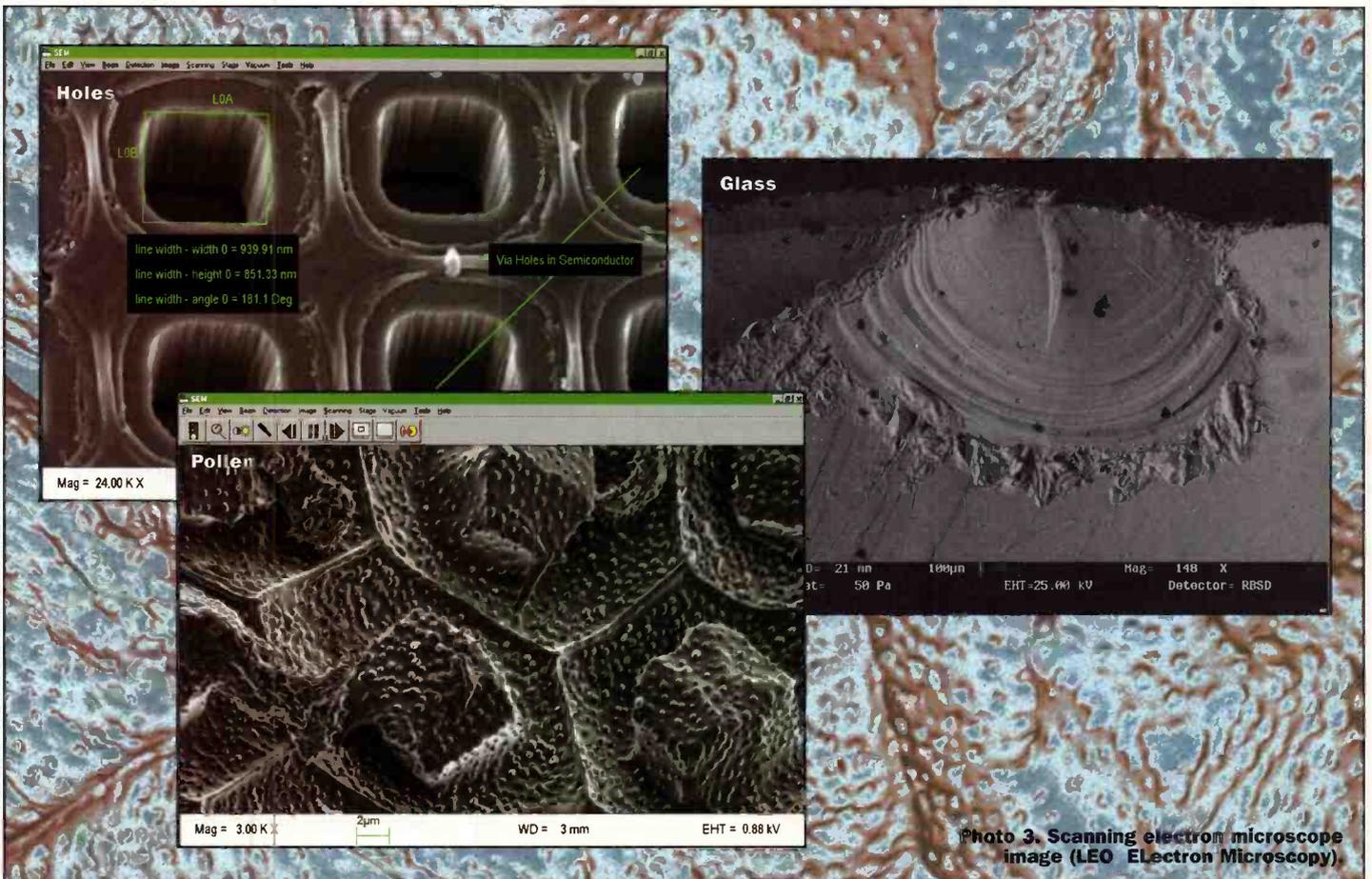
Photo 3. Scanning electron microscope image (LEO ELectron Microscopy).

Figure 9.
SEM final lens double-deflector system.

each time. However, the latest technique is helical scanning, using a slip-ring, in which the tube/detectors rotate at several thousand rpm as the patient table is moved to give a helix of slices. Gantry tilt enables angled slices to be taken. The width of each slice will depend on the amount of detail that has to be recorded - more for the head than abdomen, for example, but generally between 1-10mm.

However, X-rays show mostly the hard stuff, while the soft tissue is reproduced indistinctly. To over come this problem the opposite of magnetic resonance imaging (MR/MRI) is used to bring out the soft tissue. The device is based on nuclear

magnetic resonance (NMR), which exploits the fact that protons in certain elements will resonate in a magnetic field when RF radiation is applied. Now CT and MR slices are being combined by computer processing to show both detailed hard and soft areas in a single 3D image. Because the monitor display is only 2D the combined image is rotated slightly side to side to enhance the 3D effect, and different areas can be given their own colours to further aid discrimination. This is being used by surgeons during operations to locate, say, a tumour, while also showing the blood vessels and bone around it, with a second monitor showing the actual operation on video. In the future a virtual reality headset could be worn.

Figure 10. Constant current probe in STM.

Figure 11. AFM probe arrangement

Positron emission tomography (PET) is another means of producing slices. This requires a radionuclide substance to be injected into the bloodstream. Radioactive nuclei emit positrons which are annihilated in interactions with electrons, each annihilation producing two photons which are simultaneously detected by rings of hundreds of photomultiplier tubes. A computer is used to translate the signals from the photomultipliers into images that show the radionuclide distribution within slices of the body. A variation on this device is used to detect single photons from gamma ray emitters.

A gamma camera enables whole areas of the body to be imaged - again after the injection of a radionuclide substance. This uses one or more sodium iodide crystals to convert the energy of photons from radioactivity to light.

Photo 4. Phillips ultrasound image.
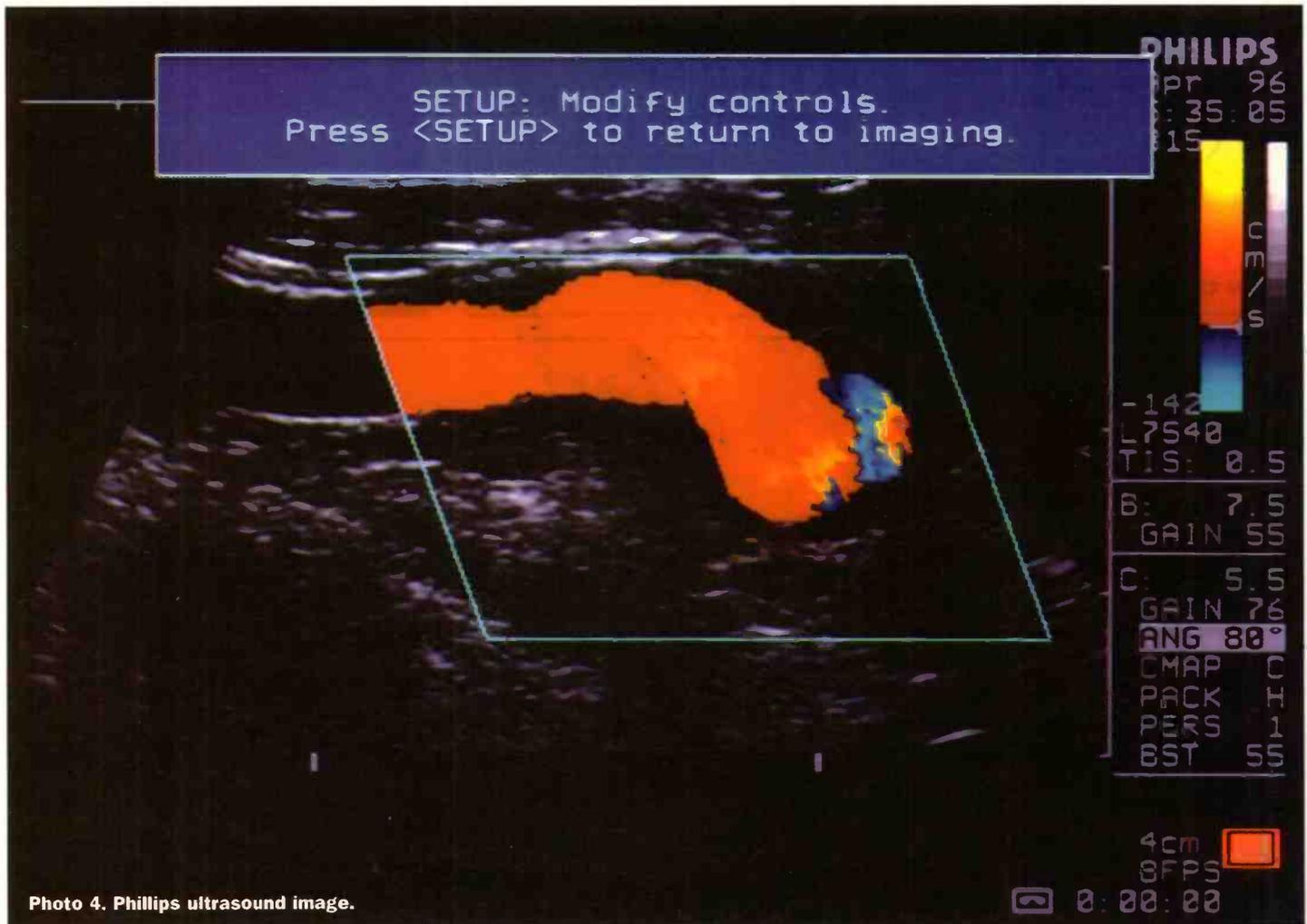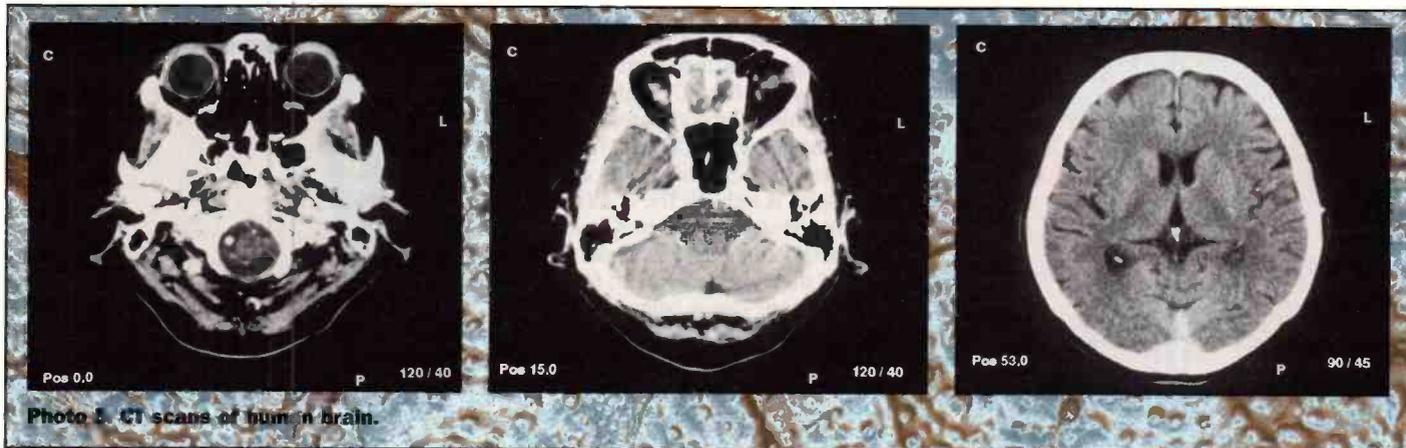
Photo 5. CT scans of human brain.

And Tomorrow?

All the above devices artificially extend the range of vision; but they are of no use to people whose normal vision is severely restricted. This is a deficiency that the V-Max vision enhancement system has been designed to, at least partially, overcome. It is essentially a virtual reality headset with LCD screens for viewing, but using a colour camera mounted on top to provide the signal. The system is powered either by a battery or an ac adaptor. A control unit enables the user to zoom in and out, with the facility for setting five levels of magnification for specific needs, and autofocus. Compensation for small head movements is provided by a digital image stabilisation system. While edge enhancement increases the contrast at the edges of imaged objects to enhance their clarity. In keeping with most modern cameras, it will operate in comparatively low lighting. An optical docking stand allows the camera/headset to be attached to a column from where it can image the pages of a book, or whatever, on an X-Y table and feed the signal to a monitor. The growth and scope of imaging devices has been considerable, and within a comparatively short space of time. But they form just the foundation for what will follow in the next century. Not only will there be new types of imaging technologies, but existing technologies will be further developed to improve their cost/performance ratio, together with their ease of use and portability. **ELECTRONICS**
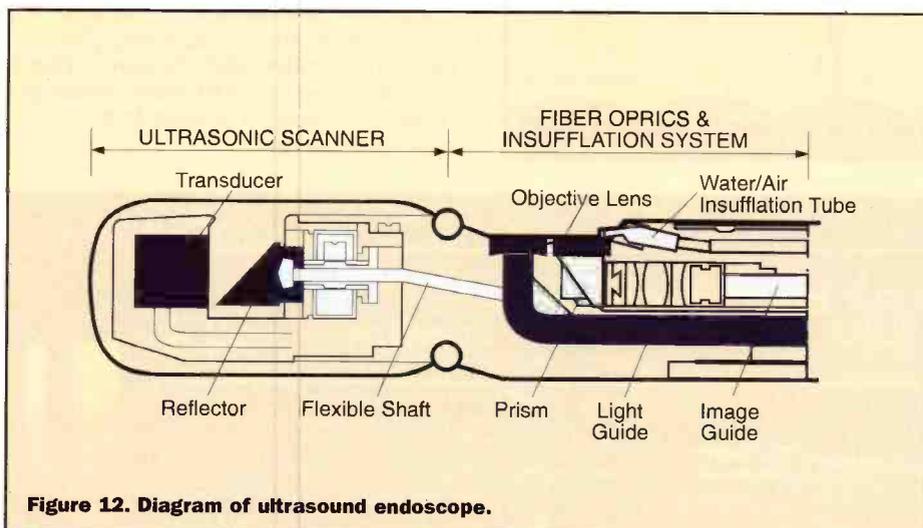
Figure 12. Diagram of ultrasound endoscope.
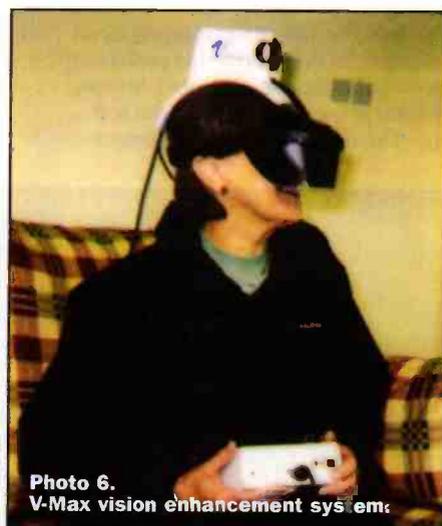
Photo 6.
V-Max vision enhancement system.
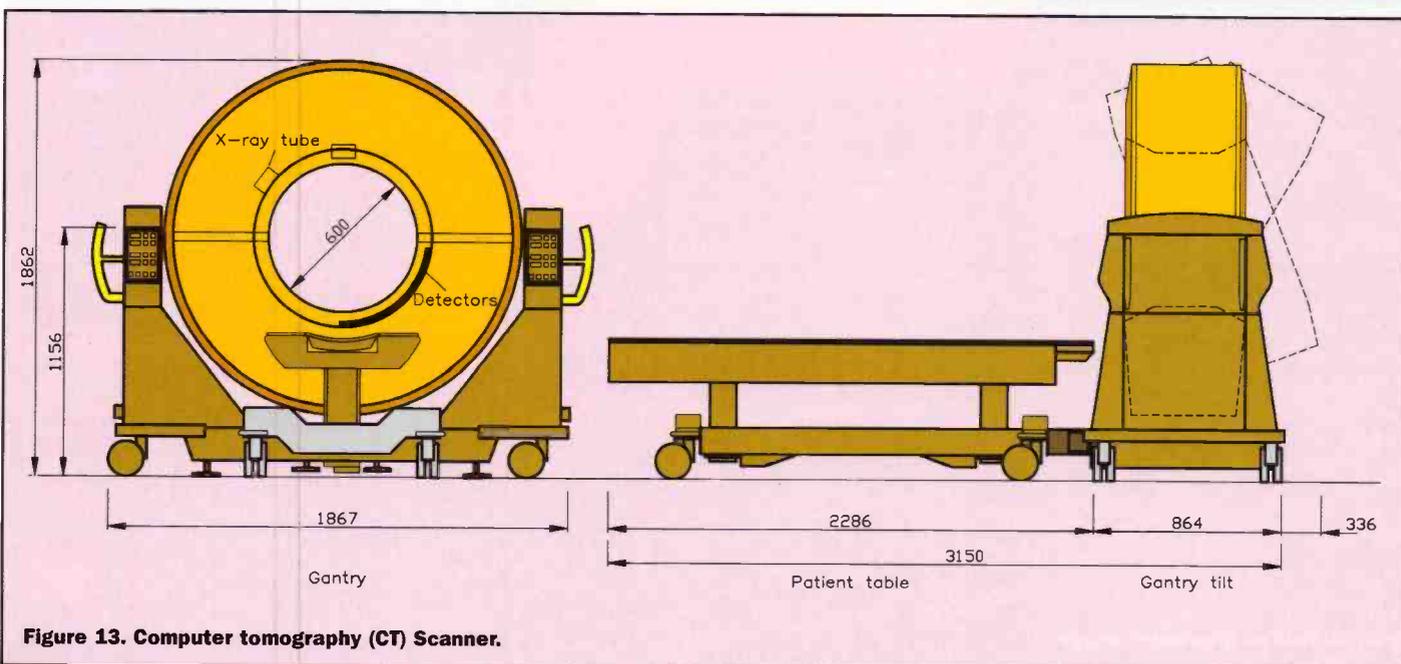
Figure 13. Computer tomography (CT) Scanner.

Software
HINTS & TIPS

by Mike Bedford

Confused about the difference between paste, paste special and object linking? Let's see how to get the most from these powerful facilities.

'Cut and paste' is a phrase which must be familiar to all Windows users but many people don't make the most of opportunities offered. This month we'll explain the difference between pasting, object embedding and object linking and show you how to use these important facilities. First the basics.

You'll find the block of three buttons shown above on the toolbar of virtually all Windows applications. In all probability you've already used these, but if you are new to computing, here's a quick explanation. If you select any part of a document and press the first button (cut), the selected text, graphics or whatever will be removed from your document and placed in an area of memory called the clipboard. Alternatively, if you press the second button (copy), the selected object won't be removed from your document but a copy will, nevertheless, be placed in the clipboard. Now, if you place the cursor somewhere else – either in the same document or a different one – and press the third button (paste) in the appropriate application, the contents of the clipboard will be inserted into the document at the cursor position. So by using cut and paste you can move a portion of a document from one place to another and by using copy and paste, you can copy a portion of your document somewhere else.

An important feature of cutting and pasting is that you can paste virtually any type of information into any type of document. So, for example, you can paste a portion of a spreadsheet into a word processor document or a piece of graphics into a spreadsheet. However, it's important to be aware of exactly what happens when you attempt to do this sort of thing.

In fact, there are no hard and fast rules – the exact action tends to vary from one application to another. For example, if you paste a portion of an Excel spreadsheet into a Word document, Word converts it into a table. There are alternative ways of pasting but in order to control exactly what ends up getting pasted, you have to use Paste Special rather than the standard paste and to do this, you have to use the Edit menu, a typical portion of which is shown below.
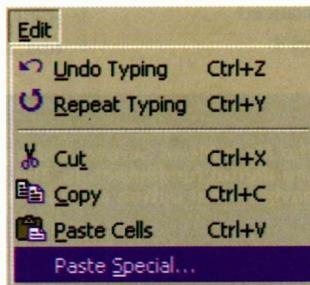
Clearly this menu gives you an alternative method of regular cutting, copying and pasting but of concern to us here is the Paste Special option. When you select this, you'll be given further options in a dialogue box similar to that shown below. Note, however, that the number of options you'll be given depending on the destination application and also on whether or not the source application is still open. Here, I'm copying from Excel into Word and Excel is still open. Had Excel been closed, I'd only have been presented with a couple of these options, specifically those for pasting in a textual form.
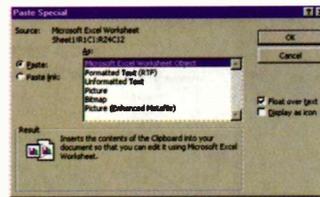
You can see that in addition to the default table format, the spreadsheet data can also be pasted into the document as unformatted text or as images of various types. However, one option which is particularly interesting is that of pasting as a Microsoft Excel Worksheet object. Note that the wording of this option will vary depending on which application you've cut or copied from but the concept is the same. If you select this option, then something which looks exactly like an Excel spreadsheet will be pasted into your document but more than this, the object actually is an Excel spreadsheet. So, if you were subsequently to double click on it, portions of the Excel user interface would appear thereby allowing you to edit that spreadsheet. This method of incorporating information created in another application is called *object embedding*. Of course, in some cases this is the only sensible way of using information from another application. For example, you can paste multimedia information such as a sound clip into a Word document but here, the only viable option is that of object embedding since the only way of accessing that information is via the functionality of the media player. Although Word does allow you to simply paste a bit of graphics to represent the sound clip, this is not a particularly useful option to say the least.

When we looked at the Paste Special dialogue box to achieve object embedding, we made no mention of the radio buttons. Instead we accepted the default option which is Paste. However, you'll notice in the screen shot above that the alternative option is Paste Link and this gives access to the *object linking* feature which we're now going to take a look at. Although we've seen that there are various ways in which pasted data can be represented in the destination document, one thing which all methods have in common is that it's a copy of data in the source document which is used. And what this means, of course, is that if the data in the source document is modified, the copy in the destination document will remain unchanged. In many cases, this is exactly what you'd want to happen, but in other cases, it would be useful if a change to the source document would be reflected in the destination document. For example, you might have a standard letter in Word which refers to information stored in an Excel spreadsheet. Using the techniques we've seen so far, every time you send the letter you'd first have to copy and paste up-to-date information from the spreadsheet. Object linking obviates the need to do this. Let's see how it works.

Having copied data into the clipboard from your source application, select Paste Special from the Edit menu of your destination application. Now, instead of accepting the default Paste option, select the Paste Link radio button. You'll now find that most of the same options for methods of formatting the pasted data are the same so you can select whichever option is most appropriate to your requirements. When you press the OK button, the end result will appear to be identical to that achieved by pasting or object embedding, but if you experiment with editing the source file, you'll see that the result is quite different. Now, instead of pasting in a copy of the data, the destination file simply contains a link to the file containing the information.

Try it out

In this single page, I've only been able to give you a feel for the opportunities provided by cut and paste, DDE and OLE to use the official Microsoft terminology. However, there's lots of options I haven't been able to describe so the best way to learn is to try it out for yourself and experiment. Do be aware, however, that what we've covered here is the way a typical Windows application operates. These things aren't universal, however, and you may find that although all applications should be able to do cut & paste and copy & paste, some may not have support for object embedding and/or object linking.

Digital ELECTRONICS CD

Mike Tooley has released his latest CD – Digital Electronics from Matrix Multimedia, John Mosely has a listen.

The renowned author Mike Tooley in association with Matrix Multimedia has already produced two educational electronics CDs – *The Parts Gallery* (Maplin Order code PF02C) and *Electronic Circuits & Components* (Order code PF03D). The latest one in the series *Digital Electronics* is now available, and it is intended to cover the following courses:

◆ Design & Technology: Key Stage 4
◆ Electronics GCSE: Key Sage 3, Key Stage 4
◆ GNVQ Electronics: Advanced
◆ BTEC Electronics: Level 3

PC requirements are modest – a 486 processor running at 25MHz, 8MB RAM (12MB recommended), 12MB hard disc space, VGA/256 colours graphics card, CD ROM, Microsoft compatible mouse and Windows 3.11/95, with an optional sound card.

Introduction

Digital Electronics takes users through the subject of digital electronics up to the operation and architecture of microprocessors. It has full text search, full audio commentary and many interactive virtual laboratories which allows the user to operate circuits on screen. Installation is simple and relatively straight forward and once complete shows how it is compatible with other electronics applications. However, when I tried to run the program, I was confronted with a message telling me to reduce my pixel display rate. In Windows 95, this means clicking 'Start' then 'Settings' followed by 'Control Panel', then 'Display', then 'Settings' and reducing the desktop area to 640 x 480 pixels. The computer then has to be restarted. However, once opened the programme is presented in an attractive, easy-to-use format with large bold buttons that help the user to navigate through the package in a clear and self-evident manner.

The CD covers the subject up to pre-university level and features a well rounded range of products that will suit anyone who is studying electronics, and includes logic gates, combinational and sequential logic circuits, clocks, counters, shift registers, and displays. The CD ROM also provides an introduction to microprocessor based systems.

In-Use

Once loaded, a menu screen is displayed, and a choice is selected. The screen is very easy and explicit, and once a selection is made, the topic is quickly displayed. To the right is normally displayed the associated text, and the audio control panel (play,
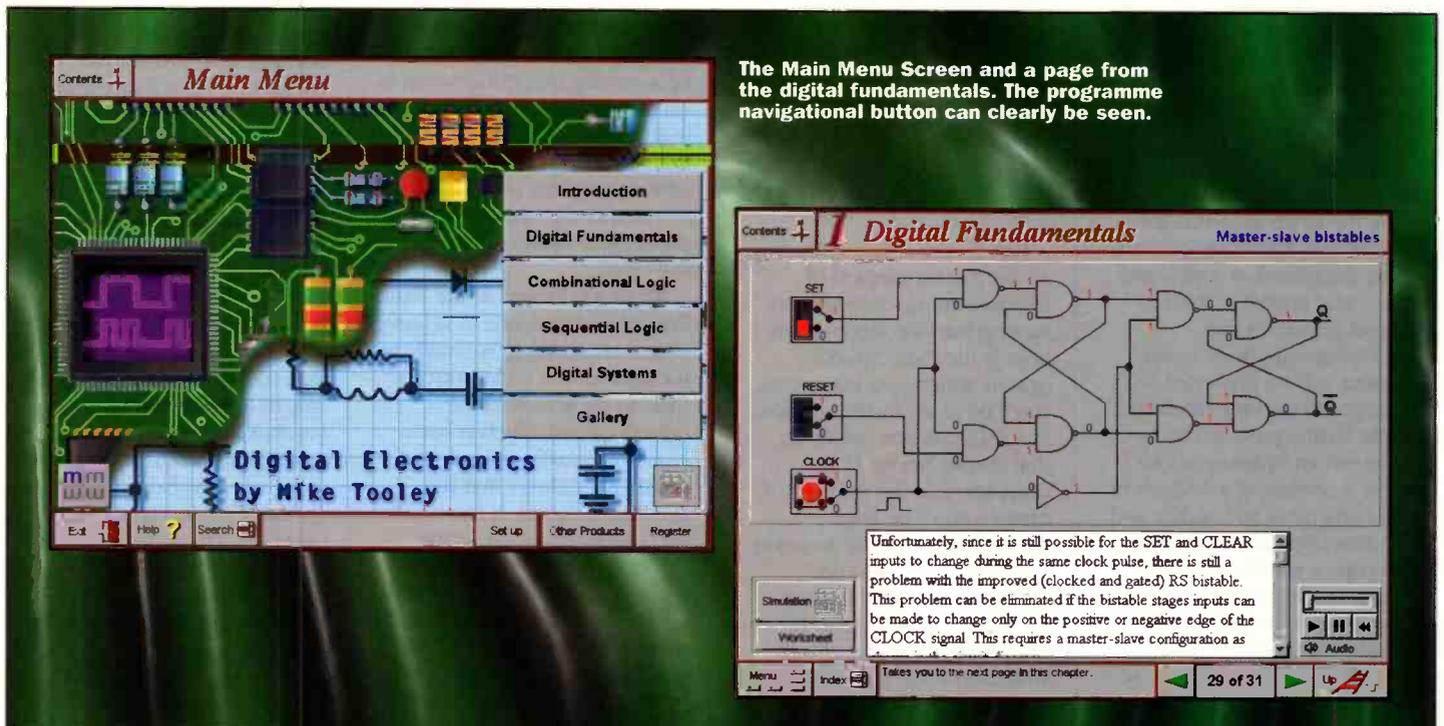
The Main Menu Screen and a page from the digital fundamentals. The programme navigational button can clearly be seen.

A3 A2 A1 A0
Word A

This screen shows a 4 bit comparator. By clicking on the buttons by the binary read outs you will be able to alter the status of each bit and follow the logic through the circuit.

See if you can use this basic circuit to design an 8 bit comparator.

1 if word A = word B
0 if word A ≠ word B

Word B
B7 B6 B5 B4

Example 1
Example 2

This picture shows a 2764 erasable programmable read-only memory in a 28-pin dual-in-line package. The device can be erased by exposing the window on the upper side of the chip to ultraviolet light (the window is normally covered by a sticky label). The EPROM is programmed electrically by writing a pattern of 1s and 0s to each of its internal memory locations. In order to do this, the EPROM must be removed from its printed circuit board socket and connected to a dedicated EPROM programmer.

A page from the combinational logic section, and a picture from the Gallery, with the accompanying text.

forward, stop etc. is at the bottom of the screen). The accompanying voice is clear and fluid, and using a 32x CD ROM, there was no hesitation. Below these buttons are 'page' buttons for the selected topic so that you can click forward, or backwards, through the pages. For reference, the page number and number of pages relating to the topic are continually shown. To the right of these page buttons is a 'ladder' button which returns you to the topic intro page. All very useful facilities.

The top left button returns you to detailed contents page, while the bottom left button returns you to the opening menu page, which also includes, the exit, help etc. buttons.

The audio accompaniment is invaluable when using the interactive virtual laboratories, which provide a very effective demonstration of the principals under discussion. The description of an AND gate includes a circuit diagram consisting of a power source, two switches in series and a light bulb. Accompanying the circuit diagram switches are excellent graphical representations of slide switches which can be toggled by placing the mouse over the switch and clicking the left mouse button. Both the graphical representation, and the circuit diagram switches, are then visually shown as opening and closing. When both switches are closed, the bulb lights up on screen. A truth table accompanies this action and 'follows' the switches opening and closing. Similarly, an OR gate is represented by two switches in parallel.

One interesting feature that is included is a number of assignments based on pre-designed circuits. These circuits are included on the CD in Electronic Workbench (vers 4.1 & 5) and Crocodile Clips format, which are both popular selling circuit simulation tools. These are intended to reinforce the topics that have been looked at and are a worthy addition to the program.

One very useful facility is that text can be easily copied in to a wordprocessor by left clicking the mouse over the text, and then

right clicking the mouse and simultaneously holding <shift> on the keyboard. The default wordprocessor is opened and all the text in the box is automatically displayed in the opened document page. The default wordprocessor is Wordpad which is shipped with Windows 95, or Windows Write which comes with Windows 3.11. This can be altered to your own preferred wordprocessor if you so wish. Similarly, if you click the mouse over a photograph, you open the default drawing package – Paintbrush with Windows 3.1 and MS Paint with Windows 95 – and again this can be set to be your favourite drawing program. This certainly makes homework a lot easier.

Often two examples are given via buttons, which brings up a small two-part window with the left part displaying a relevant example/question. By pressing the solution button, the right part of the window then displays the answer.

The images and outlines in the Parts Gallery are detailed and clear, and provide a convenient library of pin-outs, and include standard 7400 and 4000 devices which are accompanied by an audio/text general explanation. Similarly, the pictures of actual devices cover fundamental ICs such as shift registers, hard disk controllers, crystal clock oscillators etc., and again include audio/text general explanations.

The following is a breakdown of the topics covered.

Digital Fundamentals

Signals and data, binary, hexadecimal, ASCII. Introduction to the basic logic gates and their truth tables. Monostables and their function, simple bistables, master-slave and SR bistables/flipflops, J K flip flops and D type flip flops.

Combinational Logic

Multiple AND and OR gates, Equivalent logic functions, Specialised logic functions including comparators, parity checkers, scramblers, code converters, half and full adders. Karnaugh maps and Karnaugh simplification.

Sequential Logic

Clocks, Counters – binary and decimal, and shift registers.

Digital Systems

Traffic light controller, A/D and D/A converters, memories and an introduction to microprocessors.

Gallery

Definition of basic gates, an introduction to the 74 series of integrated circuits, and the CMOS 4000 series of ICs. There is also a picture gallery of examples of digital circuitry.

Conclusion

This CD ROM is designed to encourage investigation of electronic circuits and components. Mike Tooley does stress that when using the CD ROM that you do so with a particular question or hypothesis to investigate, rather than just browsing the material. I certainly would go along with this recommendation, for to get the most from this package, you need to sit in front of the computer and work through a topic, and then try the examples and assignments that may be suggested with the topic. It is not necessary to start from the beginning and systematically work through the whole package, each topic is self-contained and can be viewed accordingly.

To get the initial reactions of a student, I asked my 14 year old son, who is studying Electronics Products at GCSE, what he thought of the program, and he was suitably impressed! If I have one gripe then it has to be the inability to switch to other programs while in Digital Electronics, but, it is still a very attractive and well presented piece of software that electronics students will find a very convenient reference and learning tool.

The CD ROM is available from Maplin Stores or mail order (Order code OA24B) for £46.94 inclusive of VAT. The Matrix Multimedia web site can be found at **http://www.MatrixMultimedia.co.uk**.

ELECTRONICS Classified

Wanted

Organ Chip M108. Does anyone have this IC to sell. Tel: (01495) 225219, or write to J. Jenkins, 3 Orchard Court, Pontllanfraith, Gwent NP2 2NG.

Help wanted programming PIC devices by blind hobbyist, willing to pay. Please reply by fax to Paul Boult (0115) 9100028, or by letter to 22 Kelvedon Garden, St. Anns, Nottingham NG3 1LQ.

For Sale

Large box of electronic components including microprocessors, ICs, crystals, sockets, books etc. £60. Tel: (01692) 536323 (Norwich area)

Electronics Magazine from June 1987. Offers? Tel: (01202) 707103.

Club Corner

ARS (Aberdeen Amateur Radio Society) meets on Friday evenings in the RC Hall, 70 Cairngorm Crescent, Kincorth. For details contact: Martin, (CMOJCN), Tel: (01569) 731177.

The British Amateur Electronics Club (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details send S.A.E. to: The Secretary, Mr. J. F. Davies, 70 Ash Road, Cuddington, Northwich, Cheshire CW8 2PB.

Bury St. Edmunds Amateur Radio Society. Meetings held at Culford School, 7.30pm for 8.00pm on the third Tuesday of each month, unless otherwise stated. Further details from Kevin Waterson, (G1GVI), 20 Cadogan Road, Bury St. Edmunds, Suffolk IP33 3QJ. Tel: (01284) 764804

Crystal Palace and District Radio Society meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, (G3DSC), Tel: (0181) 699 5732.

Derby and District Amateur Radio Society meets every Wednesday at 7.30pm, at 119 Green Lane, Derby. Further details from: Richard Buckby, (G3VGW), 20 Eden Bank, Ambergate DE56 2GG. Tel: (01773) 852475.

Electronic Organ Constructor's Society. Details of programme magazine, membership and details of provisional dates of regional meetings for 1998 from: Don Bray (Hon. Sec.), 34 Etherton Way, Seaford, Sussex BN25 3QB. Tel: (01323) 894909, Fax: 01323 492234.

E.U.G. User group for all 8-bit Acorn Micros, since 1991. Still going strong. Programming, news, information, sales. Contact: E.U.G., 25 Bertie Road, Southsea, Hants. PO4 8JX. Tel: (01705) 781168.

Itchen Valley Radio Club meets every 2nd and 4th Friday of month (not Aug.) at Scout Hut, Brickfield Lane, Chandlers Ford, Hants. Details from Sheila Williams GOVNI Tel: (01703) 813827.

The Lincoln Short Wave Club meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. For further details contact Pam, (G4STO) (Secretary). Tel: (01427) 788356.

The Lincon Short Wave Club Meetings every Wednesday from 7.45pm at Lincoln Railway Sports and Social Club, The Ropewalk London. Lincoln Hamfest 98 on Sunday 13th September. Contact: Cliff Newby G3EBH. 25 Sudbrooke Lane, Nettleham, Lincoln, LN22RW. Tel 01522 750637. Packet BBS G3EBH @gb7dx.#26.gbr.eu.

MERG? 2 first class stamps (or 4 IRCs) to John Weal, 23 Chapel Street, Yaxley, PE7 3LW brings you a substantial introductory pack to the Model Electronic Railway Group – actively applying electronics and computers to the model railway operation.

7th Northern Cross Rally - Sunday 15th February. 1998 - Large hall venue - Thornes Park Athletics Stadium, Wakefield - Details: Pete Smith G0BQB Tel: 01924 218217.

Preston Amateur Radio Society meets every Thursday evening at The Lonsdale Sports and Social Club, Fulwood Hall Lane, Fulwood, (off Watling Street Road), Preston, Lancashire PR2 4DC. Tel: (01772) 794465. Secretary: Mr Eric Eastwood, (G1WCQ), 56 The Mede, Freckleton PR4 1JB, Tel: (01772) 686708.

Science At Your Fingertips. Want to meet friends interested in Science? Send an SAE to: Daniel Gee, S.A.Y.F., 37 South Road, Watchet, Somerset TA23 0HG, or Scott Mason, S.A.Y.F., 58 Park Avenue, Devonport, Plymouth PL1 4BP. http://homepages.enterprise.net/icedragon/says.htm.

SEEMUG (South East Essex Mac User Group), meet in Southend, every second Monday of each month. For details Tel: Michael Foy (01702) 468062, or e-mail to mac@mikefoy.demon.co.uk.

Southend and District Radio Society meets at the Druid Venture Scout Centre, Southend, Essex every Thursday at 8pm. For further details, contact: P.O. Box 88, Rayleigh, Essex SS6 8NZ.

Sudbury and District Radio Amateurs (SanDRA) meet in Gt. Cornard, Sudbury, Suffolk at 8.00pm. New members are very welcome. Refreshments are available. For details please contact Tony, (G8LTY), Tel: (01787) 313212 before 10.00pm.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent. TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information. Contact: Eric N. Wiltsher, TESUG, P.O. Box 576 Orpington, Kent BR6 9WY.

Thanet Electronics Club. For school age Ham Radio and Electronics enthusiasts, enters its 16th Year. Meetings held every Monday evening from 7.30pm at The Quarterdeck, Zion Place, Margate, Kent. For further details contact: Dr. Ken L. Smith, (G3JIX), Tel: (01304) 812723

Wakefield and District Radio Society meet at 8.00pm on Tuesdays at the Community Centre, Prospect Road, Ossett, West Yorkshire. Contact Bob Firth, (G3WWF), (QTHR), Tel: (0113) 282 5519.

The (Wigan) Douglas Valley Amateur Radio Society meets on the first and third Thursdays of the month from 8.00pm at the Wigan Sea Cadet HQ, Training Ship Sceptre, Brookhouse Terrace, off Warrington Lane, Wigan. Contact: D. Snape, (G4GWG), Tel: (01942) 211397 (Wigan).

Winchester Amateur Radio Club meets on the third Friday of each month. For full programme contact: G4AXO, Tel: (01962) 860807.

Wirral Amateur Radio Society meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the the first and third Wednesday of every month. Details: A. Seed, (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

Wirral and District Amateur Radio Society meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson, (G0JZP) on (0151) 648 5892.

Please write your classified advert using one word per box below.
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Name _____

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Daytime Telephone _____

Return your advert to: *Electronics Classified*, P.O. Box 777, Rayleigh, Essex, SS6 8LU.

AIR YOUR VIEWS

CORRIGENDA

The following points are clarification to the 'Basic Power Supply Design' article in issue 126 (June 1998) of Electronics and Beyond.

◆ The transformer used in the article is WB25C, not WB25V as stated.

◆ The primary fuse should be rated within the power limitations of the transformer used and not using the arbitrary approach outlined in the article. The maximum power developed across the primary coil is determined by the equation $P = IV$. For a 250W transformer this would mean the maximum current that could be developed before the transformed failed would be $I = 250/230$. This gives a value of 1.1A for the maximum permissible current. Therefore the fuse in primary coil should be rated at less than this value.

◆ Figure 5 should show a ground connection from both the LM7812 and LM7805. The value of C1 and C3 is 0.33μF, the value of C2 and C4 is 0.1μF.

Transistor Tester - Issue 127 (July 1998)

On page 27, second column, last paragraph should read: Now short the BC leads, and with S3 to BC, or S4 to BC, full scale deflection is shown. No other selections show a deflection. In the parts list, the 2mm red probe socket is order code HF47B, and tie wrap type 100 is order code BF91Y.

Demise of Electronics Enthusiast?

Dear Sir

Having been an enthusiastic electronics constructor for over 30 years now, 'cutting my teeth' on such fine publications as Practical Electronics in the 60s and 70s and then ETI and Elektor from the 70s and 80s, I was delighted to discover the Maplin Magazine as a fresh source of inspiration. The ultimate demise of P.E. and the degeneration of Elektor into an almost spiritual, computer-orientated publication, and the convenient decline of ETI for reasons of its own left me only with Electronics, which I have taken since issue number 22.

Sadly, the intervening 11 years have been unkind even here, and the quality and quantity of constructional articles seems to have eroded in favour of informative articles, kit reviews and computer-orientated items. In my opinion articles regarding resonance imaging, electron microscopy, cave radio to name but a few - whilst interesting in their own right - simply do not have any place in what was originally supposed to be a magazine for constructors. Is this not somehow betraying your sole purpose in life - to sell electronic components, or have I missed some fundamental point?

Dave Marsden
Hull

An unfortunate fact of life, as we have concluded here, is that the electronics hobbyist/constructor is a dying breed. Add to this the cost of developing kits, especially the burden of meeting EMC requirements, and perhaps you can start to understand why the content of the magazine has altered. You only have to look in any newsagents to see the proliferation of computer magazines, and so we are attempting to balance computer articles/projects with electronics related articles to capture a wider readership. Our computer articles are an attempt to be more 'engineering' biased - hence our articles on building your own PC, spreadsheets and sound cards will confirm. Hopefully, by broadening our readership we may persuade some readers to dabble in electronics construction - and so sell components! Maplin Electronics now has a very broad range of products for sale, and it is not our 'sole purpose in life' to sell electronic components. It is still our intention to include a diverse range of electronic projects in the Magazine. I often wonder about the fate of the electronics industry in this country, for if the younger generation are not taking electronics up as a hobby, then what is the likelihood of then taking it up as a career?

Fuse Rating

Dear Sir

There are a few points I would like to make about Stephen Waddington's article in Issue 126 of Electronics and Beyond.

Since the formula for the reservoir capacitor value in terms of ripple voltage is rather simple, it would have been helpful to mention it. The formula is $C = I/2fV$, where I is the dc load current, f is the ripple frequency (100Hz for a bridge rectifier) and V is the rms ripple voltage.

The permissible ripple voltage can be found from the fact that the minimum voltage across the regulator, with 10% low mains voltage and at the negative peak of the ripple waveform must be greater than the maximum drop-out voltage specified for the regulator used. The peak ripple voltage is close to 1.15 times the rms voltage, since the waveform is a sawtooth.

On no-load, the dc output voltage across the capacitor rises to the peak secondary voltage, not the rms value. In addition, the mains voltage could be 10% high. Consequently, the voltage rating of the capacitor should be at least the square of the rms no-load secondary voltage.

Stephen is quite right to call attention to inrush current, and this has two components. One is due to the capacitor charging and is predictable, while the other is due to the magnetisation of the transformer core and varies greatly, according to the point in the mains voltage waveform at which it was last switched off and the epoch at which it is switched on.

However, the inrush current cannot exceed the current determined by the effective winding resistance, in this case 1.04A. Furthermore, the high inrush current only lasts 40ms at most. The solution is to use a fuse rated at no more than twice or 2.5 times the full-load primary current, and use a time delay type, which will withstand the inrush current. For a really good job, one should compare the inrush current waveform with the current/time curves for the chosen fuse.

John Woodgate
jmw@jmwa.demon.co.uk

Stephen Waddington replies:

This article was intended to be practical and so was admittedly light on theory. John Woodgate highlights some important points, which were omitted in the original article. For further information, please refer to corrigenda above.

Spreadsheets
FOR ENGINEERS & SCIENTISTS
PART 2

In this final part Mike Bedford exploits the full potential of this type of software.

Simulation

Simulation of continuous systems by solving sets of differential equations is usually carried out using either dedicated simulation software or mathematical packages like MathCad or Mathematica. However, it's not at all difficult to solve differential equations numerically by the Euler method using a spreadsheet. The following is the Van der Pol equation which was first used to describe a valve-based circuit with non-linear resistance:

$$\frac{d^2x}{dt^2} = \varepsilon(1-x^2)\frac{dx}{dt} - x$$

where x is voltage, t is the independent variable time, and ε is a constant which defines the amount of positive feedback in the system. You'll notice that it is a second order differential equation which makes it rather trickier to deal with, however, it can be re-written as the following pair of first order differential equations:

$$\frac{dx}{dt} = y$$

$$\frac{dy}{dt} = \varepsilon(1-x^2)y - x$$

As you'll probably remember from school maths lessons, differential equations are solved by integrating the right hand side. And although the analytical methods of integration which are taught in maths classes are not at all easy to implement by computer, the alternative method of numerical integration is eminently suitable. Figure 2 shows the principle of the Euler method – the very simplest numerical integration scheme which we'll use here. The integration is performed step-wise, using the values of each of the variables and their derivatives at one time to evaluate each of the variables at a subsequent time. The method relies on the fact that the first derivative of a variable is the slope of the curve. So the value of a variable at one time plus the derivative multiplied by the size of the time step gives the value of that variable at a subsequent time. Of course, this assumes that the derivative remains constant throughout the time period and in the general case, this is not a valid assumption. This means that the Euler method only gives an approximate result. However, the error can usually be reduced by selecting a smaller time step although this will, of course, increase the number of steps and hence the computing time.

With that bit of background, we'll present a spreadsheet to solve the Van der Pol equation, that is to simulate the operation of the circuit in question. The instructions will be more terse than in the previous examples since you should now be getting au fait with many of the principles.

1. Start with a new work book, give it a suitable title and put the column headings **t**, **dy/dt**, **dx/dt**, **y** and **x** in cells A3, B3, C3, D3 and E3. Put the labels **Epsilon** and **dt** and in cells J1

Figure 2.

Slope = dx/dt = -2 R1 A B

Actual curve for A

Error (can be reduced by using smaller time interval)

Slope assumed constant over time interval

A at end of time interval calculated from slope and width of interval

x

t (time)
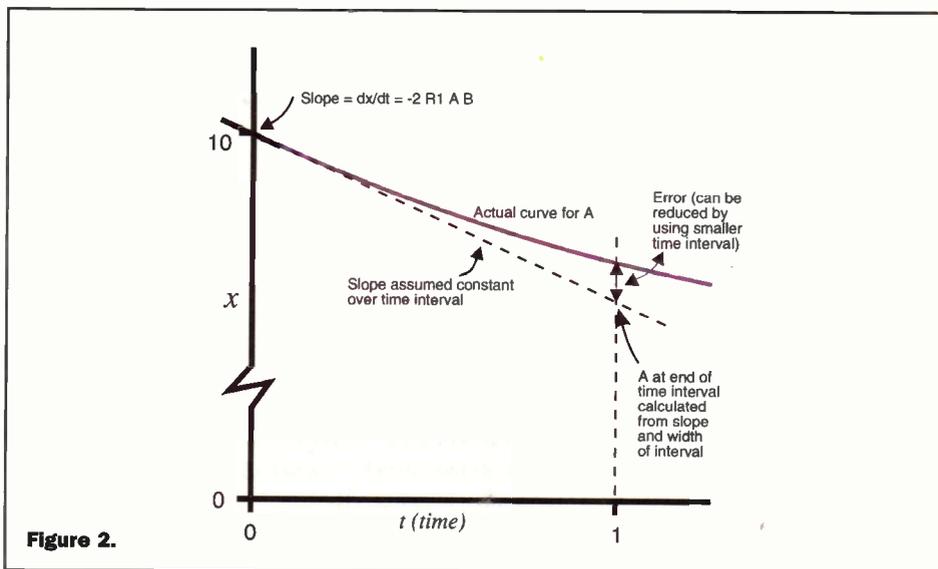
Screen shot 8.

Screen shot 9.
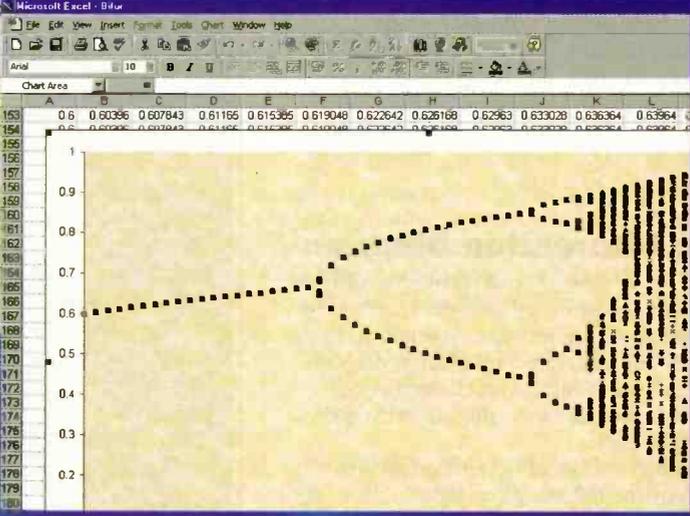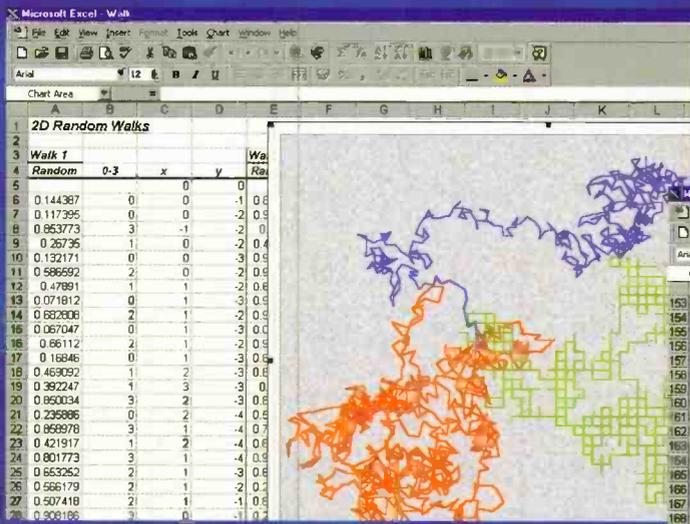
Screen shot 11.

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and J2 respectively and put the values for these constants (*dt* is the time step) in cells K1 and K2 respectively. Initially, use values of 1 and 0.1.

2. Enter the initial values of *t*, *y* and *x* – 0, 0.01 and 0.01 respectively – in cells A4, D4 and E4.

3. Now put the expression for the differentials in cells B4 and C4. These are the expressions on the right hand sides of the differential equations and appear in the spreadsheet as **=$K$1*(1-E4^2)*D4-E4** and **=D4** respectively.

4. The second value in the *t* column is equal to the previous value plus the time step so enter **=A4+$K$2** into A5. The second values in the *dy/dt* and *dx/dt* columns are the same as the first values in these columns (except that the relative cell references will end up pointing to different cells) so simply copy the values from B4 and C4 into B5 and C5. And the second values in the *y* and *x* columns require the formulae the Euler method of numerical integration. So type **=D4+$K$2*B4** into D5 and fill right into E5. All that now remains to carry out the simulation for around 50 seconds is to fill down the values from row 5 to rows 6 to around 500.

5. To complete this exercise, you need to produce some graphical results. One important graph is of *x* and *y* against time. You've already seen how to do this and you'll find that the circuit being simulated is, in fact, an oscillator. More specifically, it's a so-called relaxation oscillator. However, it's also interesting to look at the phase diagram for the Van der Pol equation. This is a graph of *x* against *y* and it is created by selecting just columns D an E and specifying a scatter plot (make sure that you pick one of the scatter plot variants which includes lines – the default only plots

points). This diagram shows how the operation of the circuit settles down to a limit cycle. In Screen Shot 8, you can see both a graph of x and y against time and a phase plot.

If you'd like to have a go at solving a different set of differential equations, try the following set:

$$\frac{dx}{dt} = c(y-x)$$

$$\frac{dy}{dt} = bx - y - yz$$

$$\frac{dz}{dt} = xy - az$$

Use initial values of 5, 0 and 0 for *x*, *y* and *z*, use 2.66666, 28 and 10 as the values of the three constants *a*, *b* and *c*, use a step size of 0.01 and solve the equations for a couple of thousand steps. You can use a very similar spreadsheet to the previous one but produce a phase plot (points only – no lines) of *x* against *z*. The result should be like Screen Shot 9 and, if you're familiar with chaos theory, you'll recognise it the Lorenz Strange Attractor.

Some Other Examples

What we've seen so far should, hopefully, have given you a feel for some of the potential of a spreadsheet for mathematical, scientific and engineering applications. And in an article of this length, that's about as much as we could expect to achieve. But if you've been inspired to use the spreadsheet as a scientific tool in the future, it would be a good idea to get some additional practice now. So to conclude this article, we'll present a few more examples which you could try out. Unlike the other examples, I won't tell you how to solve the problem – I'll just present the basic facts you'll need to know, a graph showing the sort of result you should expect and perhaps the odd tip or two.

A Random Walk

The curiously named random walk has been used in a variety of applications ranging from solving the Laplace equation for heat transfer to modelling diffusion-limited aggregation. My reason for suggesting it as an exercise is that it brings in two more useful Excel features, the random function and the if statement. So what is a random walk? I'll start by describing a two-dimensional random walk constrained to a rectangular grid. Start in the middle of a football field and spin two coins – say a 10p and a 50p coin. If you get two heads take one step north, if you get two tails take one step south, if you get heads on the 10p coin and tails on the 50p coin take one step east, otherwise take one step west. Now start again by flipping the coins and taking a step in one of four directions and repeat the exercise until you get bored. The path you'll have traced out is the random walk. A slightly different two-dimensional random walk is where you still only move one step at a time but you're no longer constrained to just four directions of movement. Instead, you can move in any direction at random. And in our third example of a two-dimensional random walk, even the distance you move is no longer constrained –you move a random distance within certain limits. An alternative way of looking at this final random walk is that you speed up or slow down randomly at each move and this is a close parallel to the Brownian motion of molecules.

To set you on the right track, I'll provide details on the random function and the if statement. The syntax for the random function is simply **RAND()**. No argument should be supplied and each time the spreadsheet is evaluated, a new random value in the range 0-1 is generated. So, for example, if we want a cell to contain a random real number in the range 0 – 10, the following would be entered **=10*RAND()**.

The syntax for the if statement is **IF(condition, true, false)**. So, for example, suppose we want a cell to contain the value of A1 divided by A2 unless A2 was 0 (which would give a numeric overflow) in which case we want to give the answer 0. To do this, the following would be entered **=IF(A2=0,0,A1/A2)**.

With that bit of background, you should find it fairly easy to produce a graph showing the three types of random walk I described earlier. The results of no two spreadsheets will look exactly alike, and every time you change a cell, all the random numbers will be re-evaluated. Nevertheless, Screen Shot 10 is typical.

The Bifurcation Diagram

Since we've already entered the peculiar world of chaos theory with the Lorenz Strange Attractor, let's return briefly to that subject and generate a bifurcation diagram. If you're not familiar with chaos theory, here's a word of explanation to set you on the right track.

A simple model of population growth is given by the following equation:

$$x_{n+1} = ax_n(1-x_n)$$

where x_n is the population at time period n and a is a growth constant. Populations are normalised over a range 0 to 1 where 1 is the maximum population the environment can support. The four graphs in Figure 3 show what happens with various values of a – no prizes for guessing what software tool I used to prepare these graphs! The first graph is for $a=2.7$ and you'll see that after a short period of instability, the population stabilises at around 0.63. For values of a up to 3 the population stabilises in this way, although the final value increases with a. The graph of $a=3.4$ is typical of what happens for a greater than 3. We end up with a "boom and bust" scenario in which – once again, after the initial fluctuations have stabilised – the population settles down to cycle between a pair of values. At about $a=3.45$, the number of possible final population values doubles again and, as we can see in the third graph of $a=3.55$, the final population cycles between four values. As a increases, we get further doublings to 8, 16 and so forth until, at around $a=3.75$, the population appears to fluctuate randomly. This is the situation illustrated in the fourth graph which is for $a=3.975$. This is so-called chaotic behaviour that is, the behaviour shows super-sensitivity to the initial conditions. With the first three graphs, the population would settle down into the pattern shown whatever the initial value of x. However, in the chaotic region, a tiny change in the initial conditions will result in totally different long term behaviour. To illustrate this, the final graph has a couple of traces, one for an initial value for x of 0.1 (red) and the other for an initial value of 0.11 (green).

The way in which the final population depends on a is summarised in the bifurcation diagram. To produce this, generate population histories for values of a from around 2.5 (you could start at 1 but things aren't too exciting between 1 and


a=2.700

a=3.400

a=3.550

Figure 3.

a=3.975

Screen shot 12.

Figure 4.

The first stage is to implement this single rule, with each generation being represented by a row of cells, and the progression through time being shown down the page. If you start with a single cell equal to 1 and all the others equal to 0 in the first generation and generate a contour plot, you'll find that you produce a Siernpiñsky gasket as shown in Screen Shot 12. To elaborate on this, make the spreadsheet work with any of the 16 possible totalistic rules for a 2-neighbour, 2-state, one dimensional cellular automata. A totalistic rule is one in which you're only concerned with the *total* value of the neighbourhood and the reason that there are 16 possible rules is that to cope with all possible combinations. So, for example, you could have a rule which stated:

> If *total-neighbourhood-value* = 2 or 3
> then $cell_{n+1} \rightarrow 1$
> *Else cell$_{n+1}$* $\rightarrow$ 0

You'll find that, from a random starting point, some rules cause a continuation of random behaviour, others produce order, and others give rise to a variety of patterns.

Oscillating Membranes

In our next example, you get the opportunity to turn your hand toward producing some works of art. However, this doesn't mean that we've abandoned our theme of using spreadsheets for mathematical and scientific applications. Because although the graphical results are certainly eye catching, the basic principles are firmly grounded in the sciences.

Early last century, the German physicist E Chladni discovered that the patterns of an oscillating quadratic membrane can be calculated by solving a partial differential equation. The solution to the differential equation is given by the formula:

$$s(x,y)=b_1 \sin(a_1 x) \sin(a_3 y)+b_2 \sin(a_2 x) \sin(a_1 y)$$

If the membrane is excited with two or more frequencies at the same time, multiple equations like that above, each with different parameters, can be superimposed. So, for example, with two frequencies, we end up with the following equation:

$$s(x,y)=b_1 \sin(a_1 x) \sin(a_3 y)+b_2 \sin(a_2 x) \sin(a_1 y) +b_3 \sin(a_3 x) \sin(a_4 y)+b_4 \sin(a_4 x) \sin(a_3 y)$$

Using the techniques we've already employed, it should be a comparatively easy task to write a spreadsheet to generate a contour plot for this function for values of x and y between 0 and π. If you assign cells to the eight parameters $a_1, a_2, a_3, a_4, b_1, b_2, b_3,$ and b_4 it will be easy to experiment with different values of these parameters, noting the significant difference to the final result which an apparently minor change can make. a_1 to a_4 should be positive integers and b_1 to b_4 should be real numbers between −1 and +1. And finally, when you get bored with just a pair of frequencies, you could try extending the spreadsheet to work with three or more. The four images in Figure 4 are typical of the results you should achieve.

2.5) to 4 (above 4 the system becomes unstable). Now, discard the first hundred or so values of x to make sure the system has stabilised to its final behaviour, and plot the next hundred or so x values against a. You should end up with a diagram similar to that shown as Screen Shot 11. I'll give you a tip here. If my experiences are typical, you'll find that it's very easy to generate the necessary figures but much less so to produce the graph. If you find this, it's probably because you've selected rows instead of columns or vice versa for "data series in" in step 2 of the Chart Wizard. Note, however, that there's a limit to the number of data series which, in turn, means that there's a limit to the number of generations you can plot. Note also that, by default, you'll end up with a rather gaudy plot since every data series will be rendered in a different colour. Unless you want to edit the colour of each of, perhaps 255 data series, the best solution would be to edit the colour palette.

Cellular Automata

We don't have space to go into all the theory of cellular automata or to say anything about their applications. However, they have fascinated mathematicians and computer users for generations as was evidenced by the "Game of Life" craze in the 70s. In fact, you can still get Game of Life programs for the PC. The Game of Life is an example of a 2D cellular automaton, but our aim here is to create a one-dimensional cellular automaton.

A cellular automaton is a group of cells, the state of which varies on the tick of some global clock which delineates one generation from the next. The rules which dictate how the state of a cell changes are concerned with the state of that cell and its immediate neighbours. We'll take a simple example in which each cell can have just two states, 0 or 1, and to determine how the state changes from one generation to another, we look only at the cell itself and its two immediate neighbours. Here are the rules:

If *cell$_n$* + *left-neighbour$_n$* + *right-neighbour$_n$* = 2 *then cell$_{n+1}$* $\rightarrow$ 1
Else *cell$_{n+1}$* $\rightarrow$ 0

Figure 5.

Figure 6.

Julia & Mandelbrot Sets

On the basis of what we've seen so far, you might be excused for believing that Excel is the universal panacea for scientists and mathematicians. Of course it's not, but by making use of the built-in Visual Basic programming language to write macros, its scope can be extended considerably. One application which I could find no way to do using the standard facilities was to plot fractals such as Julia Sets or the Mandelbrot Set. However, once a simple macro was written, the problem became trivially simple.

No doubt you've seen pictures of the Mandelbrot and Julia Sets but if you're going to produce them in Excel, we need to look at them from a mathematical viewpoint. Let's start off with Julia Sets. Take a point on the complex plain (if you don't know what that means, I'll have to refer you to a mathematical textbook on complex numbers), square it and add a complex constant. If the radial distance of the resulting point is more than 2 from the origin, the original point is not in the Julia set. If the radial distance is less than 2 from

the origin, carry out the transformation again – i.e. square the complex number and add the same complex constant. Once again, if the radial distance of the resultant point is more than 2 from the origin, the original point is not in the Julia set. With some starting points, however many times you carry out this transformation – the result will never get far from the origin – these are the points in the Julia Set for the particular constant. For other starting points the result soon heads off towards infinity. Of course, it's not possible to carry out the transformation an infinite number of times, so some arbitrary limit has to be placed on the number of iterations which are carried out. 200 is typical although if you use a larger number, then you'll get a more accurate result at the expense of a longer computing time. So, to get a picture of a Julia Set, you carry out the above process for a large number of points on the complex plain, plotting a mark for those points which are in the Julia Set. Commonly, rather than just plotting whether or not a point is in the set, a

number representing now many iterations were required to move the resultant point to further than 2 from the origin is plotted. Now, if a contour plot is produced, coloured contours indicate how close a point is to being in the Julia Set. The results are visually attractive in the extreme. To put this in more mathematical terms, the Julia set for the complex constant c is defined by the transformation $z \rightarrow z^2 + c$.

The following is the macro I produced to determine whether or not the point represented by (re, im) was in the Julia Set for the constant (cre, cim). The function is called from Excel and returns a value between 1 and 200.

```
Function Julia(re, im, cre,
cim)
    i = 0
    x = 0
    While i < 200 And x < 2
    ren = re ^ 2 - im ^ 2
    imn = 2 * re * im
    re = ren + cre
    im = imn + cim
    x = Sqr(re ^ 2 + im ^ 2)
    i = i + 1
    Wend
    Julia = (i)
End Function
```

You might like to build a spreadsheet based around this macro and experiment with plotting various Julia Sets. The spreadsheet I produced allowed the user to define the constant c plus the portion of the complex plain to plot. This allows the user to zoom in on an area of interest. As a starting point, I suggest you investigate the Julia Set for $c = 0.744 + 0.097i$ between $-1.5 - 1.5i$ (top left hand corner) and $1.5 + 1.5i$ (bottom right hand corner) using an array of 100 by 100 cells. One word of advice – in all the other examples, you'll have found that every time you made a change to the spreadsheet, all the cells would have updated almost immediately. That won't be the case with this spreadsheet. You could easily find that it will take 30 seconds for all the cells to be updated, even longer of you increase the 200 limit of iterations in the macro. So, it would make sense to turn off automatic recalculation and manually perform a re-calculation when you need one. Screen Shot 13 is of the spreadsheet I used and Figure 5 is a zoomed in portion of a Julia Set.

And finally, you might like to modify the macro in order to produce the Mandelbrot Set instead of a Julia set. Simply change the macro to always use (0, 0) as the starting point and supply the value c as the parameter. Now plot the results for values of c in the complex plain. I'm sure you've seen pictures of the Mandelbrot Set but just so you know that you're on the right track, Figure 6 shows the complete Mandelbrot Set and a zoomed-in portion produced using Excel. Perhaps these are not quite as spectacular as some of the high resolution images produced by dedicated software, but for the humble spreadsheet, I thir **ELECTRONICS**
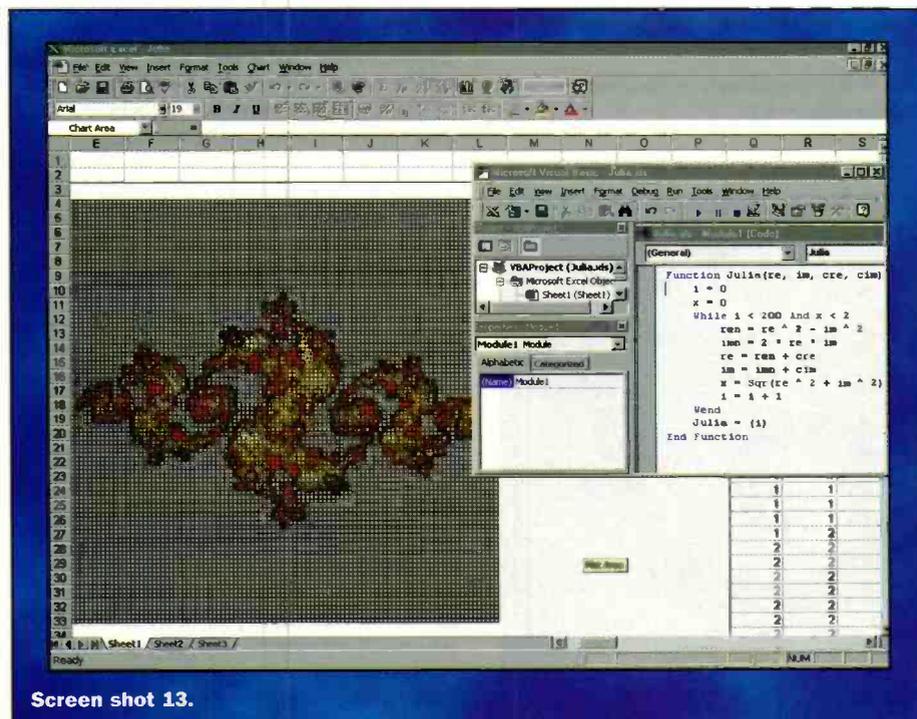
Screen shot 13.

Microcontroller
DEVELOPMENT USING THE STAMP
ARCHITECTURE FUNDAMENTALS
• • • • • • • • • • PART 1 • • • • • • • • • •

Using a microprocessor is supposed to be an elegant design solution, but all too often computing and electronics enthusiasts struggle to get to grips with the intricacies of machine code. Here Stephen Waddington takes a look at an environment that licks microcontroller development in the first of a three part series.

Have you ever tried to program a microprocessor? How did you get on? It's hard work isn't it? For a long time a PC equipped with BASIC and an I/O card was the solution for electronics enthusiasts that wanted to experiment with computer control but did not want the hassle of learning a machine level language.

Machine code is nasty. Anyone that has ever tried to get to grips with the PIC microprocessor family, the Z80 or the 68000 will know this. Here's the greatest irony in my mind. Software development in its rawest form is a creative process, but ultimately requires the programmer to adopt a mathematical approach and think like a machine.

Control Solutions

Sophisticated development environments can help, but they are a tool rather than a solution. Software debug and in-circuit emulation devices allow engineers to test and revise program software on the fly, providing common-sense explanations when code fails, rather than merely crashing the target system.

The BASIC PC-driven I/O approach can be successful. But a £1,000 Pentium PC complete with a 32-bit I/O board is a hell of an overhead to pay for a basic control application. If it's an I/O application that needs to be used outside or in a small space, a PC simply is not practical.

Help is at hand, for I believe I have a solution. Let me introduce you to a device I discovered earlier this year that is compact and relatively easy to program. The BASIC STAMP is a microcontroller, so called if the marketing blurb is to be believed, because it is only slightly bigger than a postage STAMP.

STAMP Technology

STAMP devices are manufactured by a US company called Parallax. The good news for UK readers is that they are distributed in the UK by Milford Instruments and have started to appear in the Maplin Catalogue. Check the resources list at the end of this article for details of Parallax and Milford Instruments.

The STAMP devices are literally self-contained computers. The STAMP comes in two flavours; BASIC STAMP 1 (BS1 Order code NW32K, £32.90 inc. VAT) and its more sophisticated counterpart the BASIC STAMP 2 (BS2 - Order code NW33L, £51.70 inc. VAT). Each device includes a 5V voltage regulator, microprocessor, crystal clock, brown-out control circuitry, serial EEPROM, and a PBASIC interpreter.

STAMP devices can be programmed using a dialect of BASIC, called Parallax BASIC (PBASIC). As they are EEPROM based they can be programmed and re-programmed as many times are you like. Even better is the fact that the development environment and the devices themselves are relatively inexpensive. It's possible to get started with a prototyping board, development software and STAMP device for under £100.

STAMP microcontrollers have fully programmable I/O pins that can be used to directly interface to TTL-level devices, such as buttons, LEDs, loudspeakers, and potentiometers. And with just a few extra components, these I/O pins can be connected to typically non-TTL devices, such as solenoids, relays, RS 232 networks, and other high current/voltage devices.

STAMP technology can be used to accomplish a large number of different control applications and tasks such as sophisticated logic circuits, servo drivers, communication, and LCD drivers. Its key advantage over other approaches is that it enables a working prototype to be developed far quicker than by using conventional components. If modifications are required they can often be quickly incorporated within the software rather than requiring a new board layout.

Downloading code from a PC to a STAMP device takes a single keystroke. The STAMP will then start to execute the stored programme until either reset, another programme is downloaded over it or the power removed. If power is removed the programme is fully preserved and will resume execution once power is restored.

A PBASIC program is stored in the non-volatile serial EEPROM, which is read from and written to by the interpreter chip. This interpreter chip fetches the instructions one at a time and performs the appropriate operation on the I/O pins or internal structures within the interpreter. To program BASIC STAMPs, you just connect them to an IBM PC or compatible and run the editor software to edit and download your program.

Stamp development kit, Kit 1 (Order code NW23A), Kit 2 (Order code NW25C).

Functionality	BS1	BS2
I/O lines	8	16
2 RS 232 ports		
EEPROM	256 bytes	2,048 bytes
RAM	7 word registers; all are byte addressable; two are bit addressable	16 word registers; all are byte, nibble and bit addressable
Maximum program length	Approximately 80 instructions	Approximately 500 instructions
Clock speed	4MHz	20MHz
Programme execution speed	2,000 instructions per second	4,000 instructions per second
Current requirements	2mA running, 20mA in sleep modes	7mA running, 50mA in sleep modes
Environment	0 to 70°C	0 to 70°C
Serial I/O speed	TTL serial at 300 to 2,400 baud	TTL and RS 232 serial at 300 to 50,000 baud
Package	14-pin SIP module	24-pin DIP module
Processor	PIC16C56	PIC16C57
PC programming interface	Parallel port	Serial port

Table 1. Feature comparision between BS1 and BS2 microcontrollers.

Reset

◆ **RES:** Reset input/output pin goes low when power supply is less than 4V, causing the BS1 to reset. Can be driven low to force a reset, *but do not drive high*.

Prototyping System

Each of the STAMP devices has a corresponding development board, which provides a prototyping area and battery clips for a 9V PP3 supply. A useful approach is to mount the prototyping board on a piece of wood or plastic, and extend leads out from the prototyping area to a piece of breadboard for added flexibility.

The BS1 development board is shown in Figure 2. The 9V battery connection provides

Performance and Packaging

For such compact devices, the BS1 and BS2 pack impressive levels of functionality. The BS1 has 8 I/O lines which are configurable on the fly, together with 256 bytes of EEPROM, which is equivalent to approximately 80 instructions. The BS2 meanwhile has 16 I/O lines, 2 RS 232 interfaces and 2,048 bytes of EEPROM, which is equivalent to approximately 500 instructions.

The BS1 is packaged on a 14-pin single-in-line package (SIP), while the BS2 is contained within a 24-pin dual-in-line (DIL) package. Both devices are shown in Figure 1 and are based on PIC microprocessors. The BS1 uses a PIC16C56, while the BS2 uses a PIC16C57. A complete list of the features of the STAMP devices is shown in Table 1.

For the purposes of this initial article we'll focus on the BS1, but making the transition to the BS2 is a straightforward task. Aside from the increased performance capability of the BS2, there are only a few register addresses and BASIC instructions that are different between the two devices.

The layout of the BS1 is shown in Figure 1. There are four key types of connection to the outside world:

Programming

◆ **PCO (PC Out):** connects to PC parallel port pin 11 (BUSY) for programming.
◆ **PCI (PC In):** connects to PC parallel port pin 2 (D0) for programming.
◆ **GND (PC Ground):** connects to PC parallel port pin 25 (GND) for programming.

Power

◆ **PWR:** Unregulated power in accepts 6 to15V dc which is then regulated to 5V. This pin may be left unconnected if 5V is applied to the +5V pin.
◆ **GND:** Ground input/output connection for power and system I/O.
◆ **5V I/O:** if an unregulated voltage is applied to the PWR pin, then this pin will output 5V. If no voltage is applied to the PWR pin, then a regulated voltage between 4.5V and 5.5V should be applied to this pin.

Control

◆ **P0 to P7:** General-purpose tri-state I/O pins, each capable of sinking 25mA and sourcing 20mA. Total of all pins should not exceed 50mA (sink) and 40mA (source). These pins can be set in one of the following three conditions using software; high impedance input, low output (0V) and a high output (5V).

Figure 1. BS1 and BS2 packages and pin-out details.

Figure 2. BS1 development environment.

Word Name	Byte Names	Bit Names	Comments
port	pins	Pin0 to pin7	I/O pins; bit addressable
	dirs	Dir0 to dir7	I/O pin direction control; bit addressable
w0	b0	Bit0 to bit7	Bit addressable
	b1	Bit8 to bit15	Bit addressable
w1	b2		
	b3		
w2	b4		
	b5		
w3	b6		
	b7		
w4	b8		
	b9		
w5	b10		
	b11		

Table 2. BS1 memory organisation

a convenient means to power the device. If you prefer you can also use a 5V to 15V supply, but ensure you connect the supply to the appropriate part of the BASIC STAMP. A regulated 5V supply can be connected directly to the +5V pin, but a higher voltage should be connected to the PWR pin. Connecting a high voltage supply to the +5V input will kill the microcontroller.

The BS1 device uses 1 to 2mA of power under normal circumstances. When configured as an output, an I/O pin can sink up or source up to 20mA, sufficient to light an LED. The combined current load of all I/O pins should not exceed the 50mA operating limits of the on-board PIC microprocessor. Additional driving circuitry is required to drive larger loads. These will be examined in Part 3 of this series.

Registers

The BASIC BS1 has 14-bytes of user defined RAM devoted to I/O and the storage of variables. The first two bytes are used for I/O – 1-byte for actual pins and 1-byte for direction control – leaving 12-bytes for data. The variable space configuration is shown in Table 2.

These 14-bytes may be allocated on a bit, byte (8-bits) or word (16-bits) basis depending on the expected numerical value range for the variable; 0 to 1 for bits, 0 to 255 for bytes, and 0 to 65,535 for words.

The PBASIC command symbol is used to define a variable, so if the value of a variable counter is between 0 and 255, then allocate it to a byte variable by using the following statement:

symbol counter = b2

If it is likely that the variable will be larger than 255 (up to 65,535) then it must be allocate a word variable:

symbol counter = w2

Note that w2 comprises byte variables b4 and b5, so we cannot allocate w2, b4 and b5 to different variables in the same programme.

In many cases, a single bit may be all that is needed, such as when storing a status flag. In this case use a bit variable:

symbol pressed = bit0

One thing to watch out for is variable overflow. This occurs when the value of your variable exceeds the space allocated. For example, had the variable 'counter'

been allocated to byte variable b4, if counter had exceeded 255 in the programme, rather than reaching 256 it would revert to 0.

Programming Without Pain

To programme either of the STAMP devices, you'll need an IBM 286 with MS-DOS 2.0 or greater, a parallel port and 128K of RAM. This development environment is not going to place too much of a strain on today's state-of-the-art Pentium PC system. To program a BASIC BS1, you'll need to connect it to your PC and then run the editor/downloader software. This is a straightforward exercise. To connect the BS1 to your PC, follow the steps shown in Table 3 and shown in Figure 3.

With the PC connected to the BS1 development board, you're ready to boot-up the software editor/downloader.

The DOS based application is supplied on a single floppy disk together with the manual. Rather than working from the floppy

disk, I copied the editor/downloader on my hard disk. From here if you're using Windows 95 or 3.1, its simply a case of double clicking on the STAMP application. Alternatively if you're using a DOS based PC, move to the directory in which the editor/downloader is located and type STAMP.

The BASIC STAMP software is a primitive application which will take you back almost a decade. That said, it is very highly effective, and makes you realise that Windows is not such a huge improvement on well-written DOS applications. The editor screen is dark blue, with a single line across the top that names various functions as shown in Photo 1.

The following list shows the keys that are used to perform various functions:

◆ Alt-R Run program in BASIC STAMP (download the program on the screen, then run it)

◆ Alt-L Load program from disk

◆ Alt-S Save program on disk

◆ Alt-Q Quit editor and return to DOS

Housekeeping

There are few housekeeping restrictions on how programs and data is entered using the editor. If you have used BASIC before you'll recognise many of the formats.

Comments or Remarks

Comments can be added to your program to make it more readable. Comments begin with an apostrophe (') and continue to the end of the line. You can also designate a comment using the standard REM statement found in many versions of BASIC.
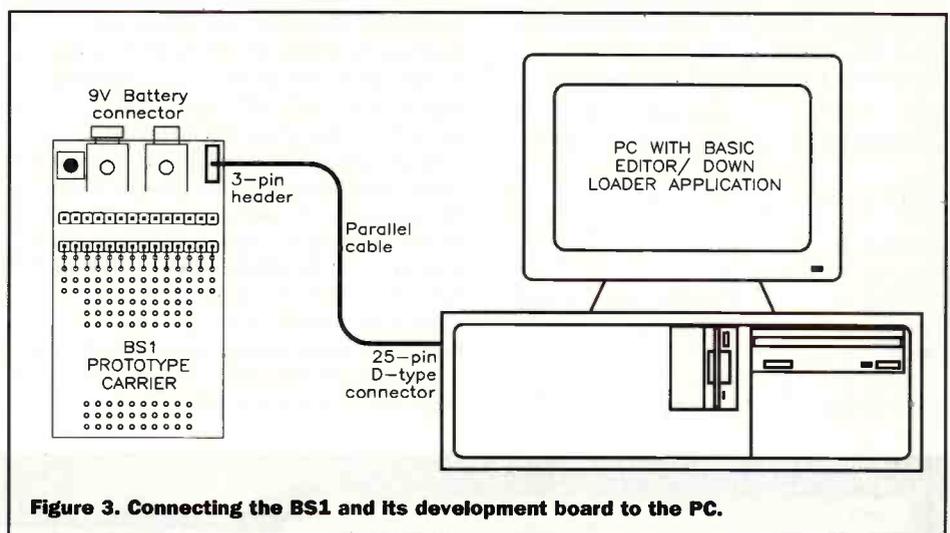
Figure 3. Connecting the BS1 and its development board to the PC.

1. Ensure the PC and BS1 device are powered down. Plug the BS1 onto the carrier board. The BS1 plugs into a 14-pin SIP socket, located near the battery clips on the carrier. When plugged onto the carrier board, the components on the BS1 should face the battery clips.

2. In the BASIC BS1 Programming Package, you received a cable to connect the BASIC STAMP to your PC. The cable has two ends, one with a 25W D-type parallel connector and the other with a 3-pin PCB connector. Plug the D-type parallel connector into an available parallel port on the PC.

3. Plug the remaining end of the cable onto the 3-pin header on the carrier board. On the board and the cable, you'll notice a double-arrow marking; the markings on the cable and board should match up.

4. Supply power to the carrier board, either by connecting a 9V battery or by providing an external power source.

5. With the BASIC STAMP connected and powered, run the editor/downloader software.

Table 3. Instructions for connecting the BS1 development board to the PC ready for programming and downloading.

Photo 1. The PBASIC editing environment.

Photo 2. BS1 development environment.

Photo 3. Assembling and downloading code to the BS1.

Constants

Constant values can be declared in four ways: decimal, hex, binary, and ASCII. Hex numbers are preceded with a dollar sign ($), binary numbers are preceded with a percent sign (%), and ASCII values are enclosed in double quotes ("). If no special punctuation is used, then the editor will assume the value is decimal. Most programs use decimal values, since this is most common in BASIC. However, hex and binary can be useful.

Address Labels

The STAMP editor uses labels to refer to locations or physical addresses within your program. This is different from some versions of BASIC, which use line numbers. Generally speaking, label names can be any combination of alphanumeric characters, but the first character of the name must not be a number. Also, label names cannot use reserved words, such as instruction names and variable names.

When first used, label names must end with a colon (:). When called elsewhere in the program, labels are named without the colon. The following example illustrates how to use a label to refer to an address:

```
REM           Programme to
demonstrate use of label names

loop:

TOGGLE 0      'Toggle pin 0
FOR b0 = 1 to 10
TOGGLE 1      'Toggle pin 1 ten
times
NEXT

GOTO loop     'Repeat the
```

process

Variables

Variables share the same syntax rules as address labels, but value labels don't end with a colon (:), and they must be defined using the symbol command.

Formatting

The editor is not case sensitive, except when processing strings such as "hello". Multiple instructions and labels can be combined on the same line by separating them with colons (:).

Running Your Program

To run the program shown on the screen, press Alt-R. The editor software will check all available parallel ports, searching for a BASIC STAMP. If it finds one, it will download and run your program. Note that any program already in the BASIC STAMP will be overwritten. If the editor is unable to locate a BASIC STAMP, it will display an error as shown in Photo 2. Assuming that you have a BASIC STAMP properly connected to your PC, the editor will display a bargraph, which shows how the download of your program is progressing. Typical downloads take only several seconds, so the graph will fill quickly.

As the graph fills, you'll notice that some of the graph fills with white blocks, while the remainder fills with red blocks as shown in Photo 3. These colours represent how much of the BASIC STAMP's EEPROM space is used by the program. White represents available space, and red represents space occupied by the program.

To load a PBASIC program from disk, press Alt-L. A small box will appear,

prompting you for a filename. If you entered the filename correctly, the program will be loaded into the editor. Otherwise, an error message will be displayed.

If you decide not to load a program, press ESC to resume editing. To save a PBASIC program on disk, press Alt-S. A small box will appear, prompting you for a filename. After the filename is entered, the editor will save your program.

Resources

The Web is packed with information relating to the STAMP environment. Visitors to the Parallax Web site at www.parallaxinc.com as shown in Photo 4, can download data sheets, instruction manuals and project examples.

Milford Instruments in Leeds is the UK distributor of STAMP products. You can reach the company by telephone on (01977) 683665, or write to Milford Instruments, Milford House, 120 High Street, South Milford, Leeds LS25 5AQ. Alternatively check out the Milford Instruments' Web site at www.milinst.demon.co.uk as shown in Photo 5.

You can learn from other users that are developing on the STAMP environment, join the e-mail mailing list run by Parallax. To join this list simply send e-mail to majordomo@parallaxinc.com, and type 'subscribe STAMPs' in the body of the message. If you prefer, you can subscribe using the online subscription form on the Parallax Web site at www.parallaxinc.com.

Next Month

In the second article in the series, we'll take a look at how to exploit the versatile

Photo 4. Parallax Web Site.

Photo 5. Milford Instruments Web Site.
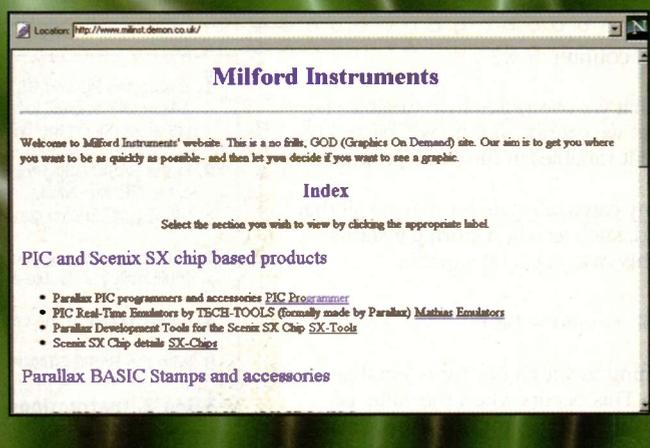
Science Line

A selection of the most popular questions that people ask

## Is there such a thing as a Red Dwarf?

A dwarf star is a small, low luminosity star at the end of its life. Dwarfs are usually white but come in a variety of colours that change as time passes and the star cools. Red dwarfs have a temperature of about 2500°K compared to our Sun whose 'surface' temperature is about 4000°K.

Matter in white dwarfs is strange – it is a degenerate gas. This means all the electrons are stripped from their parent atoms. In this state, gas is almost a perfect conductor of heat and does not obey the ordinary gas laws. A white dwarf can be compressed to very high densities (because there's little outward radiation from nuclear reactions) typically 10,000,000 grams per cubic centimetre. Such a white dwarf has no source of energy and simply cools down forever becoming a yellow dwarf and then a red dwarf.

It might take trillions of years to completely lose its energy, but the end state of a star like this is typically a ball about the same size as the Earth, with a density about 50,000 times that of water, covered maybe with a thin layer of ice and surrounded by an atmosphere a few metres thick.

The Sun will become a white dwarf but first will turn into a red giant engulfing Mercury and Venus. It will blow away the Earth's atmosphere and boil the oceans. Fortunately, this won't happen for about five billion years!

Why are birds eggs coloured?

After the egg has been made inside the bird, it passes down a long tube called the oviduct on its way out of the bird. It is in the oviduct that the egg can be coated with pigments. If the egg is stationary in the oviduct then it will be spotted, but if it is moving when the colour is applied it will be streaky. Although bird's eggs may be anything from blue to red to green, the colouring is produced by just two pigments which are related to the bird's haemoglobin . One is a bluish green pigment that comes from bile and the other pigment comes in a range of tones that can result in eggs colours from pale yellow to black.

What does caffeine do to your brain?

The leading theory explaining how caffeine acts on the nervous system is that it is an antagonist (inhibits) adenosine receptors within the central nervous system. Adenosine is a nucleoside that appears to function as a neuromodulator (a chemical that modulates, that either stimulates or inhibits the nerve impulse as it passes from one neurone to another) and possibly a neurotransmitter (the chemical in the synapse which is responsible for the transfer of the nerve impulse from one neurone to another). Caffeine may also affect neurones that use dopamine as a neurotransmitter and withdrawal symptoms may involve neurones that use nor-adrenaline and adrenaline as neurotransmitters.

Why do you get two tides a day?

Although the Moon only pulls on one side of the Earth, you get two tides – one on the side facing the Moon and one on the opposite side. The one facing the Moon is because of the Moon's gravity pulling the water in that direction. The one on the opposite side is because of centrifugal force. The Moon doesn't simply go round the earth – the two are going round a common centre of gravity. This isn't at the centre of the Earth but slightly off-set. This means there's a 'bulge' of earth sticking out, throwing water off to make a second tide.

Are there any animals other than seahorses where the male of the species raises the children?

Two spring to mind. In pipefish, females lay their eggs in their partners pouches, as in seahorses and it is the males that carry the offspring. Also, in one species of beetle, the golden egg laying beetle, females dump their eggs primarily onto males that are mating with other females and the males do all the carrying. In fact, this is a pretty brave job as once the eggs are laid they are bright yellow and so the males are now incredibly conspicuous to predators and much more likely to be eaten!

How do you cut diamonds?

Diamonds have a grain similar to the grain in wood. It is easier to cut with the grain than against it. You can cleave diamonds with the grain using an axe, but you have to use a saw to cut across the grain. A diamond also has impurities – like knots in wood.

An axe is a hard metal blade which is struck with a wooden or metal hammer using a sharp blow. A saw is a paper-thin disc of phosphorbronze that is just a few inches in diameter and impregnated with diamond dust. It rotates at speeds of 5000 to 10,000 revs per minute constantly impregnating itself with diamond dust from the stone it is cutting.

Very large stones may take three days to two weeks to cut right through although one sawyer can usually tend a battery of 20 sawing machines though.

How high up do satellites orbit Earth?

The minimum orbit for any satellite is about 150 kilometres, although some military satellites orbit at 50 kilometres. At this height these little mechanical spies often don't last more than a few weeks before they enter the Earth's atmosphere and burn up. Satellites used for communications and meteorology are found much higher at 36,000 km in a geostationary orbit. At this 'magic' distance from the Earth they orbit at the same rate as the Earth rotates – staying above the same place on the Earth's surface. Navigation satellites orbit at about 15,000 kilometres whilst polar and Earth observation satellites orbit at only 500 kilometres.

Project Millecom–
WORLD YOUTH ON THE AIR

This project being co-ordinated by youth organisations and the RSGB, will celebrate the year 2000, by involving all the various youth organisations, schools, universities, and other youth establishments of the World in the operation of a network of radio stations manned by young people.

Objectives

The primary object of the project is to promote communication and expand international friendship between young people world-wide throughout the year 2000 using hobby radio as a medium. Additionally, it is hoped to promote a practical interest in the science of communication with a view to long term study and involvement, and to provide a practical insight into the international electronics and communications industries.

Background

Radio communication is a source of practical education to all people of all abilities both physical and mental. 'Project Millecom' is designed to encourage young people, up to the 25 years of age, from all nations, to participate in the science of communication world wide through the means of hobby radio.

To celebrate the year 2000, the Radio Society of Great Britain (RSGB) has agreed to co-ordinate a proposal initiated by the Air Training Corps of the United Kingdom to involve the various youth organisations, schools, universities and other youth establishments of the World in the operation of a network of radio stations by young people.

Outline plan

Most countries have the ability to operate hobby radio equipment and many have existing volunteer amateur radio organisations. In fact several of the youth organisations within these countries have introduced radio as part of their studies into the electronic sciences. It is proposed to utilise this existing amateur network in conjunction with additional stations in order to take part in this world-wide exercise over the year 2000 and to give all young people the opportunity to speak on the air. Frequencies to be used will vary with the range required to transmit over a related distance and with the time of day. In order to ensure that control is exercised and an information point is available, it will be necessary to provide a central radio station to co-ordinate transmission and to provide an information service for would-be users.

It is envisaged that existing amateur radio societies in each country would utilise the facilities available amongst their respective radio amateurs, however, it is felt that a central co-ordination station would be needed to be set-up in the UK at a suitable place where young international visitors would be able to see the centre in operation and use the facilities available, if desired.

It has been agreed that the project should be open to all young people and that a co-ordination centre will be established at the Royal Air Force Museum at Hendon, which will give maximum access to visitors whilst at the same time offering them the opportunity of an additional attraction. It is intended that the project will run from New Years Eve 1999, and continue through the year 2000. Competitions will be held with certificates and prizes being awarded for winning entries and specific achievements. All radio stations, including Hendon, will be operated and manned by young people (under supervision) from various countries, with access to all including the disabled. It is planned to provide all those who wish to participate with an educational information pack.

Hendon co-ordination centre

It is hoped to position a mobile trailer with state-of-the-art communications equipment in the RAF Museum grounds at Hendon. It is intended that the trailer will be big enough to accommodate several operating stations and allow for 'through transit' and observation areas. The trailer and its equipment will be used for further projects and educational purposes, touring the UK as a marker for the Millennium, and be able to link to other associated activities. A separate mobile unit will transport the necessary mobile aerials.
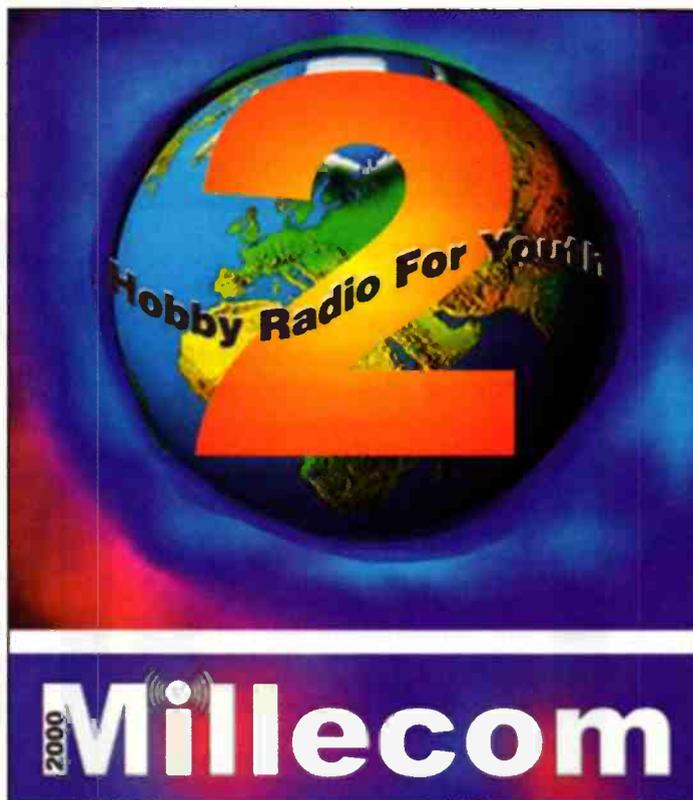
Callsigns

The United Kingdom Radiocommunications Agency is responsible for issuing callsigns to its various operators, as this is a special event, a unique callsign will be issued, which will almost certainly be considered collectable world-wide by those interested in amateur radio. A specially prepared card (QSL card) will be issued to confirm that the contact was made for exchange between operators.

Operating times

The practical operating times of the project will be in three parts - the 24 hours covering the New Years Eve (related to the various time zones), every weekend throughout the year 2000, and for two separate weeks. The first week will be at the end of the summer school time and the second week during the summer school holiday.

Further information about this exciting project can be obtained from G. A. King, 2EIGEX, Project Co-ordinator, Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE.

ELECTRONICS

Gardens of Eden

The Greenwich Millennium Dome is not the only Dome to capture the public imagination. Cornwall's plans to build a high-tech domed international scientific institute and research centre in a former china clay pit near St Austell are nearing completion. The Millennium Commission recently granted an award of £37m to Cornwall's Eden Project which has been met with delight by all involved. The ambitious £74m scheme (half coming from public and private sector sponsors) will construct the world's largest tropical plant houses to display and explore man's interdependence with plants, bringing a helpful boost to the Cornish economy, (ground plan in Figure 1). Eden is supported by a considerable number of bodies, from the European Regional Development Fund to SWEB, and expects upwards of 750,000 visitors per year.

Project founders Tim Smit and Jonathan Ball said "This is fantastic news for the whole region. We will now have a landmark project to be proud of, one which truly embodies the spirit of the new millennium. It has always been an ambitious project and thankfully the Millennium Commission has now taken the leap of faith required to unlock the matching funds and allow the real work to begin."

Often billed as 'the largest greenhouse in the world', the 'Humid Tropics Biome' is shown in a spectacular model, Figure 2. This, the larger of Eden's two plant conservatories reaching 60m in height, will in time be capable of growing tropical rainforest plants and trees such as teak and mahogany to maturity in sweltering temperatures of 40°C with high humidity, see Figure 3. The geometry of the structure is specially designed to trap as much solar heat as possible. Willows grown nearby will be burned in a vast, low emission furnace which will blast hot air into the domes (Figure 4). Another ecological friendly source of fuel to give additional heating to the dome is the dung of 6,000 cows which will be delivered in the form of dried slurry! According to calculations the biomass will release about as much carbon dioxide when it is burnt as it absorbs when it is growing, so there should be minimal effect on the environment. Solar and biomass energy should supply two thirds of the heating and

RESEARCH NEWS

by Dr. Chris Lavers

the rest will come from ordinary gas. To supply the huge quantities of pure water required, (250 cubic metres of water a day), to recreate the atmosphere of a rainforest and generate sudden rainstorms will be provided from the run off from the dome and will be pumped up to tanks at the top of the site.

Speaking on the 9th of February Project Director Tim Smit commented "I am really

proud of the tremendous progress our team has made in the last few months. I can't describe how exciting it is to see our dream becoming so real in such a short space of time." Tim Smit is of course the man responsible for the restoration of the 57-acre Lost Gardens of Heligan which was featured in a recent television series. Apparently Mr Smit and Mr Philip Macmillan Browse, the former director of RHS Wisley and now the horticulturist at Heligan had discussed building a large glass-house to grow plants which have changed the world. Some time later Mr Smit and Jonathan Ball were watching the sun go down together over the St Austell clay pits and a novel idea was born.

The Project has already acquired a five hectare nursery close to the Eden site, and its horticultural team has begun growing the plant stock that will
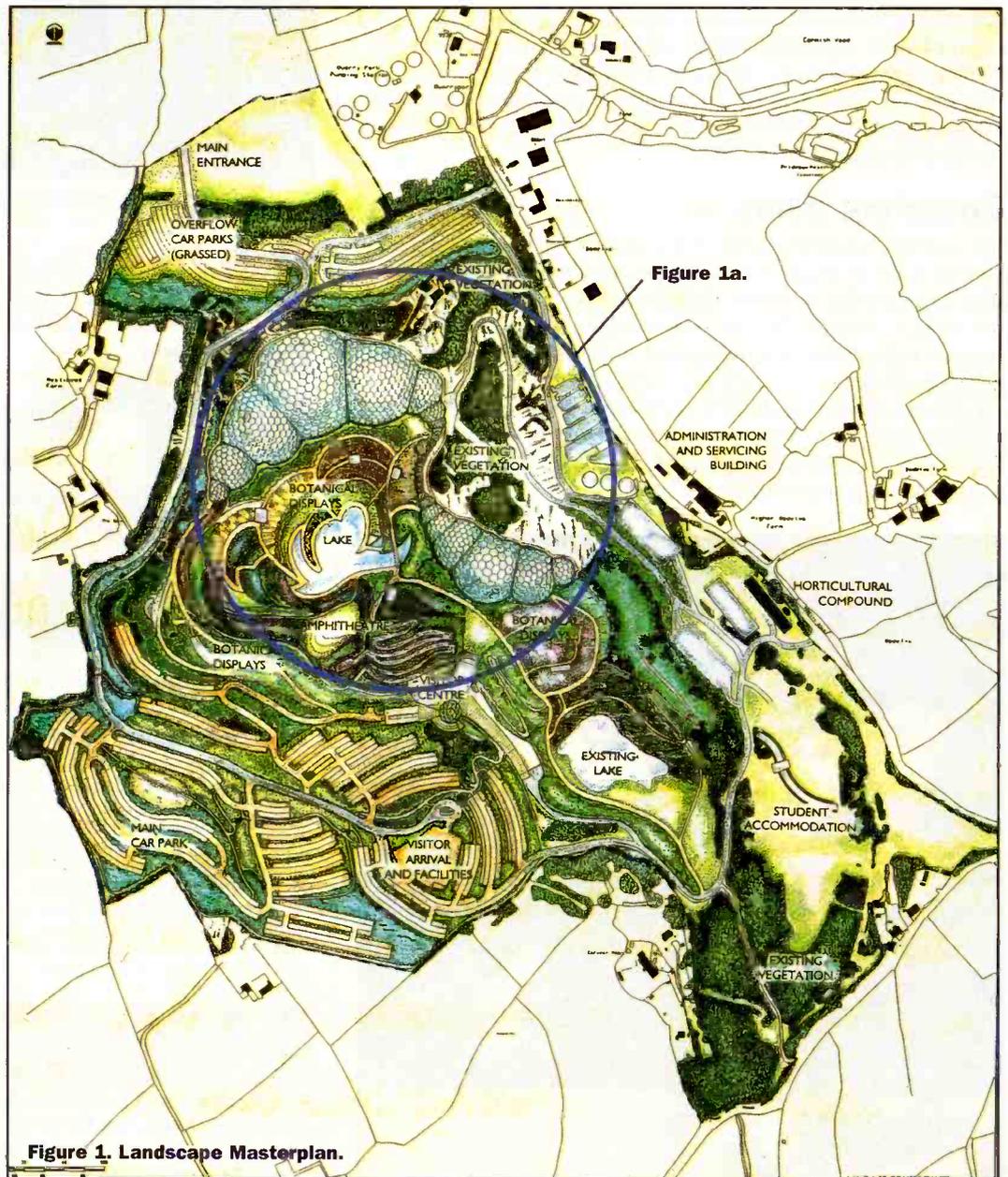

Figure 1. Landscape Masterplan.

be transferred to Eden's huge 'Biomes' in time for its opening. It is planned that the Eden Project will open to the public in April (Easter) 2000, drawing large crowds as will Cornwall's total eclipse of the sun, the first plant more than 10,000 species and varieties in the biomes and surrounding areas. Eden will reflect areas of the world that contain the greatest bio-diversity, displaying and interpreting mans' use of plants and his impact on the environment. There will be a carefully climate-controlled transparent capsule accessed via a visitor centre where visitors will experience the world of plants using time lapse photography.

The biomes will enclose three key climate regions: humid tropics, warm temperate and the external grounds. A clear distinction has been made between the interior and exterior by structuring the building as an exoskeleton, with a soft clear membrane suspended beneath the lightweight, taut steel structure.

In an effort to respond to fabrication, transportation and erection techniques, the design was based on the geometry of spheres which enabled the architects at Nicholas Grimshaw and Partners (the architects of the Waterloo Eurostar extension) to create a very lightweight structure of minimal surface and maximum volume. The system consists of straight tubular compressive members connected by standard cast connections, creating a geometry consisting of hexagonal cells spanning approximately 9m across. The cladding system is made up of optically clear air inflated foil 'pillows'. The domes will be covered with layers of the super-strong and high-tech transparent polymer foil which will be kept inflated by solar-powered compressors. It will be a very light building for its size, the foil should be strong enough for a man to walk on-allowing for possible
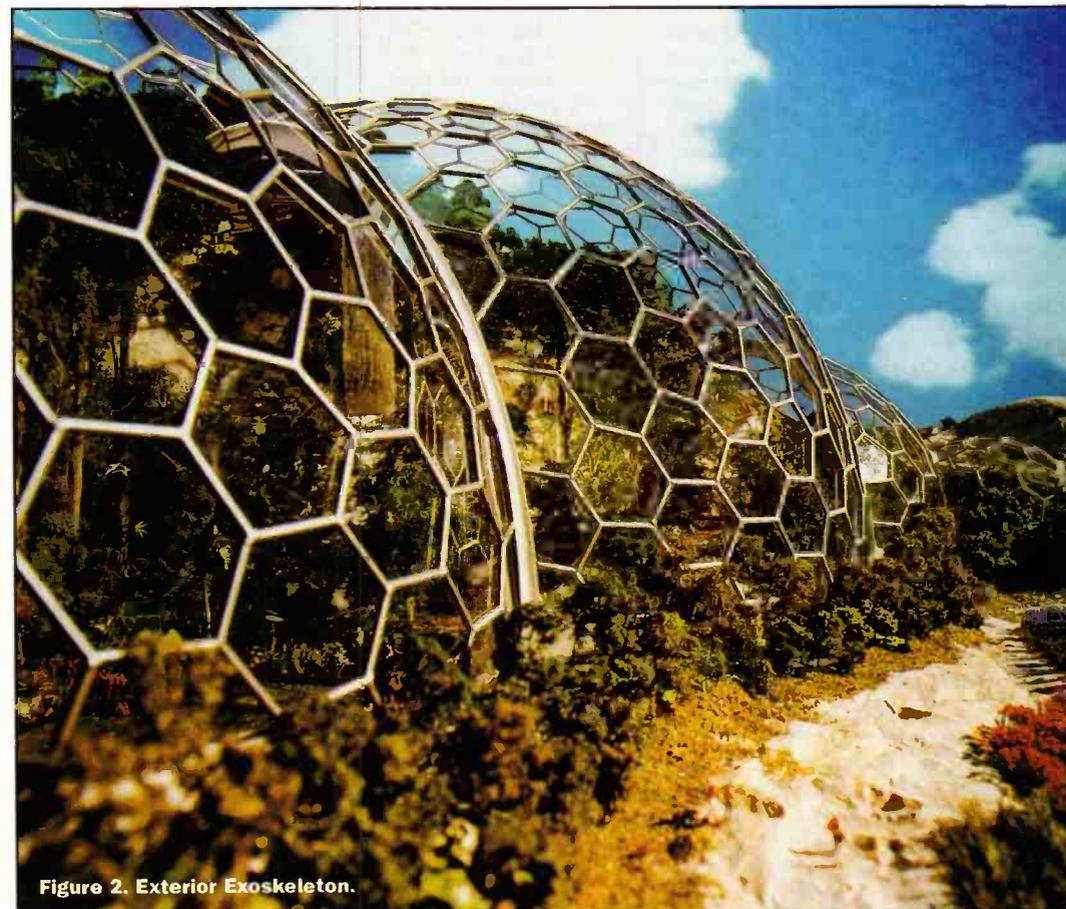
Figure 2. Exterior Exoskeleton.

total eclipse in the British Isles in over 70 years, (11.11am on August 11th, and not repeated until 2090!)

Eden's conservatories together with the plant collections, demonstrations and exhibitions will provide both an entertaining and informative attraction. Together they will aid the public understanding necessary to implement the aims of the Rio Convention. Eden will incorporate the largest and most spectacular plant-houses in the world, as well as a visitor centre and seven hectares of external grounds. It will have a Humid Tropic Biome 10m higher than Nelson's Column and would easily enclose the Leaning Tower of Pisa. Paths will be constructed through the Amazonian jungle.

Construction, already underway, will require 2,750 tonnes of steelwork, 39,000 square metres of transparent foil made from three layers of 0.2mm thick Teflon and 3.5km of trusses. A construction team equivalent to 1000 job years will be necessary. Designers aim to
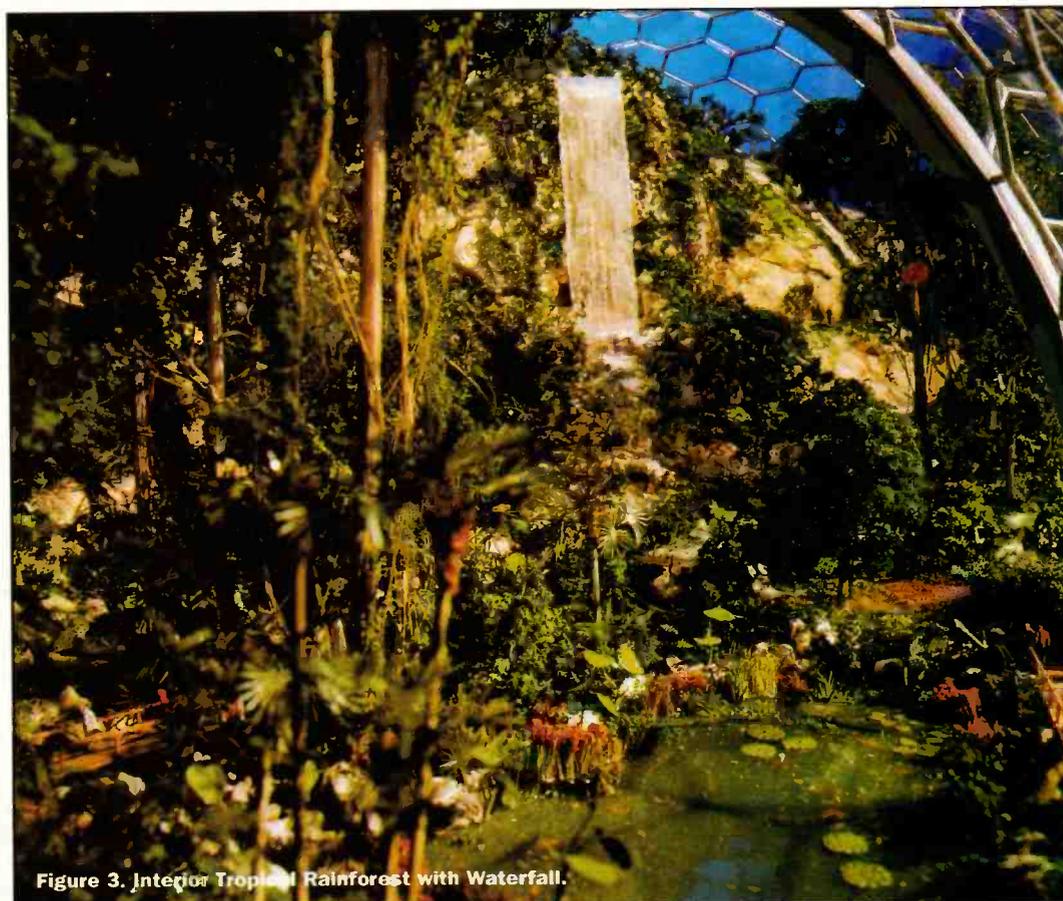
Figure 3. Interior Tropical Rainforest with Waterfall.

maintenance and a reduction in the number of steel supports. The cells provide one of the lightest envelopes ever designed. Once the construction principles were established for a single biome the complete structure was generated by adding and intersecting further spheres of differing diameters depending on internal spatial requirements. The aerial visual impression is of a biological organism figure 1a.

Eden's primary purpose is to present to the public a series of powerful images relating to the two most important land use issues facing mankind in the next millennium and will contribute to the effective

resolution of these often conflicting interests. These are:

◆ The stewardship of nature and conservation of both habitat and indigenous species,

◆ The need to produce food and other economically valuable crops to sustain the world's population.

According to Lester Brown, in 'Who Will Feed China? Wake-up call for a small planet' published by Earthscan, China is such a large nation in terms of both population and economy that its successes and failures affect us all. In a world economy, rising Chinese food prices translate into rising food prices everywhere. Land and water

scarcity in China will become everyone's scarcity. Lester makes the observation that looking at China's food prospects for the next few decades highlights the unsustainability of most national economic and population trends. China's current grain imports now exceed its production rate and must be addressed. Past experience inadequately prepares us for assessing the scale of China's future food demands. Multiplying 1.2 billion by anything is a great deal. If the Chinese were to consume seafood at the same rate as the Japanese do, China would need the total annual world fish

catch. Hence a prime function of Eden will be to inform and educate the public and interpret the Institution's objectives, and will include accommodation for visiting students and research workers from many countries.

Eden's scientific function will be chiefly concerned with the pursuit of effective solutions to practical conservation problems and sustainable agronomic development around the world. The scientific staff of Eden will initiate and co-ordinate major projects both at home and abroad.

Some comparison is no doubt invited with *Biosphere 2* in the Arizona desert, also built
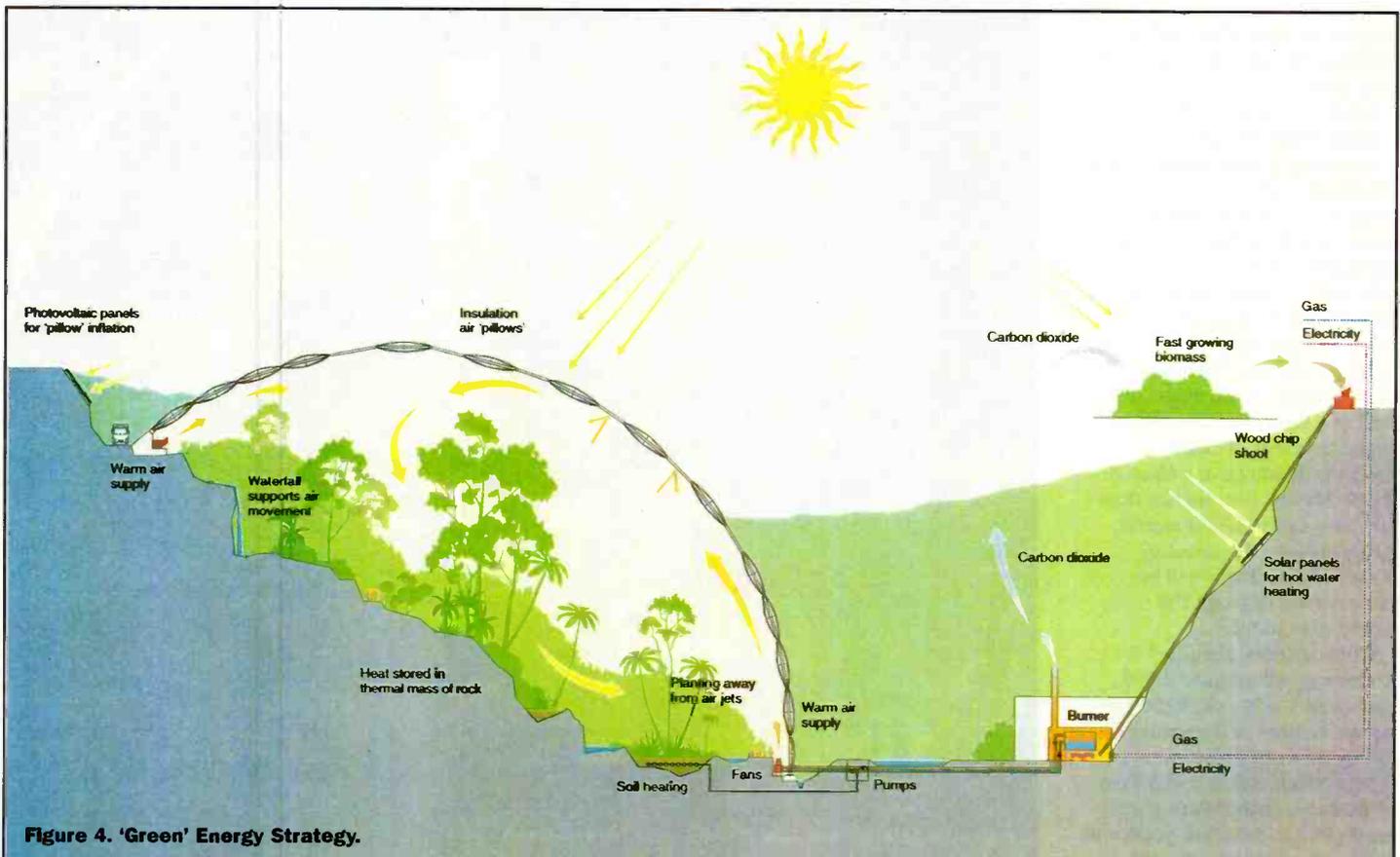
Figure 4. 'Green' Energy Strategy.

from glass and steel which contains five climatic zones: rainforest, savannah, desert, ocean and marsh. However, whereas Tim Smit's Eden Project aims to educate people about man's interdependence with plants, *Biosphere 2* was designed in part to establish whether man could live on Mars. In that respect Biosphere 2 failed. The eight man team lived in an enclosed eco-system and soon found that oxygen levels fell, until they were living at the equivalent of 17,000 feet up in the Andes. The oxygen depletion was attributed to some kind of microbacterial activity in the soil.

To rival Cornwall's Eden Project one of the world's leading zoological research centres, Paignton Zoo in Devon, has also unveiled plans to establish its own 4000 foot square tropical rainforest in the £13m transformation of a disused quarry. The intention is for a dome of 98% transparent high-tech PTFE material to open by the year 2001. The main difference between the projects is that the Zoological site plans to include not only flora, but free roaming monkeys, birds and even crocodiles! Proposed as the International Rainforest Resource Centre (IRRC) the 'dome' would become the hub for global rainforest communication and conservation links between field sites as dispersed as Peru, Zimbabwe and Malaysia.

There are in fact a large number of other domed events planned as part of the Millennial celebrations (Table 1). The Millennium Commission with matching funds from Europe, councils and industrial sponsors will contribute £600m - nearly twice the annual research funding allocated to the Engineering and Physical Research Council to build science and technology centres and domes. The largest project is the £112m Birmingham Millennium Point technology centre. Rival centres include the Leicester National Space Science Centre which will house the first 'Challenger Learning Centre' outside of North America, and Bracknell's Meteorology Weather Watch Discovery Centre.

As members of the public, with the first of these opening less than a year away, we will soon be able to judge the scientific and entertainment value of these sites for ourselves.

Forthcoming Electronics & Technical Meetings

1-4th September:
International Conference on Control will be held in Swansea UK. Topics covered will include a variety of control system interests across the major electronics and engineering disciplines. The conference will examine adaptive control, artificial intelligence, modelling and simulation. The meeting will examine applications in aerospace, the automotive industry, biomedical systems, environmental and safety systems and fault diagnosis. For more information contact the Institute of Electrical Engineering, Savoy Place, London, WC2R 0BL, Tel: 0171 344 5467.

12-14th October:
2nd International Conference on the Detection of Abandoned Landmines in Edinburgh, UK. This event will look at novel solutions and approaches to the detection of abandoned landmines, a topic highlighted in the last years of Diana Princess of Wales. Many sensor technologies will be covered including: surface penetrating radar, imaging magnetometers, with active and passive electro-optical imagers. Contact the Institution of Electrical Engineering.

The 1998 International Electronic Chart Display and Information System (ECDIS) Conference is jointly organised by the Maritime and Port Authority of Singapore and the United Kingdom Hydrographic Office (UKHO). The objective of the conference is to promote the use of ECDIS and digital data for safe navigation. ECDIS is a new navigational tool that can be interfaced with the Differential Global Positioning System to provide vessels with real-time and highly accurate positions in relation to charted features. The conference is appropriate for marine equipment specialists, port authorities, academics, maritime safety agencies and hydrographic officers. UKHO has been charting the world's seas for over 200 years and is now committing charts to electronic format. The conference will take place at the Pan Pacific Hotel in Singapore, 26-28th October 1998. For further information contact: International ECDIS Conference Manager, c/o SAFE Enterprises Pte Ltd, 3 Lim Teck Kim Road, #02-02 Singapore Technologies Building, Singapore 088934. Tel: (65) 228 0980, Fax: (65) 226 373, e-mail: **events@cyberway.com.sg**

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★ SAW controlled frequency stability
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★ Approximate size 200x50x150mm when completed

APPLICATIONS
★ Educational - robotics and simple
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★ Novelty - thrill friends and family
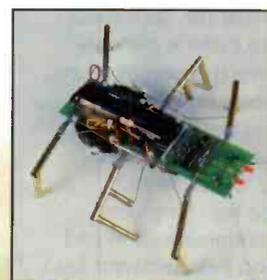
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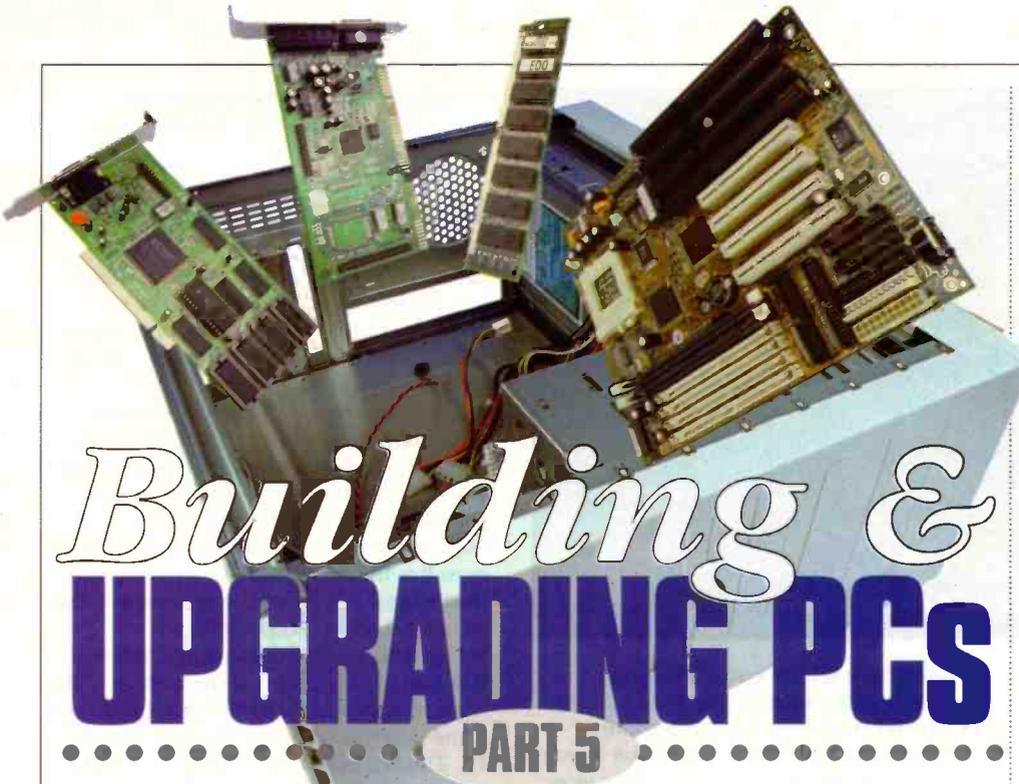
Building & UPGRADING PCs

PART 5

Mark Brighton looks at possible problems you may have encountered building your PC and upgrades.

O ver the past few months, we have shown you how to build a fully fit and functional multimedia PC from component parts chosen to meet your needs. If all has gone well and you have followed the steps set out in the series, your PC should be working well. If it isn't, I hope that this article will point you in the right direction and get you going!

Backtracking a little, we reached a critical point in the series some time ago, at the point where you first hit that power button and look at your screen in trepidation waiting for a smooth boot up, and for the prompts and sequence of events detailed in our articles.

However, life being what it is, some of you will have been dismayed to see that the hoped for cheery boot up messages didn't appear. What do you do now? Well, of course it depends on exactly what happens. There are a huge number of possible problems that could potentially prevent the PC from working for the first time, and I don't think we are likely to cover all of them in this article.

I will try to concentrate on the types of problems that have caught me out in the years I have been involved in building and upgrading PC's and hope that you will find them informative and useful in sorting out any problems you may have had.

Trouble at power up, no picture

First scenario, you switch on and the screen stays blank. I won't insult your intelligence by asking if you have connected the power leads or checked the mains fuse, but will assume that you have heard the power supply fan start up and maybe the screen has flickered but remained stubbornly blank thereafter (Note that some modern monitors may put their own fault message on screen telling you that there is no video signal and asking you to check the monitor cables).

Beeping speaker

Now, one possibility here is that your PC speaker emits a strident beeping tone sequence (assuming the speaker lead is connected correctly to the motherboard. This beeping is the result of initial tests performed by your motherboard on power up (Power On Self Test or POST) and the number of beeps indicates the nature of the fault encountered.

The Award BIOS supplies with the motherboard we recommend has a very simple set of POST beep codes. The first one is just a simple long beep, repeated every couple of seconds ad infinitum. This indicates a memory (RAM) failure and may be caused by a number of things.

First, check that your SIMMs are definitely plugged into the right sockets. There are usually four SIMM sockets on a motherboard, for two banks of memory. One complete bank of two sockets must be filled as a minimum and you may only extend this by fitting a further pair of SIMMs. Make sure that you are using a pair of sockets and not the middle two (one from each memory bank). Some motherboards do require that you start with the first bank if only one bank is used so check this too.

Many SIMMs have only tinned edge connector fingers and may not seat reliably in their sockets first time. If the positioning of the SIMMs looks correct, try removing and firmly reseating each SIMM before trying the power on again. Make sure that the spring clips at each end of the SIMM socket snap fully into the location holes on each SIMM. Do remember that on no account should you attempt removal or replacement of the SIMMs (or any other plug in cards) whilst the power is still on, or things may go from bad to worse! Beware static whilst handling the SIMMs, don't shuffle about and avoid touching the edge connector when handling them. Older SIMMs may require their edge connectors cleaning. An alcohol based cleaning solution, or contact cleaner/lubricant sparingly applied by a cotton bud or swab will be ideal for this job. Do not drench your motherboard or SIMMs in WD40 or other cleaners directly from an aerosol can (things may melt)!

If after these checks you still get the long tone from the speaker at power up, it may be that there is a fault with one of the SIMMs. If you are able to check for this by substitution of known good SIMMs (both the same size please) then do so to confirm the nature of the problem. Note that older motherboards sometimes had all sorts of restrictions on what combinations of memory modules may be used where, parity or non parity and so on. Please look very carefully at the manual or leaflet that came with your motherboard to confirm that the SIMM selection that you have chosen really is compatible with your motherboard. Check that your motherboard will accept EDO or SDRAM or whatever type of RAM you have chosen to use .If you don't have a pair of good SIMMs to verify this, you will have to assume a SIMM fault, but only after double and triple checking all motherboard connections.

DIMMs too are not exempt from these complications. Although these don't have the bank or pair fitting complication (one DIMM equals one bank), they, like SIMMs are supplied in several different basic technologies and voltages.

Lastly, although unlikely, it may be that a power supply problem or motherboard fault is producing the symptoms of a memory failure.

One long beep, then two or three short ones

This beep pattern indicates a video card problem. Power down and try unscrewing and removing the video card and replacing it again, paying special care that it seats
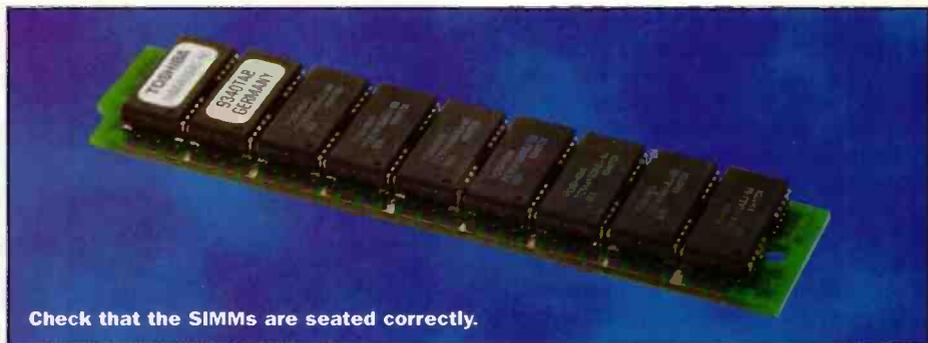
Check that the SIMMs are seated correctly.
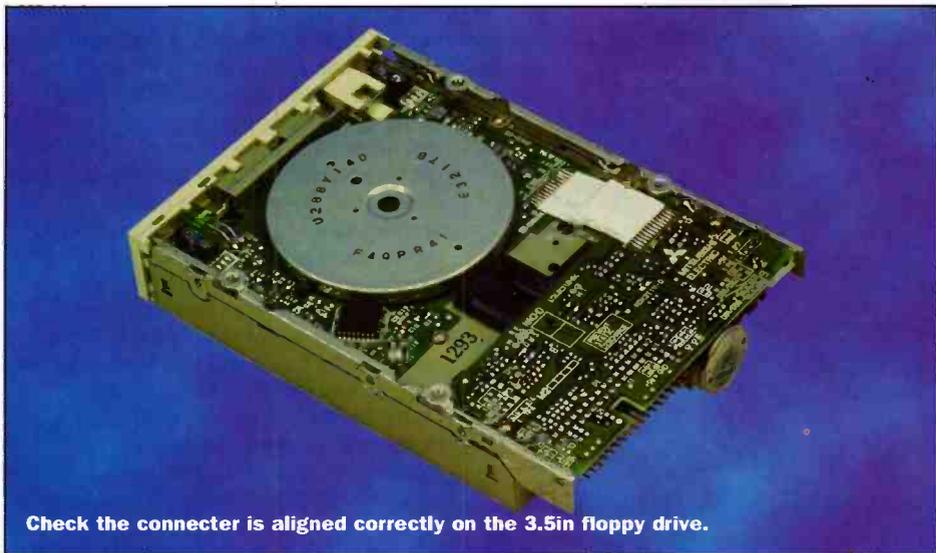
Check the connecter is aligned correctly on the 3.5in floppy drive.

properly in the socket. PCI graphics cards are usually quite easy to plug fully home, but older types can be quite difficult as they sometimes had very long edge connectors that were very difficult to plug into the motherboard, especially from new.

General wiring problems

There are not may wiring problems that can cause this sort of fault. Assuming that the power supply connectors are connected correctly (and the CPU fan will spin on power up, CDROM drive light will flash, hard drive will rattle), but there is still no picture, double check the wiring around the reset pins on the motherboard. It is possible to wire these incorrectly and to hold the machine reset all the time, which will provide just these symptoms.

Lastly, but very unlikely unless mishandled, a faulty CPU may well also cause this symptom. This is worth considering if you reach the stage where you need to return parts to the supplier for testing, but if you do return motherboard, SIMMs/DIMM and processor to a supplier, take the SIMMs or DIMM out of the motherboard and put them back into anti static packaging first! Motherboards returned by post or carrier often sustain PCB or socket damage around the memory sockets caused by stress or blows to SIMMs left in their sockets, which may void your guarantee.

Picture appears with error messages

Now, it is possible that the initial power up may display the usual screens with their Award BIOS and set up header screens, but then stop with an error message. As described in previous articles, you will need to hit the 'Del' key to enter the BIOS set up program when you first run the machine up. If it has allowed you to do that and you have made all the necessary configuration option changes we described, but subsequent restarting of the PC doesn't load up the software from your A: floppy drive and is unable to load an operating system from your (initially empty) hard drive, the system will stop with an error message telling you that there is no operating system and may prompt for a system disk.

If you have set the system boot up sequence in the BIOS correctly to A:,C:, the PC should attempt to load an operating system from any inserted floppy disk in your A: drive. You will see the A: drive light glow briefly as the drive spins up and then goes out. If the A: drive light is on all of the time, it may well be that you have got the drive data ribbon cable the wrong way around, or even offset by a pin in one direction or another (some drives have no outer shell on the data connector). If this is the case, just power down and correct the connector positioning before trying again. I will admit to doing this many times in my early dealings with PC's and fortunately it never caused any damage to anything!

Multiple drive set ups with two or more hard drives or floppy drives also offer some entertaining opportunities for errors and it is also possible to connect the motherboard (or IDE controller card) end of the cables with offsets or in reverse on some PC's. Just go over the wiring instructions again and recheck everything. Make sure that drive power connectors, which are sometimes very tight and need a good wiggle and a push, are fully home, and check Hard drive master and slave settings on dual hard drive set ups, should you have been that ambitious. More about dual hard drives later.

That about covers the main causes of failure to boot successfully, leaving the myriad of possible Windows problems where hardware isn't recognised, doesn't work or sort of works.

Windows 95 problems

Now, it's not possible to cover all of the causes of errors generated by Windows 95 in a single magazine article and I'm not about to try. In fact, just a brief note about the subject here before we go on to more interesting matters.

In my experience, Windows 95 usually gives quite good reports of problems with hardware. It also tries its level best to prompt you to insert driver disks if it needs extra software to use the hardware it detects. It quite often needs your Windows 95 CDROM as well as the new driver disks and it is very frustrating if you have left it somewhere else, so make sure you keep it to hand.

If you open Control Panel, you will see that one of the options at the bottom of the window is 'System'. Double click this to see some information about the state of your PC. The first screen you will see is a useful one, mainly from the point of identifying which version of Windows 95 you are using. The part headed 'system' includes the version number, and the main thing to look for here is the letter suffix, which may be missing altogether for early versions of Windows 95, or may be 'A', the service release 2 version should be marked with a 'B' suffix, and the latest versions are, not altogether surprisingly, marked with a 'C' suffix.

If your suffix is missing, or if it is an 'A', you may well benefit from upgrading your copy of Windows 95 to a later version. One of the easiest and cheapest ways to upgrade and improve your version of Windows 95 is to install Microsoft's Internet Explorer 4 on your machine. This browser software is to be found on a number of the PC magazine cover CD's and is a lot more than just an Internet browser! It contains a huge number of updated and new Windows operating system files and installation of this software will quite possibly iron out many of the bugs you may experience, especially when running the newest and most demanding software.

In addition to that option, the Microsoft web site on http://www.microsoft.com contains a number of upgrades and

3D FX graphics card costs £89.99 including VAT, order code PQ75S.

3D EFX graphics card will immerse you in a world of high quality animated textured graphics.

Software installation

The exact sequence of events that you need to follow when you install the software for the 3DFX card will vary slightly depending on which version of Windows 95 you are using. If you have the later version, skip the next section and go on to 'Windows 95 SR2'.

Switch on your PC. As it boots up, a 'New hardware found' window should pop up and prompt you for driver software. Click 'Select driver from disk provided by hardware manufacturer', insert the CDROM provided with your card into your CDROM drive and click 'OK' to continue. When the 'Install from disk' window appears, click 'Browse' to bring up another window.

Select your CDROM drive from the list in the new window, then double click the 'Drivers' directory from the list that appears. You will see that the filename 'modular.inf' appears. Click 'OK' and then click 'OK' again on the 'Install from disk' window. The required software drivers will then be copied to your hard drive. You will then be prompted to restart your PC to load the new drivers. Click on 'Yes' to restart and installation of your 3DFX card is complete.

Windows 95 SR2

The installation procedure under later versions of Windows is similar, but invokes an 'Update device driver' wizard when the system detects your new hardware, so the prompts appear slightly differently. Power your PC up and wait for this wizard to appear. The system will detect your new hardware and should report it as a PCI multimedia video device. Insert the CDROM that came with the card and click 'Next' to continue. The wizard will search for the new drivers, but will be unable to find them as it defaults to searching the 'A' drive.

Click on 'Other locations', then on 'Browse'. When the 'Browse for folder' window appears, locate the CDROM drive from the list that appears, double click it and then double click the 'Drivers' folder that appears in the list of CDROM contents. The OK button should no longer be greyed out, indicating that the driver has been found. Click 'OK', then click 'OK' again on the 'Select other location' window. Now click on the 'Finish' button on the 'Update device driver wizard' window and the 'Insert disk' window will appear. Click on 'OK' and the 'Copying files' window will appear. Click on 'Browse' to bring up the 'Open' window and under 'Drivers' double click the CDROM drive, double click the 'Drivers' directory and check that the filename 'Dd3dfx.drv' appears. Highlight this and click on 'OK'. After the loading process has finished, reboot your PC.

Installation of demo software

Once the drivers have been installed and your PC has been restarted, go to the start button on the Windows taskbar at the foot of the screen, and click on 'Run'. Type 'E:Setup' (assuming 'E:' to be your CDROM drive) and click OK. This will run Install Shield for the Voodoo graphics installation window. For the screens that follow, click

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improvements to older Windows installations for you to freely download and use.

Use the 'Device Manager' tab on 'Control Panel/System' to look at a list of the hardware on your PC and take note that a small round yellow icon with an exclamation mark superimposed over any device icon means that there is some sort of conflict or other problem associated with that device. Just double click it for details.

If you just can't track down the problems you may have in setting up or using your new PC, don't forget that the Maplin Technical Sales team are only a call away on 0897 501353 (premium rates apply).

Extending your multimedia PC

As promised, the remainder of this article will deal with two possible extensions to your PC system, the first being one of the wonderful new 3DFX cards that will transform the graphics ability of your PC to rival that of the very best of the dedicated games consoles, with full 3D textures and photo-realism (when using 3DFX equipped software).

The final part of this article will tell you how you may simply fit a second hard drive to your system, giving you another huge chunk of storage for all that new software you are hoping to buy!

3DFX graphics accelerator card

There have been a number of 3D accelerator cards in the past, usually supplied with drivers to allow faster and more efficient movement of graphical content in programs of an intensive nature. However, none of these should be confused with a 3DFX card based upon one of the latest number crunching chipsets from Voodoo Graphics!

The Voodoo Graphics 3DFXgraphics accelerator card is not a replacement for

your existing SVGA graphics card and may not be used alone in place of a standard graphics card. Instead, it will sit alongside the existing graphics card and will have the original video signal routed through it.

The 3DFX card stocked by Maplin (Order code PQ75S, £89.99 including VAT) will work well with any PC meeting its basic system requirements. It requires a minimum 90MHz Pentium processor (preferably 133MHz or better), an unused PCI slot, a CDROM drive, and at least 16MB of RAM. If you wish to install the 3DFX demo programs supplied with the unit, you will need at least 85MB of space free on your hard drive too.

Installation

Before fitting the accelerator card, you need to check the version of Windows 95 you are using, as described earlier in this article. Make a mental note of whether you have the early 'A' suffix or no suffix, or the later service release 'B' or 'C' suffix.

Shut Windows 95 down and switch off your PC. Disconnect the mains supply and remove the case lid (or side in our example PC) in order to gain access to the motherboard. Find an unused (usually white) PCI socket, preferably next to your graphics card, and unscrew the metal chassis plate behind it.

Observing the usual anti-static conditions, unpack the 3DFX card and offer it into position above the PCI slot on your motherboard. Press it fully home firmly and fix it to the back plate of your PC with the screw you removed with the blanking plate. Reassemble the case of your PC.

You will notice that the 3DFX card was supplied with a short jumper lead with a 15 way high density D-type connector at each end. Unplug your monitor video lead from the original graphics card and plug it into the female socket on the new accelerator card. Now connect the jumper or bypass lead between the SVGA card and the 3DFX card. Now we are ready to set up the software for your new and improved graphics system!

'Next', 'Yes', 'Next' and 'Next' again. You will then be offered the chance to install Microsofts DirectX 5 drivers and you may click 'Yes' to install them at this point.

Your 3DFX equipped system is now ready to run your games. Click on the taskbar 'start' button, choose 'Programs', '3Dfx' and select a game demo such as 'Vally of Ra'. The game demo should run and immerse you in the world of high quality animated textured graphics, but if it doesn't run then something has not gone quite right with your installation.

Troubleshooting

If Windows 95 didn't auto detect your 3DFX card, it may be that you didn't plug it fully home into the motherboard PCI slot. Do recheck this before assuming that the board is faulty.

If the installation all seemed to go well but the demos won't run, there are a number of possible causes. A system with a lot of added peripherals may not have a spare interrupt (IRQ) between IRQ9 and IRQ15 to map the card into, but assuming this isn't the problem, it may be to do with compatibility with your existing graphics card.

Some older S3 based graphics cards (864, 868, 964 and 968) do not work correctly with the 3DFX system unless you add a patch program called 'fxremap.exe' to your system. Happily, this is provided on your driver CDROM and may be copied to the root directory of your hard drive (drag and drop it from Windows Explorer).

You will need to run fxremap.exe each time you start your PC by adding the line 'C:\fxremap.exe' to your 'Autoexec.bat' file. Autoexec.bat is also located on your root directory and may be edited by using Windows notepad, or DOS Edit. You will then need to restart your PC to invoke the new patch program, at which point the demo 3DFX software should now work.

Adding an extra Hard Drive

Its not at all difficult to add an extra hard drive to your PC, but there are a number of possible configurations to take into account, especially if you already have an IDE CDROM drive on your system (most modern CDROM drives plug into the same controller sockets as your hard drive).

Most modern PCs will be equipped with two IDE controller channels. Each of these channels has its own socket on the motherboard (or on the plug in controller card). Each of these two channels is in turn capable of accepting two IDE devices, this gives up to four possible drives. Some IDE data cables will have just two sockets on them, one at each end. These may (obviously) not be used to connect more than one peripheral to the PC, so you will need to ensure that your leads have a third socket crimped onto the cable to accept the second IDE device on that channel.

Also check that you have a space available to mount your new hard drive in and that a spare power connector (the larger type) is available. Adapters are available to convert single power connectors to double ones if required.

These data cables are simple, straight through cables and don't have a twist in them to differentiate between 'A' and 'B' drives or whatever. Therefore, each IDE drive must identify itself on the common channel connections. Each IDE device has a set of links that will set it to be either a 'Master' drive or a 'Slave' drive. In addition to this, the 'Master' drive will usually have a second link identifying whether there is a 'Slave' drive present or not.

Now, the exact configuration you choose for your PC will depend on a number of things, not least on the physical layout of your PC case and hard drive positions. It may not always be possible to connect two given drives to the same cable because the lead won't reach!

For our example PC, we connected the main hard drive to IDE channel 1, and the CDROM drive to IDE channel 2. Both drives were therefore set as 'Master' drives, with no slave connected. In adding another hard drive to our system, it would seem logical to fit it on IDE 1, set to 'Slave'. We will therefore need to modify the jumper settings of the main (bootable) hard drive to indicate that a 'Slave' drive is now present. Failure to do this results in the second drive not being recognised and remaining inaccessible.

The exact convention for the drive linking just discussed is not a fixed one, with different manufacturers using different link positions and numbers of links to indicate the configuration. For the purposes of this article, we will be fitting another Western Digital 'Caviar' 3.2GB hard drive alongside the one already fitted in our multimedia PC. Should you be fitting another make or type of drive, you will need to refer to the manufacturers instructions for the exact link settings. Note that these settings are usually printed on the drive case, or screened onto the PCB on the underside of the drive.

The Western Digital 33200 hard drive (Maplin order code KV49D) is provided with its jumper link pushed into a position where it has no effect. The unlinked position of this drive is the default single drive position (called 'Master, no Slave' by some manufacturers).

It is also worth noting that the Western Digital hard drives stocked by Maplin are provided with very comprehensive installation guides, whereas many hardware vendors provide hard drives in bare OEM (Original Equipment Manufacturer) format, where all you get is the drive in an anti static bag with no instructions whatsoever!

Fitting the hard drives

Before you start to install your new hard drive, it is a wise precaution to start your PC up, hit 'Del' when prompted to go into the BIOS setup and go to the 'Standard CMOS' settings screen in order to see the existing hard drive settings. Make a note of these numbers before you go on, just in case you need to manually reconfigure the drive settings at any stage. If you don't know these numbers, you will be locked out of your hard drive if the auto detect feature of your motherboard can't identify the hard drive. Now shut the PC down (switch off) and unscrew and remove the case lid (or left side for our example tower case).

Please observe anti static precautions whilst fitting the hard drive and avoid touching the drive electronics or connector pins wherever possible.

Referring to the small chart printed on the hard drive, set the main hard drive already on your system to 'Master' by unplugging the link (jumper) on the double row of pins and plugging it back in such that it links the middle pair of pins in each row (pins 5 and 6). Take your new hard

The software installation for the EFX card varies depending on the Windows 95 version.

Adding an extra 3.2 GB of hard disk storage is very easy and affordable. Maplin Order code KV48C.

drive and plug its link onto the pair of pins second from the power connector (pins 3 and 4). Note that some makes of hard drive will need to be removed from the case before it is possible to change the linking.

Fit the new hard drive alongside the original one using the short screws provided. Note that it may be easier to disconnect the original hard drive temporarily to gain clear access to the drive bay.

Having now fitted both drives in the bay, side by side, it should be simple to push the two data connectors on your hard drive cable onto the drives. Again, users of other makes of drive should beware that they observe the correct polarity of these plugs, which may not always be the same as for our example (pin 1/red stripe nearest power connector end).

Push a power connector firmly home into each drive and hardware installation is complete! Reassemble the case as necessary.

PC configuration

Switch on your PC and hit the 'Del' key when prompted in order to enter the CMOS setup utility program. Select 'IDE HDD Auto Selection' and hit return. The 'Primary Master' drive will be detected, hit 'Y' and 'Enter' to accept. All being well, the new drive should now be detected as 'Primary Slave', 'Y' and 'Enter' to accept. Use your 'Enter' key to drop through the secondary detection's and you will return to the CMOS set up menu. Note that your CDROM drive, although fitted with an IDE interface and connected to your secondary 'IDE 2' controller channel, will not be detected by this test. This is quite normal. Select 'Save and exit set up' and press 'Return'. Confirm this by pressing 'y'

If your PC already supports large hard drives, or has already had the Western Digital 'EZ-Drive' BIOS extension program enabled, you will not actually need to worry

about partitioning your new hard drive too much (only for recent versions of Windows 95). However, if your motherboard BIOS program is not able to handle large hard drives, you may wish to run EZ-DRIVE (supplied with your hard drive) which will make it easy to format and partition your new drive.

It may be that you simply prefer to break down your hard drive into more manageable 'virtual hard drives' or to assign different drives to different members of the family. It is also worth considering that for all earlier operating systems and most versions of Windows 95, the use of a number of disk partitions or 'virtual drives' allows your PC to make much more efficient use of the space on your hard drive and will actually save a lot of storage space in the longer term.

If you power up your PC with its new drive configured as described above and the PC locks while booting, or checking the new hard drive size from explorer reports a far smaller drive than you were expecting, it is most likely that your BIOS cannot handle the large drive size and you will have to run EZ-DRIVE or install another compatible BIOS extension program (maybe supplied with your drive).

You may use EZ-Drive to format and partition your new hard drive, or you may prefer to run the DOS Fdisk and Format programs. The EZ-DRIVE program is very well documented in the installation guide supplied with the WD hard drives, so I won't repeat all of their instructions here, but those of you using Fdisk and Format from DOS may have a little more difficulty, especially if your experience of PCs is fairly recent and you are not used to typing command line instructions on that lovely old white on black DOS screen!

For those of you who wish to try using the old DOS commands, use 'Start', 'Programs', 'MS-DOS Prompt' to get to a DOS screen (you will find it easier to read if you use 'Alt-Enter' to expend this window to a full screen). Type 'Fdisk' and press 'Enter'.

If your version of Windows is recent enough to have support for partitions over 2.1GB, you will be notified at this point and given the warning that enabling large partition support may affect the ability of other operating systems or disk utility programs to work correctly when attempting to access this drive. If you are using just standard Windows 95 software and do not use third party disk doctoring software, this should not be a problem, but for the sake of this example, we will assume that you are using and older version of the operating system and are not offered this choice, as will be the case for a vast number of the Windows 95 disks out in the real world. Now read the information given in the box to the left.

Well, that rounds off this short series of articles about building your own PC. I hope that you have found it interesting in some way and that it has helped you to gain the confidence to tackle some upgrading jobs in your PC, even if you still don't want to start from scratch. If you would like to buy a basic bare bones computer system and add your own peripherals, rather than starting from scratch, take a look at the new computers featured in the forthcoming September Maplin catalogue and you may be pleasantly surprised.

READ THIS CAREFULLY BEFORE CONTINUING!

◆ Once you have reached the main Fdisk menu, you will need to select your new hard drive before creating any new partitions. If you do not change to the new drive by selecting option 5 'Change current fixed drive', and choosing the new drive from the list. Just to add to your confusion, you will probably find that your drive letters have now moved around and that your new drive is now sitting between your bootable 'C:' drive and any other partitions on that original drive (if any). You cannot go too far wrong if you choose the drive number that does NOT contain drive 'C:'!

◆ Having done this, use menu option 1 to create a DOS partition, and select option 1 from the menu following to create a primary DOS partition on this drive. If you require multiple partitions, answer 'n' to the following question and you will be prompted to enter the partition size in MB. The partition will be created and a letter assigned to it. You may then create an extended partition if required, following the on screen prompts, and then create logical DOS drives in that extended partition. When finished, hit 'Esc' twice to exit Fdisk and then use Format to format each partition In turn, using the format 'Format X:', where 'X' is your drive letter. Watch out that you don't accidentally format your 'C:' drive though or you will lose everything!
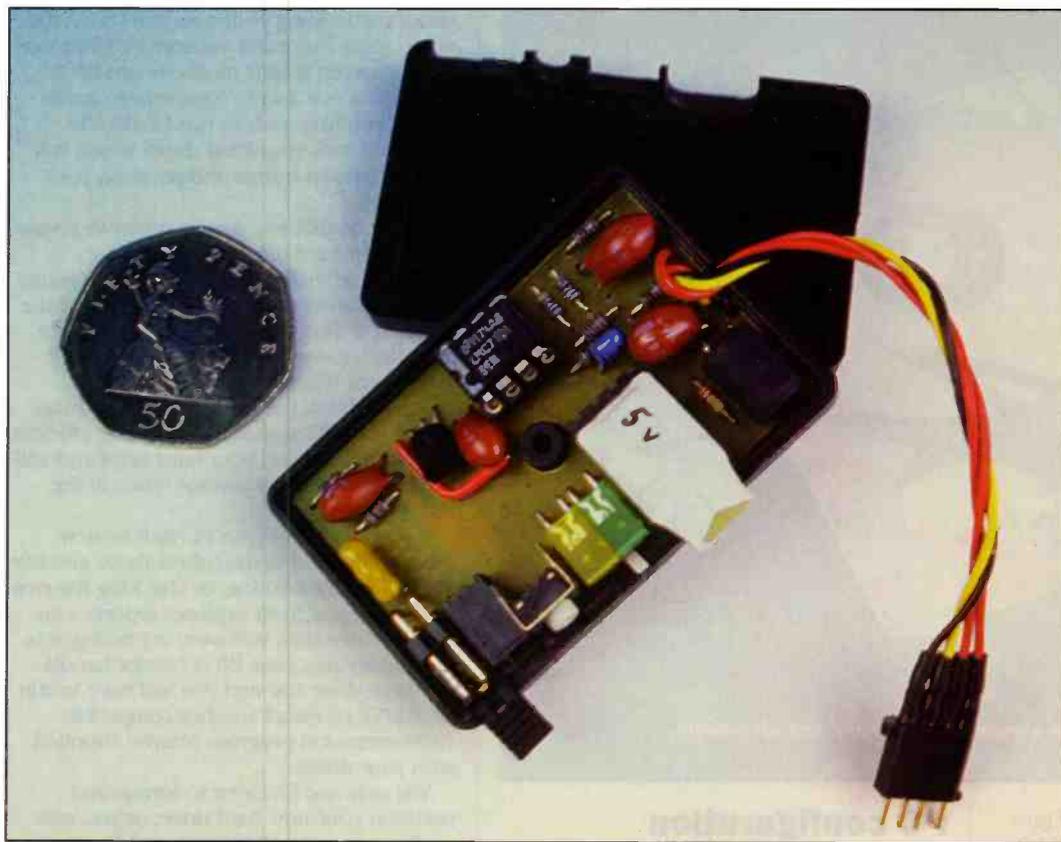
Driving
SERIAL
EEPROMS

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Dr Mike Roberts believes 'adding data memory to microcontrollers is easy with serial EEPROMS.' In this article he explains.

Introduction

Serial Electrically Erasable Programmable Read Only Memory - what a mouthful! Perhaps it is better to think of these little devices as several kilobyte hard drives squeezed into an 8-pin DIL chip with a serial input/output and only costing a couple of pounds. They are fantastic for storing relatively small amounts of information. They even retain their data when power is removed. A typical application is for the number memories in telephones. However a 16k bit (2k byte) EEPROM can store 50 A4 pages of numbers at one line per number, which is a fair bit of data. I have used them in model aircraft 'black box data recorders to record battery voltage and to record electric motor current and voltage. With a 2k byte EEPROM one can store a battery voltage every

second for 34 minutes. In last months article (Intelligent Universal Battery Cycler/ Charger) an EEPROM was used to record the discharge and charging performance of rechargeable batteries.

The description here covers the 24LC16 (16k bit - order code AD23A) EEPROM. This includes assembly code routines to interface these with Arizona Microchip PIC microcontrollers.

Interface

The electrical interface is a great deal simpler than the software routines! It is simply two wires. One is a 'clock' signal and the other is a two way 'data' line. See Figure 1. To avoid electrical short circuits resulting from both the microcontroller and the memory trying to transmit at the same time, the 'data' line is normally driven from open collector outputs in both devices. When the memory is close to the microcontroller a 10k pull-up resistor is fine. It there is a longer link a smaller resistor must be used to overcome capacitance on the wire. I was surprised when I was working with the components on a breadboard that adding two inches of wire to an additional strip was enough to prevent data transmission.

Conveniently the RA4 pin on the Microchip PIC16C6X, PIC16C7X and PIC16C8X microcontrollers has an open collector output ideal for this application.

Data Protocol

Given the need to send data in two directions and to specify which memory location the data is to be sent to or taken from, there needs to be a clever protocol for the serial communication. The one used here is called I²C™ (a trademark of the Phillips Corporation).

The data transmission of a single byte (in either direction) is a conventional serial transfer with each bit read on the positive going edge of the clock, starting with the most significant bit. The clock is always under the control of the PIC which in the protocol is referred to as the 'master'. The EEPROM is not surprisingly referred to as the 'slave'. This transmission of individual bits is straightforward. However, we still need to know when a data transmission is about to start or has finished. This is accomplished by having a rule that during normal data transfer the data signal will only be changed while the clock signal is low. This then allows for two unique situations. A data line change from high to low while the clock is high is read by the slave as a 'start' and a data line change from low to high while the clock is high is read by the slave as a 'stop'. See Figure 2

The last key part of the data transmission is that the data receiving device (master or slave) is expected to 'acknowledge' when it has received the full byte of data by pulling the data line low.

Now that we have starts, stops and byte data transfer sorted out we need to see how to differentiate between bytes representing data and bytes representing control information like 'read', 'write', and memory location. This is handled by the protocol.

Writing to the EEPROM

The simplest sequence is 'single byte write'. This is shown in Figure 3. The sequence is triggered by a 'start'. The next byte identifies the device type, whether a read or write is intended (write here) and high address (3-bits). This is followed by the low address byte. With the memory address defined the data byte itself can be sent, followed by a 'stop'. The 'stop' condition triggers an internal write cycle within the EEPROM which takes 10ms. During this
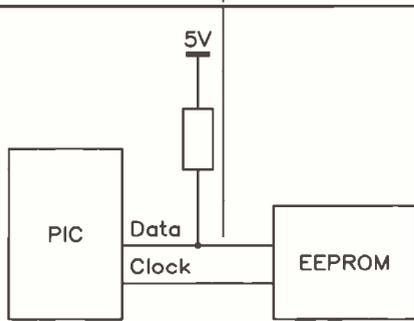
Figure 1. EEPROM interface.
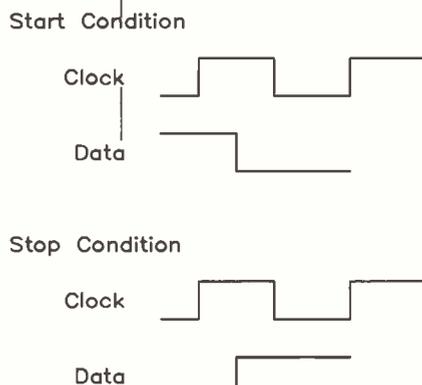
Figure 2. Start and stop conditions.

Figure 3. Single byte write.

Figure 4. Page write.

**Figure 5.
Current address read.**

**Figure 6.
Random address read.**

period the EEPROM will not respond to the master.

I will come back to the exact form of the first control bytes. Overall 3-bytes of information have to be sent to store/write one byte of data. Each of these control/data bytes is followed by an ACK (acknowledge) by the EEPROM (slave). I have left the ACKs out for clarity.

Fortunately, one can also send up to 16-bytes of data in a row to sequential locations using 'Page Write'. This is shown in Figure 4. The address counter (bottom 4-bits only) is incremented after each data byte is sent. Hence the data bytes must be sent to the same 16- byte block (i.e. to same high address byte and top four bits of the low address byte). Again the 'stop' condition kicks off the internal write cycle (10ms for all the bytes sent).

Reading from the EEPROM

The basic read sequence is 'current address read'. This reads the data from the address set by the current setting of the internal address counter i.e. the last address used. This is shown in Figure 5. Note that there is no ACK sent by the master after the data is received. The master only sends a 'stop'. The reason for this will become apparent later.

The next, more useful read sequence is 'random address read'. A more appropriate title might be 'specific address read'. This starts like a 'single byte write' in that it sends the address as if a write is required (two bytes). The effect of this is to set the internal address counter to the desired address. This is followed by another 'start' and the 'current address read'. See Figure 6. Again there is no ACK sent by the master after the data is received. So to read a specific item of data four bytes of information have to be exchanged.

Both the 'current address read' and the 'random address read' can be extended into a 'sequential read'. This is achieved (you guessed it) by the master sending an ACK rather than a 'stop' after each piece of data. Using this technique the whole of the memory can be read from the current or a set address. Figure 7 shows a 'sequential address read'.

First Two Bytes

The first two bytes sent in the single byte write and random address read have a specific format. The first control byte is made up as follows:

b7	b6	b5	b4	b3	b2	b1	b0
DeviceSelect				HighAddress			R/W
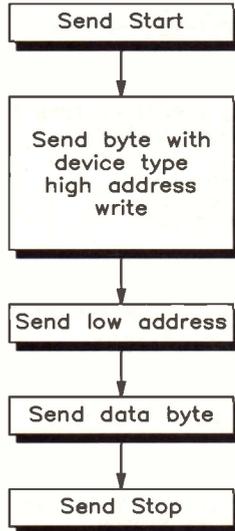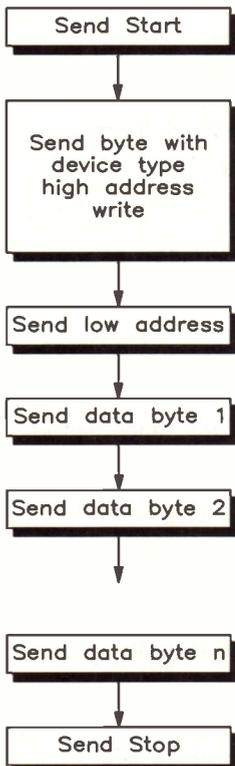
The device select is always '1010' for the 24C16. To address 2k bytes of memory we need 11 bits. The high address is the top three of these. R/W is read/write. This is '1' for read, '0' for write.

The second byte is simply the low address.
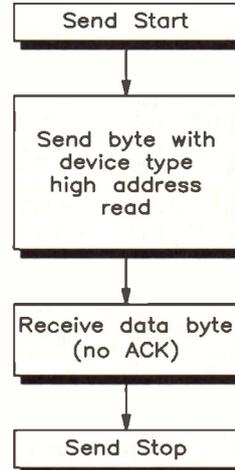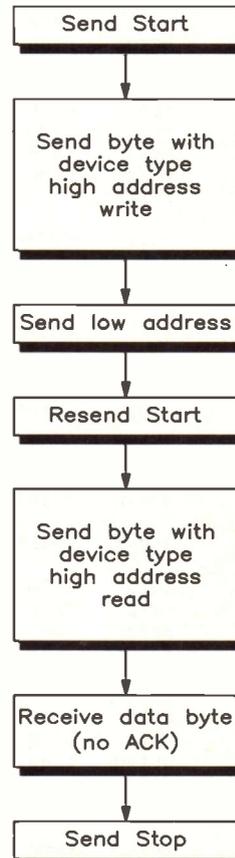
Timing

The standard operation of the 24C16 is with a maximum clock speed of 100kHz. The Arizona Microchip 24LC16 operates at this speed when in low voltage mode but can operate with a 400kHz clock when running from a 5V supply. The code here assumes 100kHz operation using a 4MHz or slower crystal (1MHz instruction frequency)

```
        ;  data register definitions

temp     equ     h'C'            ;temporary register
temp2    equ     h'D'            ;temporary register
cnt      equ     h'E'            ;bit counter
addlow   equ     h'F'            ;address low byte
addhigh  equ     h'10'           ;address high byte
din      equ     h'11'           ;data read from EEPROM
dout     equ     h'12'           ;data to EEPROM

flag     equ     h'13'           ;flags
err      equ     h'0'            ;error bit
done     equ     h'1'            ;EEPROM full

         ;PORTA
scl      equ     h'3'            ;clock output to EEPROM
sda      equ     h'4'            ;data line to EEPROM

         ;subroutine to send 'dout' to addhigh/low
BWRITE   call    DSTART          ;send start bit
         movlw   b'00000111'
         andwf   addhigh,W       ;w=3 bits of addhigh
         movwf   temp
         bcf     STATUS,C        ;clear carry
         rlf     temp,W
         addlw   b'10100000'     ;dev sel, addhigh, write
         call    DSTORE          ;send to EEPROM
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         movf    addlow,W        ;w=address low byte
         call    DSTORE          ;send address
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         movf    dout,W          ;w=dout
         call    DSTORE          ;send data
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         call    DSTOP           ;send stop

         return

         ;subroutine to read addhigh/low to
'din'
BREAD    call    DSTART          ;send start bit
         movlw   b'00000111'
         andwf   addhigh,W       ;w=3 bits of addhigh
         movwf   temp
         bcf     STATUS,C        ;clear carry
         rlf     temp,W
         addlw   b'10100000'     ;dev sel, addhigh, write

         movwf   temp2           ;temp2 = start word

         call    DSTORE          ;send data
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         movf    addlow,W        ;w=address low byte
         call    DSTORE          ;send address
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         call    DSTART          ;send start bit
         incf    temp2,W         ;dev sel, addhigh, read

         call    DSTORE          ;send data
         call    SACK            ;slave acknowledge
         btfsc   flag,err
         return                  ;return if no ack

         call    DREAD           ;read data

         call    DSTOP

         return

         ;  subroutine to trigger start
DSTART   bsf     STATUS,RP0      ;bank 1
         bcf     TRISA,sda       ;data line to PIC
         bcf     STATUS,RP0      ;bank 0

         bsf     PORTA,sda
         bsf     PORTA,scl       ;both lines high
         nop
```

```
         nop
         nop
         nop                     ;wait 4.7us
         bcf     PORTA,sda       ;trigger start
         nop
         nop
         nop
         nop                     ;wait 4us
         bcf     PORTA,scl       ;ready for data
         RETURN

         ;  Stop bit
DSTOP    bsf     STATUS,RP0      ;bank 1
         bcf     TRISA,sda       ;data line to PIC
         bcf     STATUS,RP0      ;bank 0
         bsf     PORTA,scl       ;clock in
         nop
         nop
         nop
         nop                     ;wait 4.7us
         bsf     PORTA,sda       ;data high
         RETURN

         ;  subroutine to send 'w'to EEPROM
DSTORE   bsf     STATUS,RP0      ;bank 1
         bcf     TRISA,sda       ;data line to PIC
         bcf     STATUS,RP0      ;bank 0
         movwf   temp            ;temp=data
         movlw   h'8'            ;w=8
         movwf   cnt             ;bit counter =8
STO1     rlf     temp,F
         bcf     PORTA,sda       ;clear data
         btfsc   STATUS,C
         bsf     PORTA,sda       ;set data
         bsf     PORTA,scl       ;clock in
         nop
         nop
         nop
         nop                     ;wait 4.7us
         bcf     PORTA,scl       ;clock low
         decfsz  cnt,F
         goto    STO1
         RETURN

         ;  Read data
DREAD    bsf     STATUS,RP0      ;bank 1
         bsf     TRISA,sda       ;PIC releases data line
         bcf     STATUS,RP0      ;bank 0
         movlw   h'8'            ;w=8
         movwf   cnt             ;bit counter =8
DR1      bsf     PORTA,scl       ;clock in
         bcf     STATUS,C        ;clear carry
         btfsc   PORTA,sda       ;
         bsf     STATUS,C        ;set carry
         rlf     din,F           ;push in
         bcf     PORTA,scl       ;clock low
         nop
         nop
         decfsz  cnt,F
         goto    DR1
         RETURN

         ;  Slave acknowledge
SACK     bsf     STATUS,RP0      ;bank 1
         bsf     TRISA,sda       ;PIC releases data line
         bcf     STATUS,RP0      ;bank 0
         bsf     PORTA,scl       ;clock in
         movf    PORTA,F         ;read data
         bsf     flag,err        ;error bit
         btfss   PORTA,sda       ;ack low?
         bcf     flag,err        ;error bit
         bcf     PORTA,scl       ;clock low
         RETURN

         ; Master acknowledge
MACK     bsf     STATUS,RP0      ;bank 1
         bcf     TRISA,sda       ;data line to PIC
         bcf     STATUS,RP0      ;bank 0
         bcf     PORTA,sda       ;data low
         nop
         nop
         nop
         nop                     ;wait 4.7us
         bsf     PORTA,scl       ;clock in
         nop
         nop
         nop                     ;wait 4.7us
         bcf     PORTA,scl       ;clock low
         RETURN
```

Listing 1 - EEPROM Drive Routines.

**Figure 7.
Sequential address read.**

on a Arizona Microchip PIC. The timing is achieved using 'nop' (no operation) instructions. These can all be removed when working with the Arizona Microchip 24LC16 at 5V.

Assembly code

Listing 1 gives a set of routines which include 'single byte write' and 'random address read'. These can easily be expanded to create 'page write' and 'sequential reads'.

I have started the register definitions at hex(C). This is the start of the general purpose registers for the PIC16C61/71/84 devices. This may need to start at a higher number for other devices e.g. hex(20) for PIC16C554/6/8 series.

The subroutines perform the following functions:

BWRITE

This drives a 'single byte write' of the data in 'dout' to the memory address set by 'addhigh' and 'addlow'. This sets the 'err' bit of the 'flag' register and returns immediately if the EEPROM does acknowledge any byte transfer.

BREAD

This drives a 'single byte read' of data in the memory address 'addhigh' and 'addlow' and puts this data into 'din'. This also sets the 'err' bit of the 'flag' register and returns if the EEPROM does acknowledge any byte transfer.

DSTART

Sends 'start' condition.

DSTOP

Sends 'stop' condition.

DSTORE

Sends the contents of 'w' to the EEPROM.

DREAD

Receives one byte of data from the EEPROM and puts it into 'din'. This needs to have been preceded by 'DSTORE's sending address/control information.

SACK

Slave acknowledge. This sets the 'err' bit of the 'flag' register if the EEPROM does not pull the data line low.

MACK

Master acknowledge

Conclusion

Just do it! Its easy. Photo 1 shows a finished design. I have used such designs in model aircraft 'Black Box' data recorders using surface mount PIC16C71s and surface mount 24LC16s in one case to record the receiver battery voltage and the other to record the current and voltage of the motor in an electric powered model.

Software

A disk with the assembly code in Listing 1, the assembly code from Electronics issue 113 (alphanumeric display and serial transmission code) and a programme for receiving data into text files (DOS/Windows) is available from the author for £5 including postage.

Dr M P Roberts, 4 Thames Avenue, Guisborough, Cleveland, TS14 8AD.

CORRIGENDA Intelligent Battery Charger - July 1998

Diagram above shows component layout for Intelligent Universal Battery Charger that was unfortunately missed from last months magazine. Please view in conjunction with Figure 9, July (Issue 127).

Below is the PCB foil for the Intelligent Universal Battery Charger.
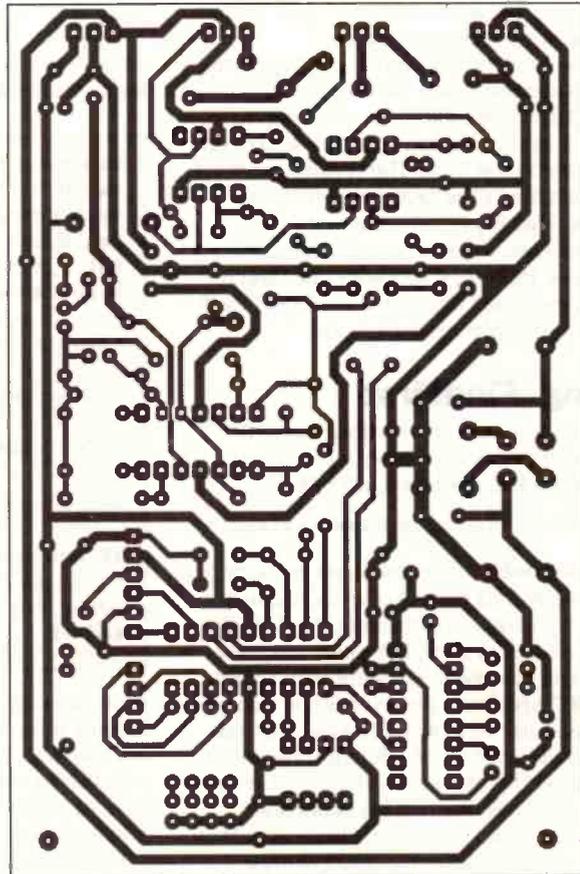
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by Mike Holmes

Part 5 – Null's, ISAM's And Installs – The how-to's & pit-falls of handling native MS Access & DBASE IV databases

Creating A 'Locator'

What is a 'locator'? Several database schemes provide a means for indicating the closest comparison in a list of primary fields, or display the nearest matching record, when the user types in an associated text entry control. As each letter is entered, this mechanism tries to match what has been typed in the list as it happens in real time, scrolling the list or changing the displayed fields as necessary to make it visible. For example, you type 'springs', which doesn't exist in the database, so the record pointer in the associated list goes directly to 'springfield', which is the nearest match it can find following 'spring', which *does* exist.

Such a device is called a 'locator', because it locates things in the database through an always active, ongoing search. It's very useful if you have a large database, otherwise you would be scrolling through the records for ages to even get near the actual one you are looking for – only to find out that it isn't there after all.

Some database application languages can make a specific locator type text entry control available, having the provision to attach it to the data-aware list (or whichever controls) on the form. The connection is set at design time (The DOS based 'Clarion' system of yore was one example).

Visual Basic doesn't have anything like that, so a 'locator', if you want one (and if you've ever used one, you'll want one!), will have to be implemented in code.

Using 'FindFirst'

The simplest and most obvious way is to use the *FindFirst* method of a recordset of a data control, as described in VB Help:

```
Data1.Recordset.FindFirst Criteria
```

where *Recordset* is the Recordset property of the on-form data control object. *Criteria* is a string expression, equivalent to the WHERE clause as used in an SQL (Sequential Query Language) statement, but without the word 'WHERE', specifying the records you want.

It's easy to overlook the fact that *Criteria* can include a variety of different comparison operators other than "=" – because there is no 'FindNearest' method (as in Borland Delphi, for instance), you'd think you wouldn't be able to use *FindFirst* to find a *nearest* match. Actually you can if *Criteria* equals:
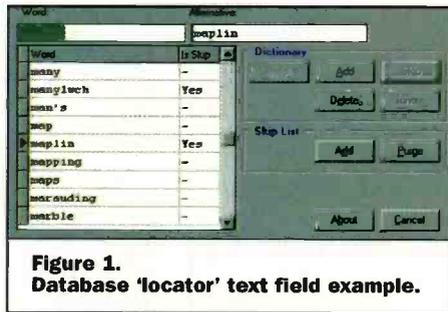
Figure 1.
Database 'locator' text field example.

```
FIELDNAME >= "blurb"
```

For reference, the equivalent SQL statement would be 'select * from TABLENAME where [FIELDNAME] >= "blurb". For the purposes of making a locator this way, *Criteria* would have to be a string constructed as follows:

```
Criteria$ = "FIELDNAME >= " &
Chr$(34) & Text1.Text & Chr$(34)
```

where Text1 is pressed into service as the locator text entry field for typing in. Figure 1 shows an example of this where the text control at top left takes the place of Text1 in our example. (Also bear in mind that in this case the list below it would be a special custom data-aware type of Grid control, and not an ordinary VB Grid control.)

Unfortunately the *FindFirst* method is slow; the ">=" operators combination

makes it even slower, and if the database is very large you might have to wait several seconds between typing each character into Text1 while it goes away to do the search! This is because *FindFirst* searches records, *not* index keys.

'Seek' To The Rescue

Searching through an index is very much faster since indexes are typically structured in such a way as to be able to find things quickly.

A 'binary tree' is a typical structure for such an index – to give you an idea, to find the 32nd record in a database, the search method needs only make six actual logical comparisons; to locate the 16,000th one, it need move only 15 levels down into the tree to find it. By comparison *FindFirst* examines all 16,000 records in turn.

Seek is Visual Basic's method for searching indexes. Seek locates a record in an indexed table (an index file must accompany the actual database table) that meets the specified *criteria* for the selected index, and makes it the current record (please note that the following examples can only be applied to Visual Basic Professional Edition only):

```
Database.Table.Seek comparison,
key1, key2...
```

Unfortunately you can't use it with an on-form data control, because it doesn't have a *Table* property. This is where it starts getting a bit complicated, because to use Seek you need to assign the name of the required index, and to do that you need to access the table.

You need to open the database a second time (the data control having opened it the first time) in code. Also the data control's *Exclusive* property must *be False* to allow multi-user access to make this possible. *The class* definition of 'database', when created in code, allows use of the Table property:

```
Dim MyDB As Database, MyTable As Table, MyRec As Recordset
Set MyDB = OpenDatabase("D:\SP_UTIL\")
MyDB.Connect = "dBASE IV;" ' as it happens
Set MyTable = MyDB.OpenTable("DICTENGL.DBF")
Set MyRec = MyDB.CreateDynaset("select [WORD] from DICTENGL")
MyRec.MoveLast     ' force populate all records

MyTable.Index = "IWORD" ' the index's name

Now we can do it:

MyTable.Seek ">=", Text1.Text

Now it's possible to do this:

If Not MyTable.NoMatch Then
    Data1.Recordset.FindFirst "WORD = " + Chr$(34) +
MyRec.Fields(0).Value + Chr$(34)
End If
```

because the record containing the *nearest* match becomes the one newly selected in *MyRec,* and it's a 'real' record.

All of this can be put into the *Text1_Change* event, so that it is executed every time the text changes. However, it would be much more efficient to put the 'Dim' statement line in the declarations

section of the form, and all of the following lines before the MyTable.*Index* point in the *Form_Load* event.

The Text1_Change event then only has the MyTable.*Index* assignment and the following If block; the created *database, table* and *recordset* objects remaining open all the time.

Even better than that, because the *FindFirst* method, that we still need to use on the data control, is slower than *Seek,* put a timer control on the form and move the above code to the *Timer1_Timer* event. Set its interval to 1000 (one second), and have a 'flag' called 'Changed' dimensioned in the declarations section. Text1 would then have:

```
Sub Text1_Change ()
    If Len(Text1.Text) = 0 Then Exit Sub
    ' else
    Changed = True
End Sub

and the timer could have:

Sub Timer1_Timer ()
    If Not Changed Then Exit Sub
    Changed = False
    MyTable.Index = "IWORD"
    etc.
End Sub
```

This gives you a reasonable delay in which to type several letters into the 'locator' field that is Text1 before the next database search is initiated on its contents.

Database Clones

There are two other things wrong with the data control (you may be able to think of more!) as provided with Visual Basic. One is that its own navigation buttons are very simplistic; for example it does not itself provide a way for scrolling up or down a recordset by groups of records, that is by 'pages'. Instead you can only move up or down by one at a time.

Paging could be done by adding two command buttons to the form to 'Page Up' and 'Page Down' using the *MoveNext* and *MovePrevious* methods, except that the other shortfall of the data control is that usually, when you use these methods to scroll up or down by a specified number of records, all the records are displayed as you move through them.

This is very undesirable if you just want to scroll through the recordset by 'pages', not least it takes a long time because all the bound controls are filled as each record's contents passes through them and their contents redisplayed by Windows. A very good article is provided as part of the *Microsoft Knowledge Base* as supplied with the Visual Basic Professional Edition, which describes how to do this, and so I won't regurgitate it here.

Suffice to say that the methods are not applied to the recordset of the control, but to a copy, a clone. Having paged to another record in the *clone,* that same record can be selected in the *visible* recordset by transfering bookmarks:

```
Data1.Recordset.Bookmark = dsClone.Bookmark
```

Because the clone has no data-aware controls bound to it, it can be scanned much more quickly and there's no untidy flickering of the bound controls on the form.

Creating A List Of Records

An extension of this idea is to have a pop-up window displaying all the primary fields from all records in a combo list control. As you know, the text entry part of a combo list acts like a 'locator' for the contents of the list.

Figure 2 shows such a window where the combo control's list is set full (not 'drop-down'). To load the list with the primary fields of all records, without interfering with the position of the currently displayed record on the 'parent' form, a *clone* is made:

```
Dim dsClone As Dynaset
Set dsClone = Data1.Recordset.Clone()
```

Then we can fill the list:

```
dsClone.MoveFirst
While Not dsClone.EOF
    Combo1.AddItem dsClone.Fields(0).Value
    dsClone.MoveNext
Wend
Set dsClone = Nothing
Done...
```

It makes it much easier to find a record by a name, for example, and have the data control go directly to it using *FindFirst* when the 'OK' button is clicked. If you want to be really adventurous you could apply the *Seek* method as described earlier, which is even faster, assuming of course that the field contents you actually want to display in the combo list are duplicated in an index.

Accessing External Databases

Visual Basic provides a number of ways for accessing data from external databases, that is, not the native Microsoft Access type. You can open a *Dynaset* on an external table using a data control by specifying the external database type in the *Connect* property, and an appropriate directory or file name in the *DatabaseName* property.

In the Professional Edition, as you saw above, you can use the *OpenDatabase* function to access external tables, setting the *Connect* part to the appropriate

Figure 2. A combo list of database record selected on a particular field, created using data from a 'clone'.

database type and any other needed connection parameters, and setting the *DatabaseName* argument to either "ODBC;" for ODBC databases, or to the directory or file name of the external database – in the case of dBASE III/IV, for instance, the *path* is the databases's name, *not* the files it contains, which are tables in that database.

However, deviating from the native Access type does leave your application open to some strange anomalies. Here are two that in the past have plagued me in particular.

Couldn't find installable ISAM

Error 3170 – which VB Help describes as resulting from an installable ISAM Dynamic Link Library (DLL) file that couldn't be found. Either an entry in the [Installable ISAM] section in the *exename*.INI file isn't valid, or one of the entries in the .INI file points to a network drive, and that network isn't connected. The DLL's must be in the Windows system directory (usually); the .INI file in the Windows directory, and it must have the same name as your application (but with the .INI extension).

What VB Help doesn't mention is that among Microsoft's own list of *seventeen* possible causes of this problem, one is that you need their *Access 2 Compatibility Layer* or it'll *never* work! The only thing is by the time you've learned all this you've already pulled all your hair out.

Invalid use of Null

Error 94 – sneaky one, this. You can read zero length string fields into bound text controls from an Access database alright, but if it's dBASE IV then they come across as the *Null* value of a *Variant* type variable. The database is trying to tell you that the data item contains no data. But of course you knew that already!

You can't assign *Null* to a string variable or text property, which is what the data control is trying to do, so this error occurs.

You can do one of two things about this: either, *never* write a zero length string to a
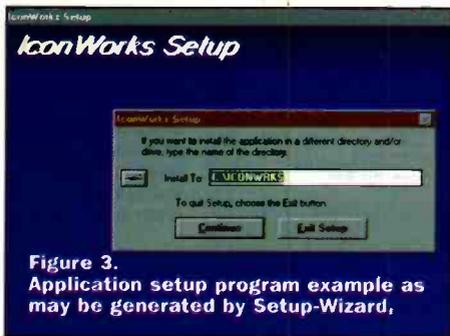
Figure 3.
Application setup program example as may be generated by Setup-Wizard.

dBASE IV record (and a space (" ") in lieu of something more meaningful doesn't count, I've tried it – dBASE IV is cleverer than that), *or*: unbind the text control from the data control at design time, then write code that will use a *Variant* variable to get the field data, test whether it's *Null*, if so assign "" to the text property, if not then it's safe to assign the *Variant's* contents. Long-winded to say the least!

Lastly, you can't use *Bookmarks* on a dBASE IV database – since it doesn't know what *Bookmarks* are.

By the way, it is possible to assign another, different database to a data control at run time that already had its properties set at design time, by only changing *DatabaseName*. Just remember to perform a Data1.Refresh afterwards or it won't appear to work.

Making Installation Disks

If making installation file sets for both Windows 3.x and Windows 95, you *must* avoid installing Windows 95 system files into Windows 3.x – make sure you *don't* have Windows 95 system files on the installation diskette(s)! Instead, have 3.x versions – Windows 95 won't allow SETUP1.EXE to install them (the files are version encrypted). These are the vital files that *must not* be Windows 95 versions:

```
MMSYSTEM.DLL    plays .WAV files
COMMDLG.DLL     Windows dialogs
TOOLHELP.DLL    GDI tools
THREED.VBX      3D controls
VER.DLL    system file version tests
```

The VB version 3 Setup-Wizard invariably takes those it finds in the Windows system directory, even if they're Windows 95. In which case always have 3.x copies handy, and replace the compressed copies on the disk(s) with compressed 3.x versions.

Setup-Wizard And SETUPWIZ.INI

Figure 3 shows a typical copy of SETUP1.EXE as might be made by Setup-Wizard. (This one has a a different style progress bar than the VB original form file.) If Setup-Wizard won't create a new SETUP1.EXE, it is usually because *Setup1a.frm* is 'corrupted' (been altered by you). Be very careful making changes to this form – if you can't recover it you will have to reinstall it from the VB installation disks.

The following are some problems

experienced by users during installation of a VB installation file set. Most commonly, there may be an error message saying 'wrong version for VER.DLL' or similar.

The user will then need to find the offending file in the Windows system directory and temporarily rename it to VER.BAK, for example. VER.DLL is used by Microsoft setup programs. The error comes about because the VER.DLL that SETUP.EXE (the initial setup utility as provided by Microsoft – not to be confused with SETUP1.EXE, *your* program) is trying to put into the Windows system directory is most likely older than the one already there. However, SETUP.EXE may also have a quirk whereby it occasionally renames VER.DLL to VER.DL before it can check it, causing the error!

Similarly if you have another Visual Basic runtime DLL named VBRUN300.DLL you can get the same error. Again rename VBRUN300.DLL to VBRUN300.BAK. So far I have come across *three* copies of VBRUN300 with different date stamps, although internally the files appear identical in every other way!

A warning about installing THREED.VBX – Windows 95 comes with its own THREED.VBX already. This shouldn't cause any problem because it should have a newer

date than that which SETUP1.EXE might be attempting to install (if your program uses 3D controls), and so Windows 95 should prevent its own, newer one being overwritten.

Never delete the Windows '95

THREED.VBX in preference for *any other* version to be installed, or you will end up having to re-install Windows 95 because it won't work any more!

Creating An INSTALL.LOG File

Readers might like to add the following code to their own *Setup1a* forms. While SETUP1.EXE copies files, showing a 'progress' window as in Figure 4, this code writes an INSTALL.LOG to the default destination directory, which lists what was installed, where and when:

Create a module called MAKELOG.BAS, and in the declarations section write:

```
Option Explicit
DefInt A-Z

Global LogPath As String
Global IconGroup As String
```

To access these utilities, MAKELOG.BAS could be included in the generic 'setup1a.mak' project file. Next, insert the following in the *Form_Load* event procedure of *Setup1a.frm*, at the position identified by these commented lines:

```
'-----------------------------
' Create destination directory
'-----------------------------
    If Not CreatePath(destPath$) Then GoTo ErrorSetup
'* here â
    CreateLog destPath$, dialogCaption$, SourcePath$
    AddPathToLog destPath$
```

Insert in the *CopyFile* procedure, in the block 'CheckForExist, If – Else' (following the 'Else' position):

```
    AddFileToLog DestinationPath$ + DestFileName$
```

Add to the end of the *CreateProgManGroup* procedure, just before 'End Sub':

```
    IconGroup = GroupName 'global var
```

Add to end of the *CreateProgManItem* procedure, just before 'End Sub':

```
    AddIconToLog IconTitle$, CmdLine$
```

Write the new routines in MAKELOG.BAS. The following new 'Sub' procedure creates a new INSTALL.LOG if one does not already exist. If it does exist, the next log is appended to it:

```
Sub CreateLog (ByVal destPath As String, Title As String, Source As String)
    Dim filnum
    filnum = FreeFile
    If Right$(destPath$, 1) <> "\" Then destPath$ = destPath$ +
"\"
    LogPath = destPath
    If Not FileExists(destPath + "install.log") Then
    Open destPath + "install.log" For Output As filnum
    Else
    Open destPath + "install.log" For Append As filnum
    End If
    Print #filnum, "*** Installation Started "; Date$; " ";
Time$; " ***"
    Print #filnum, "Title: "; Title
    Print #filnum, "Source: "; Source; "SETUP1A.EXE"
    Close #filnum
End Sub
```
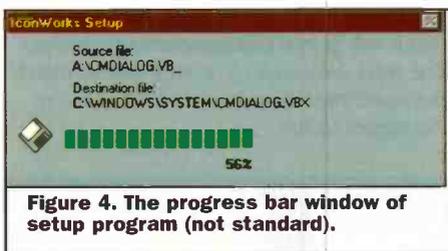
Figure 4. The progress bar window of setup program (not standard).

Figure 5. The opening screen of UNWISE.EXE – an application uninstaller utility.

(Note: the function *FileExists()* is already present in SETUP1.BAS.) Having done that, the application's destination path can be recorded:

```
Sub AddPathToLog (path As String)
    Dim filnum
    filnum = FreeFile
    Open LogPath + "install.log" For Append As #filnum
    Print #filnum, "Made Dir: "; path
    Close #filnum
End Sub
```

This adds the destination path and name of each copied file:

```
Sub AddFileToLog (FileName As String)
    Dim filnum
    filnum = FreeFile
    Open LogPath + "install.log" For Append As #filnum
    Print #filnum, "File Copy: "; FileName
    Close #filnum
End Sub
```

The following is used to add a list of created program group icons to the end of the log. Each entry is preceded by its group name:

```
Sub AddIconToLog (IconName As String, IconCmd p)
    Dim filnum
    filnum = FreeFile
    Open LogPath + "install.log" For Append As #filnum
    Print #filnum, "Icon Group: "; IconGroup 'global
    Print #filnum, "Icon Name: "; IconName
    Print #filnum, "Icon Cmd: "; IconCmd
    Close #filnum
End Sub
```

At the end of the installation process SETUP1.EXE will have generated something like the following in the application's destination path, as a simple example:

```
*** Installation Started
09-04-1997 14:06:38 ***

Title: ICONWORKS Setup
Source: A:\SETUP1A.EXE
Made Dir: C:\ICONWRKS\
File Copy: C:\WINDOWS\SYSTEM\CMDIALOG.VBX*
File Copy: C:\WINDOWS\SYSTEM\COMMDLG.DLL*
File Copy: C:\WINDOWS\SYSTEM\THREED.VBX*
File Copy: C:\WINDOWS\SYSTEM\TOOLHELP.DLL*
File Copy: C:\ICONWRKS\ICONWRKS.EXE
File Copy: C:\ICONWRKS\ICONWRKS.HLP
File Copy: C:\ICONWRKS\UNWISE.EXE
Icon Group: ICONWORKS
Icon Name: ICONWORKS
Icon Cmd: C:\ICONWRKS\ICONWRKS.EXE
Icon Group: ICONWORKS
Icon Name: Help File: IconWorks
Icon Cmd: C:\ICONWRKS\ICONWRKS.HLP
Icon Group: ICONWORKS
Icon Name: Uninstaller
Icon Cmd: C:\ICONWRKS\UNWISE.EXE

*not necessarily copied if already exist
```

Apart from providing information, this file is readily useable by something called UNWISE.EXE (because it's 'unwise' to use it). UNWISE.EXE is for uninstalling applications using the information about them in such log files. It is often redistributed with other applications, so it isn't exactly rare; it is comparatively small and doesn't need any supporting library files other than those already provided by Windows.

Figure 5 shows the opening window of UNWISE.EXE, where it can be seen that it can be instructed to remove all files or only those selected by the user, including the icons from the program group, and even the program group itself. This still works for the Windows '95 variations, that are called 'shortcuts', whose 'groups' are in reality directory folders.

Normally you run UNWISE.EXE in the same folder that contains the INSTALL.LOG. Figure 6 shows how, in the 'custom' option, various file lists are displayed for the user to select specific ones to keep or remove.

Next month: 'Help!'
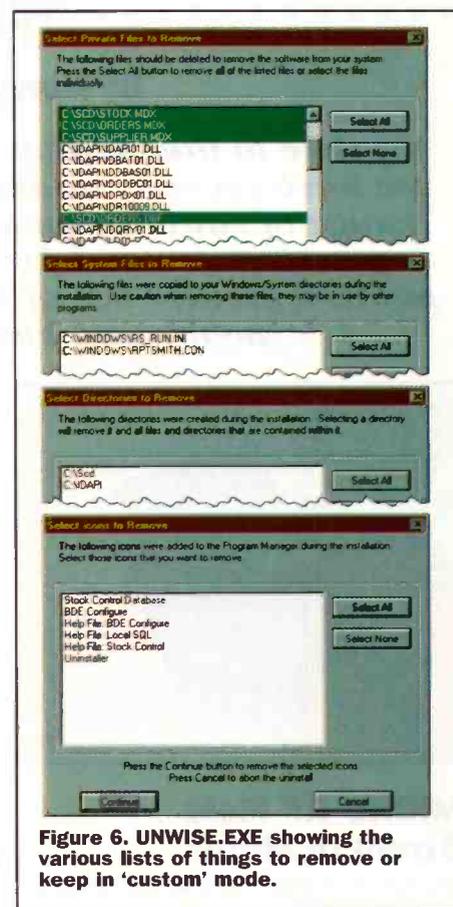
Figure 6. UNWISE.EXE showing the various lists of things to remove or keep in 'custom' mode.

Radio COMMUNICATIONS PRODUCTS

PART 6

by Harry Watkins

It's time to take a look at some more new items we have recently added to Maplin's expanding range of radio communications products. The growing demand for new items reflects the public's greater use of radio equipment for both hobby and business purposes.

Order code NW69A, retail price £119.99 inc. VAT.

MICRO-RF Field Strength Meter

The need to measure local RF field levels is catered for with this new model. Engineers often need to check RF levels in the vicinity of transmitting sites, either for adjustment purposes or for tackling interference problems. For surveillance purposes, the need to hunt out hidden transmitters can also be achieved using the Micro-RF.

Made by Optoelectronics in the USA, the unit is housed in a compact pager-style case. Described as a nearfield detector, it covers the frequency range 10MHz to 2GHz, is highly sensitive and comes with a short whip antenna. Two displays are offered. One is a simple 24-segment bargraph that provides a convenient graphic display of signal strength. The other is a numerical counter from 1 – 256 which provides a more accurate relative field strength reading. The numerical display can be

set-up to beep when a predetermined numerical level is reached. The unit is powered from a single AA battery (supplied), and is fitted with a convenient belt-clip. Alternative external antennas can be used via the 2.5mm jack socket.

Hora C-150 2 Metre Amateur Radio Transceiver.

Ham radio enthusiasts will find this a particularly interesting package, especially because of its low price. This must be one of the best bargains around at present. What's more, it is feature-packed with a keypad for programming and direct frequency entry. The unit comes complete with antenna, carry strap and belt hook. Power is from 6 x AA cells (not supplied) which fit into a removable battery pack. These provide around 1.5W of RF output, but connect the transceiver to an external 13.8V source (via the optional cigar lighter plug for example) and you achieve a very respectable 5W output. This makes it a very real alternative to a mobile transceiver. The C-150 has 20 programmable memories and a built-in 1750Hz tone burst button for accessing the UK and European repeaters. The LCD readout provides both frequency and function information. Although primarily intended for the 144MHz to 146MHz amateur band, the unit can also receive between 130MHz to 174MHz. Other features include Backlight, Dual Watch, Scanning, Battery Save, Keypad Lock, Beep on/off and Auto Power Off. I was very impressed with

this transceiver's performance and can see that it will fit into many enthusiast's budget. The tests showed it to be well able to match the more expensive models from some of the bigger names.
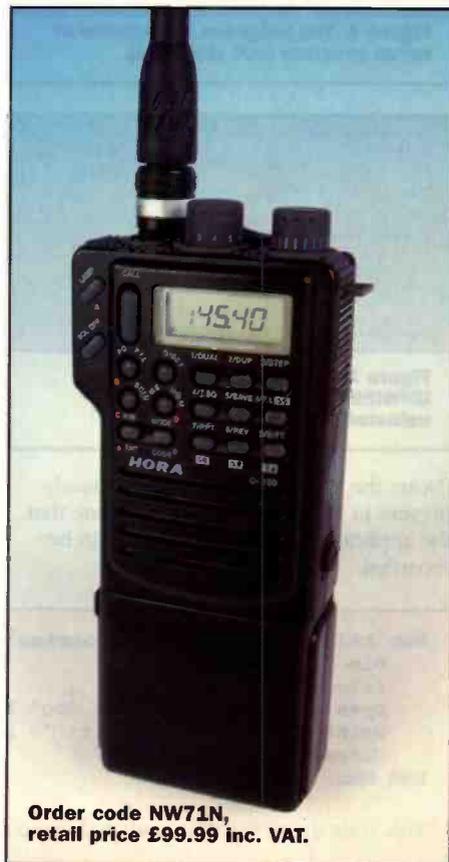
Order code NW71N, retail price £99.99 inc. VAT.

WATSON WSC-3 Radio Belt Holster

Good ideas are often simple ones and the need for a universal belt holster to fit the smaller radio transceivers and portable phones has been fulfilled by this design. It has elasticated sides and is fitted with a neat quick-release belt clip that is designed to prevent the belt from accidentally riding up. Many of our commercial customers are already finding this a most attractive and functional item. I must admit to using one myself for my portable phone when I am out walking.
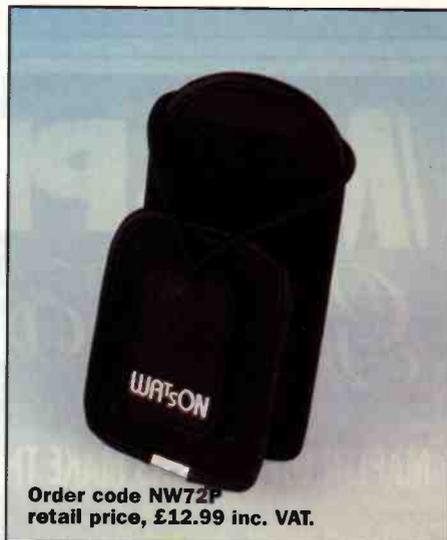
Order code NW72P retail price, £12.99 inc. VAT.

Order code NW77J, retail price £26.95 inc. VAT.

WATSON MSM-300 Motorola Style Speaker Microphone

There can be no denying that Motorola dominate the market in hand portable transceivers. Hand microphones with built-in speakers are an attractive accessory for such transceivers. They permit the transceiver to be clipped to the belt, whilst allowing full remote operation with the speaker microphone clipped to the lapel. In commercial use, these accessories can take some punishment and abuse. This model is purpose designed for the Motorola range of handies and SRBR models, and is extremely rugged. Even dropping it from some height onto a concrete floor, won't harm it. Now that's what we call tough!

WATSON SP-2000 Mobile Speaker

This leads us nicely onto another problem; where to place a remote speaker. Many modern vehicles seem to have a distinct lack of any obvious places to mount speakers, particularly in a position that offers adequate reception. The SP-2000 offers an 'aircraft-style' console that mounts onto any sun visor. Not only is this a good place audio wise, it is also out of the way and makes for a very neat installation. A generous 5m long cable, terminated in a 3.5mm plug, is provided. This allows the signal lead to be tidily dressed around the vehicle interior. A volume control is also included and the 8W speaker impedance allows it to be used with all the popular scanners, hand held and mobile radios. The overall measurements of the SP-2000 are 190mm wide x 20mm deep x 85mm high and the output level from a typical radio is more than adequate. I rate this as a very good idea and am sure that it will fulfil a worthwhile need for many radio enthusiasts.
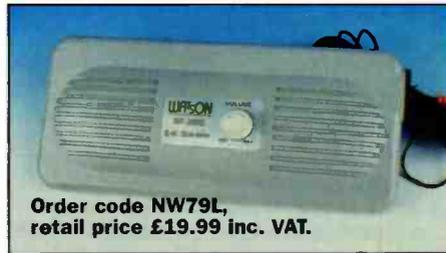
Order code NW79L, retail price £19.99 inc. VAT.

WATSON SP-170F Mobile Speaker

When operating a radio transceiver or scanner in the car, the speaker is often not placed in the best position. When cruising on motorways with higher vehicle noise levels, poor speaker placement becomes a real problem. The SP-170F sets out to solve this problem and is conveniently fitted with a variable volume control and switchable filter. This latter feature allows the listener

Order code NW78K, retail price £12.99 inc. VAT.

to select the most suitable response to match the listening environment. The unit measures 97mm wide x 67mm high x 27mm deep and weights 189g. It is fitted with 3m of cable terminated in a 3.5mm mono plug.

That concludes my column for this month. I know the staff at Maplin have got more items on the way and I hope to cover some of these in my next article.

July 1996

3 to 5 July. Emerging Broadcast Technology, Symposium Moller Centre, Cambridge, IEE. Tel: (0171) 240 1871.

5 to 10 July. High Voltage Engineering and Testing, Vacation School, University of Northumbria, Newcastle, IEE. Tel: (0171) 240 1871.

9 July. Computer Vision for Virtual Human Modelling, Colloquium, Savoy Place, London, IEE. Tel: (0171) 240 1871.

10 to 12 July. 26th History of Electrical Engineering Weekend, Weekend Meeting, University of East Anglia, Norwich, IEE. Tel: (0171) 240 1871.

13 to 15 July. Network Access, Residential Course, Warwick, IEE. Tel: (0171) 240 1871.

14 to 15 July. Handwriting Analysis and Recognition, Workshop, Hotel Metropole, Brussels, IEE. Tel: (0171) 240 1871.

17 July. Publishing A Page on the Web, Colloquium, University College London, IEE. Tel: (0171) 240 1871.

19 to 24 July. Satellite Communication Systems, Vacation School, University of Surrey, IEE. Tel: (0171) 240 1871.

August 1996

23 to 28 Aug. European Conference on Artificial Intelligence, University of Sussex and University of Brighton, Brighton. Tel: (01273) 678 448.

September 1996

1 to 4 Sept. Control Conference, University of Wales, Swansea, IEE. Tel: (0171) 240 1871.

1 to 4 Sept. UKACC CONTROL '98, University of Wales Swansea, IEE. Tel: (0171) 240 1871.

2 to 4 Sept. Electrical Generator Applications, Vacation School, Burleigh Court, Loughborough University. IEE. Tel: (0171) 240 1871.

5 Sept. Systems on A Chip, Colloquium, University College Dublin, IEE. Tel: (0171) 240 1871.

7 to 9 Sept. Embedded Systems Conference Europe, Royal Ascot, Berkshire. Tel: (0181) 855 7777.

8 to 10 Sept. Farnborough International Technology Conference - Technology for Business Advantage, Conference, Savoy Place, London, IEE. Tel: (0171) 240 1871.

9 to 11 Sept. Sixth UK Mechatronics forum International Conference Mechatronics '98, Hotel Billingehus Conference Centre, Skovde, Sweden, IEE. Tel: (0171) 240 1871.

11 to 15 Sept. International Broadcasting Convention, IBC 98, RAI, Amsterdam, IEE. Tel: (0171) 240 1871.

13 to 16 Sept. Safety Critical Systems, Vacation School, the Moller Centre, Cambridge, IEE. Tel: (0171) 240 1871.

14 to 17 Sept. Vacation School on Communication Network Design, Vacation School, Christchurch College, Canterbury, IEE. Tel: (0171) 240 1871.

15 Sept. Internet Enabled Manufacturing - the Cyber Factory, Colloquium, Imeche, Birdcage Walk, London, IEE. Tel: (0171) 240 1871.

16 Sept. ford Motor Company, Dagenham, Dagenham, Essex, IEE. Tel: (0171) 240 1871.

20 to 23 Sept. Residential Course on Universal Mobile Radio Communications, Residential Course Pembroke College, Oxford, IEE. Tel: (0171) 240 1871.

21 to 23 Sept. Power Electronics and Variable Speed Drives, Conference, Savoy Place, London, IEE. Tel: (0171) 240 1871.

21 to 23 Sept. Seventh International Conference on Power Electronics & Variable Speed Drives, Savoy Place, London, IEE. Tel: (0171) 240 1871.

22 to 23 Sept. Enterprise in Transition, The Commonwealth Institute, Kensington, London. Tel: (01908) 373311.

23 Sept. The Future Use of Intelligent Automation and Robotics in the Utility Industries, Colloquium, North West Water Laboratories, Warrington, IEE. Tel: (0171) 240 1871.

30 Sept. Simulation Conference, University of York, IEE. Tel: (0171) 240 1871.

30 Sept to 2 Oct. International Conference on Simulation, Innovation Through Simulation, University of York, IEE. Tel: (0171) 240 1871.

What's On?

Converged Networks Next Major Milestone for Computer Industry

"I believe the change to converged networks is not a mere incremental improvement but a fundamental expansion of the role and strategic benefits that data networks will provide in the future," 3Com CEO Eric Benhamou said during a keynote address to the NetWorld+Interop '98 conference in Las Vegas in May. "In fact, I view this change as the most significant next major milestone for our industry as we continue to grow and evolve towards an era of pervasive networking."

Most corporate enterprises today employ multiple network infrastructures to support applications, including voice, video and data transmissions. By converging and integrating the parallel networks, enterprises will be able to substantially reduce communications, operations and network management expenses while increasing the bandwidth available to support new applications that require different types of transmissions.

Calling the Internet now more popular than the Beatles, based on AltaVista search hits, Benhamou said that networks have become such an established part of people's lives because, "we have done a good job of making networks go faster and faster, and reach farther and farther over the last few years."

During his presentation to the annual conference, Benhamou outlined how converged network technology is changing people's lives by changing how they work as well as how they interact with healthcare, government and educational institutions.

LSI Logic and BBC Make Digital Television a Reality

If Digital Terrestrial Television (DTT) is going to take-off in Europe when it broadcasts this autumn it will require manufacturers to build cost-effective set top box decoders at a price acceptable to consumers, which is broadly judged to be comparable with the price of a video recorder.

But now LSI Logic has developed a single chip solution in conjunction with the BBC. Announced at Cable & Satellite, the DDT chip supports 2K and 8K transmission modes making it a viable cost-effective solution for pan-European DTT deployment.

Throughout the Cable & Satellite show, which took place in London from 18 to 20 May, LSI Logic demonstrated live DTT broadcast using this single chip solution to decode transmissions from the BBC's trial DTT transmitter located at Crystal Palace, London.

The LSI Logic chip, called the L64780, will be used by consumer manufacturers to form the heart of digital terrestrial set-top boxes and digital TVs using existing TV aerials. The chip receives DTT signals, then processes them into wide screen pictures and CD-quality audio.

DTT was the buzzword at this year's Cable & Satellite Show at Earl's Court in May. DTT is the third broadcast delivery system, in addition to cable and satellite, and it uses existing land transmitters and consumer TV aerials to receive broadcast services. It offers television viewers significant advantages over today's analogue broadcasts

In the UK, for example, it will offer up to 30 television program services, compared to the five or six analogue services currently available. With each digital channel capable of carrying a 'multiplex' of four or five programs, viewers' program choice will significantly increase.

Digital terrestrial television will bring new services, support data broadcasts, and regional and local programs, as well as offer interactive services. Viewers can look forward to enhanced picture quality and CD-like sound. In most cases, viewers will be able to receive digital terrestrial television using the same antennas they presently use for their analogue services.

European broadcasters including the BBC and BDB in the UK, Spain and Sweden plan to deploy digital terrestrial programs from October this year. According to Dataquest, in Europe alone, more than 200 million households currently view terrestrial broadcasts via their existing TV antennas.

Chris Smith MP Paces Out Digital Future

Culture Secretary, Chris Smith came face to face with his vision of digital television for the UK when he visited Pace Micro Technology at its headquarters, near Bradford in Yorkshire, during May.

The Minister, after a tour of Pace's manufacturing facility, was introduced to Pace's set-top box designed specifically for British Digital Broadcasting (BDB), which plans to launch its digital terrestrial service towards the end of this year.

Pace is Europe's leading manufacturer of digital set-top boxes and is the only British company to have contracts to manufacture digital boxes for both BSkyB and BDB.

COMMENT

by Keith Brindley

As always, things are moving apace in computing. Areas once long thought of as belonging to the professional are rapidly becoming the norm on the average computer user's desktop. Take digital imaging for instance. For years this has remained the domain of the likes of high-end publishers. Only they have had the equipment, money and knowledge to be able to take images (usually in hard photographic form) manipulate them, then use them to produce and publish finished results.

In recent times though things have begun to change, bringing the ability to ordinary users. For a start, digital scanners have become popular - and their popularity in terms of mass-production has meant that prices have fallen to an easily affordable level. Scanning, however, remains a process more akin to art than science. While anyone can own a scanner, it's not everyone who can use them to get the digital image results they want.

Second, digital cameras have appeared - also rapidly coming down in price to a reasonable level - which make the digital image process even easier. Their point-and-shoot ability, coupled with subsequent easy image downloading to the computer desktop, makes them ideal for the non-professional. That's not to say, though, that professional results can't be obtained from them.

Third, decent cheap colour printers are now obtainable at a good price. Many new ink-jet printers can produce results that compare quite favourably with processed photographs, with the result that images digitally obtained from scanners or cameras can finally be produced as a finished article, at high quality, in the home. Technically, all photographic operations can be controlled by and on a computer now - gone are the days of the enlarger and developing baths.

Yet all these things rely on the ability of the computer user to take advantage of their features. Here, inexperience often

brings downfalls. But it's not just experience that creates good digital images. The software used on the computer plays a vital part in coordinating digital images - from input to output. Good software can bring excellent results. Generally, the more powerful the software is, the better the results can be. However, it's not just software power that creates good results. The most powerful software in the world is useless if the user can't access the power.

Digital imaging for ordinary users is no exception. For years the only software used by professionals involved in digital imaging has been Adobe Photoshop - and for anyone interested in taking digital imaging as far as they can go, Photoshop remains unbeaten. Ordinary users, on the other hand, might find Photoshop bewildering - a fact not unnoticed by Adobe, whose new digital imaging software PhotoDeluxe is aimed at ordinary computer users who want the best they can get from their images, but want that at a reasonable price and ease-of-use.

Adobe's PhotoDeluxe is a superb example of how easy it can be to manipulate and use digital images, whether from scanners, cameras, or even PhotoCD. Borrowing from some of the internal operations within its bigger brother Photoshop, it's also particularly powerful. However, its main interface clouds the user from this power, and indeed it's not at all obvious just what sort of power is being used on images. In effect the user merely has to specify which digital image is to be manipulated (whether from scanner, camera, or disk file), then let PhotoDeluxe do the rest. Imaging operations such as balancing, sharpening and so on can be made completely automatically. There are several programs around that do this sort of thing, but PhotoDeluxe appears unbeaten in terms of all this. Processes can be manually controlled too, so that users can specify results more personally. Cutting and tracing of selected image parts can be undertaken and red-eye – common in home photography, where the flash is located close to the camera lens – is removed with a click.

If manipulating images was all PhotoDeluxe could do, readers would be happy bunnies. However, there's more. Templates are provided in the package that allow creation of greeting cards, business cards, photo albums and T-shirt transfers from photographs. Best of all, despite all its power PhotoDeluxe is not an expensive program, priced at £49 + vat. It's available in both Mac and Windows formats.

Another facet of digital imaging not always appreciated is the ease with which modern programs can recognise typed information and present it as editable text on screen. Such optical character recognition (OCR) software has improved

OmniPage Pro's toolbar allows professional and automatic OCR with just single button operation.

greatly over the last few years, helped by increased processing power of computers. As in imaging software, there are several programs around which undertake OCR. One of the best - and most famous - is Caere's OmniPage Pro. The latest version (version 8) represents probably the ultimate in OCR on the personal computer desktop. Like PhotoDeluxe which takes a complex group of tasks and automates them into single simple operations, OmniPage does the same for OCR processes. Scanners can be controlled directly from within OmniPage, or pages previously scanned can be input as disk files. Like PhotoDeluxe too, OmniPage Pro allows automatic OCR control which alleviates any necessity to understand the process involved, or it can be controlled manually, step-by-step for controlled results. OmniPage Pro is no lightweight program (reflected somewhat in its price of £395 + VAT — although users of any OCR program can upgrade for just £99 + vat). It's available in both Mac and Windows formats.

There's no doubt, as computers become more powerful, and as the programs used on these more powerful computers take advantage of this extra power, the things we expect computers to do will change dramatically. Digital imaging and optical character recognition, while closely associated in terms of how they work with external devices, are only two very diverse examples. Areas in which it was never dreamed computers would be able to be used will become ripe for clever and enterprising developers. It's really only been the last 15 years where personal computers have been able to make inroads into the home and small business to allow such powerful tools to be made available to the majority of us. The new millennium promises much, much more. ⬛ ELECTRONICS

PhotoDeluxe offers simple yet powerful control over images.

TECHNOLOGY WATCH

with Martin Pipe

Later this year, it's been said, we will be experiencing a televisual revolution. Both satellite and terrestrial TV will be going digital'. The same bandwidth occupied by a single analogue channel will support up to as many as ten digital ones. If higher quality isn't needed, then even more could theoretically be accommodated. In an age where we want more channels – or, at least, we're told we want them – digital is the only way forward. Radio spectrum these days is a valuable commodity, and digital broadcasting – plus MPEG-2 video/audio compression – is acknowledged by international standard as the best way to get it without significantly compromising quality.

At the moment broadcasting, whether terrestrially or via satellite, is an expensive business before you even consider ITC licence and programme making. Renting a transponder on the Astra satellite costs several million pounds. If ten of you were to get together and split the cost, then pan-European audiences can be achieved at a surprisingly low price. If you're a low-budget broadcaster – and let's face it, limited-audience specialist channels aimed at interests as diverse as trainspotting and cookery are unlikely to be anything else – then money considerations are important.

Sky's digital service will be starting in June, but won't really get going until the autumn. It will be the first true digital television delivery service aimed at the UK. At the time of writing, various test transmissions can be seen if you've got a digital satellite receiver, various forms of which are available from specialist retailers. The latter won't, out of interest, be automatically compatible with the Sky Digital. At this stage, details on the Sky offering are extremely limited – which is worrying considering the imminence of the

launch. We are likely to see all of the existing Sky channels, plus more (up to 50) Box Office pay-per-view events such as movies, concerts and sports. It is likely that subscription-based special-interest channels will follow suit, and that other channels will be enhanced.

Of rather more interest are the selected terrestrial channels that will, according to Sky's literature, be carried by the Sky multiplex. As a result, there's a fair chance that we'll be able to see good pictures from BBC1, BBC2, Channel 4 and Channel 5 from our dishes! Because there are so many regional ITV channels, it's highly unlikely that they'll be offered via Sky Digital. Regular readers will know that satellite rebroadcasting of terrestrial channels is a hobby horse of mine. I think it's a complete joke that in some areas in Britain, viewers have to stump up the complete licence fee to watch a dismal picture that's barely recognisable through all the noise, simply because they're too far away from the nearest transmitter (as a sideline, those of us who live in the South East won't have to put up with frequent co-channel interference from powerful TV transmitters in mainland Europe)!

Such matters don't apply to satellite; as long as you're within the footprint and have a clear view of the sky, then reception is possible. Hats off to Sky, then, for

implementing what should have been done with the old BSB satellite nigh on a decade ago! Other features planned for Sky Digital include an enhanced programme guide, interactivity (via an in-built modem) and up to 50 themed channels of DJ-free CD quality' music. Two digital pay-radio services were carried via the Astra satellite on previous occasions, but they never really took off in the UK. This might be something to do with the psychological barrier of paying to listen to radio, but it's probably more related to the cost of the extra hardware that was involved. Seeing as Digital Sky receivers will handle the service from the outset, it remains to be seen whether it's successful or not.

The Sky service won't be broadcast from the Astra 1x satellite cluster at 19.2E, mainly because the number of free transponders is insufficient. Instead, a new satellite – Astra 2A, at 28.2E – will be used. This is likely to create all kinds of problems. Dish installation won't be easy – particularly as far as the consumer is concerned. You can't simply aim your dish at roughly the right position, and simply tweak for minimum sparklies, as you can with the FM-based analogue transmissions. With digital, it's all or nothing. Astra 2A won't offer any of the analogue channels that would act as a dish alignment aid in conjunction with an existing receiver. For self-installation, a signal strength meter will be essential.

Another problem will concern reception of both satellites. It's probably true to say that many of the non-Sky channels that are currently relayed via Astra 1x won't move over to 2A in digital form. Some may move (or dual-illuminate) in time, but the chance of their availability from the outset is slim. Several of these unencrypted analogue channels, which include Cartoon Network and CNN, are highly popular. There are also encrypted special-interest and foreign-language channels. These are highly unlikely to move, since Astra 1x carries digital versions of them already.

If any of these existing channels are of interest, you will need a system that allows both satellites to be received. Having two dishes is ugly, and won't be appreciated by the planning authorities. A motorised dish, on the other hand, is overkill for two satellites. Fortunately, you can get a twin-feed attachment that allows two satellites to be seen by a single dish. This attachment consists of a bracket that sits at the end of the LNB mounting arm. Each of the desired satellites, which must be spaced by no more than 1° if reliable reception is to be achieved, is seen' by its own dedicated LNB. Although this system is cheap – high-performance LNBs are now extremely affordable – it's tricky to set up for best pictures from both satellites. In addition, you'll need two LNB cables – one to the digital receiver, and another to the analogue one.
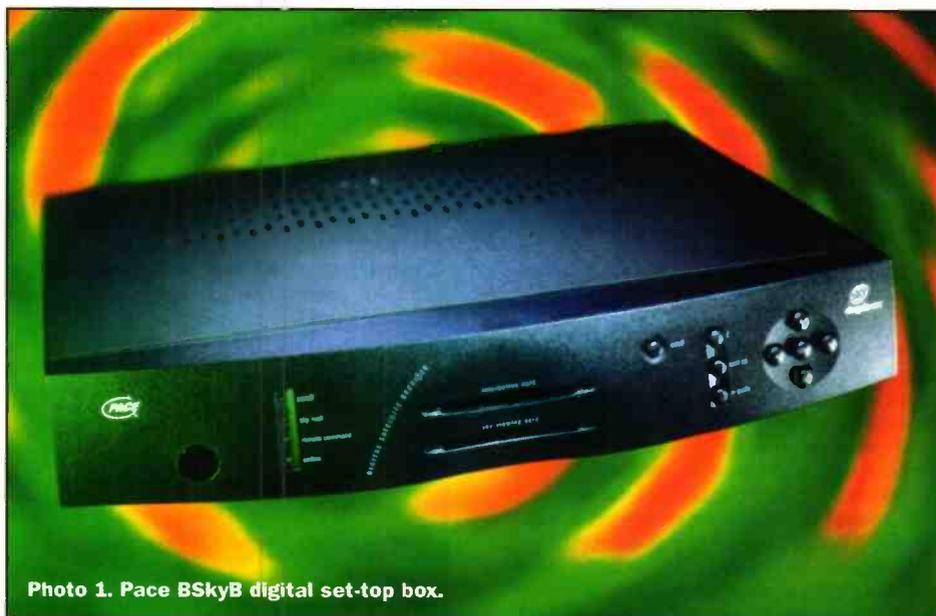
Photo 1. Pace BSkyB digital set-top box.

Sky is rumoured to be sourcing a specialist easy fit dish designed for dual-satellite reception. At launch, there will be four receivers available from Amstrad, Pace, Grundig and Panasonic, see Photo 1. Indeed, they could be seen at the Cable and Satellite trade fair earlier this year. At least one receiver looked suspiciously like a mock-up. Regarding cost, a Sky spokesperson couldn't confirm how much the receiving equipment would be, or whether it would be available at a discount to regular Sky subscribers. At a rough guess, I would say that the receivers would have an unsubsidised cost of between £400 and £500. If bought with a monthly subscription, the viewer is unlikely to pay more than £200 for the hardware.

The Sky spokesperson didn't reckon that the monthly subscription would be much different to that already being asked for the current analogue service. The conditional access system to be used by Digital Sky will be NDS, developed by News International subsidiary News Datacom. It is not known for how long the analogue Sky transmissions will continue, but it's likely they'll run for several years. After all, there are several million Videocrypt IRDs out there.

What of digital terrestrial TV, or DTTV? This is planned for the autumn, and will be broadcast from existing transmitter sites, such as Crystal Palace and Emley Moor. it's reckoned that most of the country will be able to receive the services via their existing rooftop aerials – no dish will be needed. It depends on the condition of those aerials, and how well they're aligned. In some cases, a new aerial will be required, not least because the digital channels will be transmitted on frequencies outside the existing aerial's grouping. In a few cases, the installation of new aerials will be conducted free-of-charge to the viewer. Some far-flung parts of the UK won't be able to receive DTTV – their only hope for terrestrial digital will be via the aforementioned Sky service.

There are two programme providers – the BBC, and a new ITC-licensed outfit known as British Digital Broadcasting (BDB). Both claim that they will be offering regular widescreen broadcasts and enhanced teletext. Let's start with the BBC offerings, which will be offered free-to-air – in other words, no subscription will be needed. In addition to the existing BBC1 and BBC2 there will be two new channels. BBC Choice will be, to the best of my knowledge, a best of the BBC channel. In other words, more repeats! The other contribution, BBC News 24, will be the same rolling news service that can currently be seen, in analogue form, on the Eutelsat Hot Bird satellite (13E, 11620MHz, vertical polarisation).
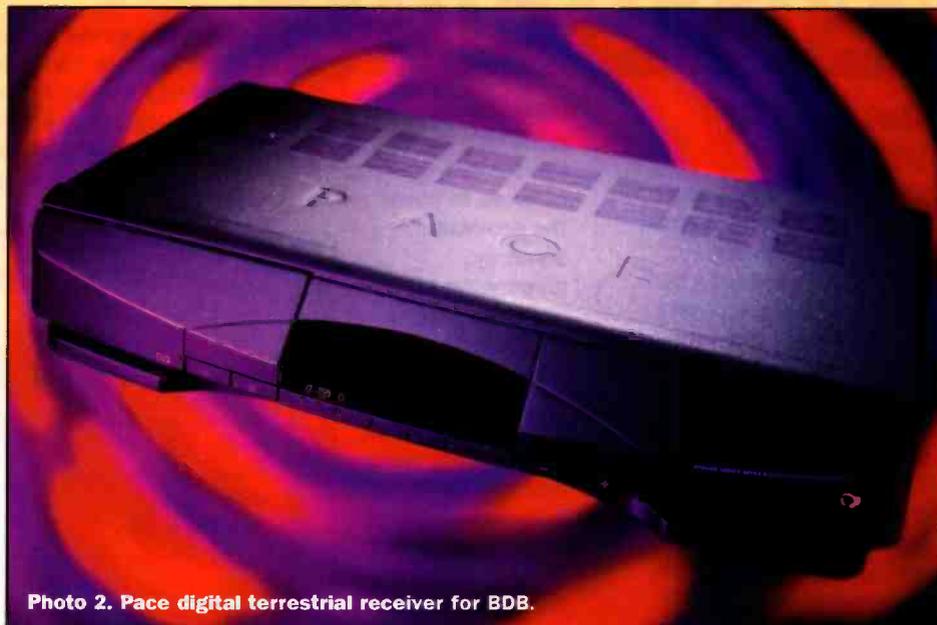
Photo 2. Pace digital terrestrial receiver for BDB.

BDB, which is operated by partnership between ITV companies Carlton and Granada, will offer a basic subscription package of 12 channels. Many of these will be familiar to Sky subscribers – Sky One, Granada Plus and UK Gold, for example. The three premium services that will also be offered – Sky Screen One/Two and Sky Sports – all have a familiar ring to them. Sky's participation in this project is made all the more interesting bearing in mind their recent feud with BDB; the latter dropped the NDS conditional access system in favour of the incompatible SECA. DTTV will also offer, on a free-to-air basis, the local ITV station, Channel 4 and Channel 5. Transmission services for the latter channels, and those of the BBC, will be provided by a company known as Castle Tower International (CTI). Before it was privatised last year by act of the last Government, CTI was the BBC's transmission network.

Most of the current brown-goods manufacturers – including Sony, Philips and Toshiba – will be offering DTTV receivers, see Photo 2. The BBC is currently conducting tests, and these could be seen at Cable and Satellite where Nokia was demonstrating its Mediamaster 9850T receiver, see Photo 3. Picture quality was pretty poor, but I believe that a duff test tape was responsible. When the service is launched, picture quality will be one of DTTV's selling points. There will be no ghosting or grain for example (as far as the latter problem is concerned, a weak signal means you won't be able to receive a picture at all – with digital you'll either get a perfect picture or a blank screen!). That's not to say that pictures will be perfect; MPEG does

introduce compression artifacts that can be seen by the critical eye.

The DTTV receivers offered by BDB will start at £350, or £200 with subscription. According to a spokesman, they'll be capable of tuning into satellite broadcasts. This is possible, since both terrestrial and satellite systems adhere to a common standard known as DVB, which is based around MPEG-2 compression. The only significant difference concerns the frequencies and modulation scheme used (DTTV employs OFDM, while satellite uses QPSK). The combined receivers will have dual tuners. Unfortunately, because Digital Sky and BDB now use different conditional-access systems, a NDS sidecar module will be needed (in addition to the relevant subscription, and dish/LNB) if that BDB box is to tune into Sky. As with Sky, the first receivers will be set-top boxes. VCR and TV combinations will follow shortly afterwards.

As with satellite, you won't be able to watch one programme while recording another – even if you have two receivers. This is because you'll need a subscription for every BDB box in the house. People aren't used to this with current analogue terrestrial channels – they can watch one programme while taping another. Fortunately, the SECA system is based around a smart card, one of which is issued to each subscriber. I can imagine that we'll begin to see smart card multiplexers that will allow one card to service more than one receiver.

Such trickery was originally developed for analogue Sky's Videocrypt scrambling system. That said, the free-to-air channels are unlikely to be subject to such constraints, although you'll still need two digital receivers. Out of interest, the analogue terrestrial channels will continue for some time, although you can bet your bottom dollar that the Government can't wait to sell the frequencies off to the highest bidder. This matter will be discussed in December 2001, and a possible terminal date for analogue transmissions announced if DTTV has been successful. **ELECTRONICS**

Photo 3. Nokia Mediamaster 9850T for BDB and UK digital terrestrial broadcasts.

@Internet

Get the big picture

Ever wondered how to make panoramic images if you can't afford a costly panoramic camera? Live Picture's PhotoVista lets you do it from the comfort of your computer with ordinary images. It works by joining together a series of photographs presented as multiple images of a scene, and creates a single panoramic image which you can use to create multimedia movies or images ideal for use on Web sites or for emailing. The series of photographs can be taken with an ordinary camera whose images are later scanned, or downloaded from a digital camera. The program gives help on calculating the number of images required to cover the panorama correctly (depending basically on lens focal length). It then allows basic manipulation of images to ensure their correct order, followed by automatic stitching, blending and warping of images to create the final panorama. Using PhotoVista couldn't really be simpler and the results are very good. Panoramas can be saved in bmp, jpeg, ric, pict, or qtvr (Macintosh only) formats, for use in any application or project you care to mention. Filesizes of complete 360° panoramas in jpeg form can be as low as 100kb, making them ideal for Internet use. PhotoVista is available on a hybrid CD-ROM in both Macintosh and Windows formats.
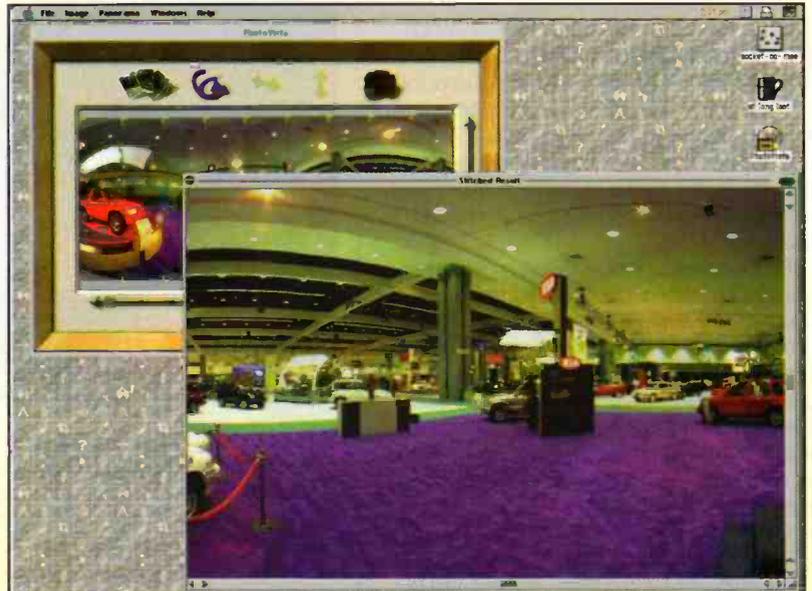
Science Made Stupid

A fantastic Web site that explains away many complex scientific theories in an amusing, but plain English style has been launched this month at www.moonboy.com/sms. Science Made Stupid dismisses years of debate by combining Darwinism and creationism theory into a hilarious modern theory of evolution. Other theories spun by the creators of the Web site include the history of the universe and the foundation of the periodic table.
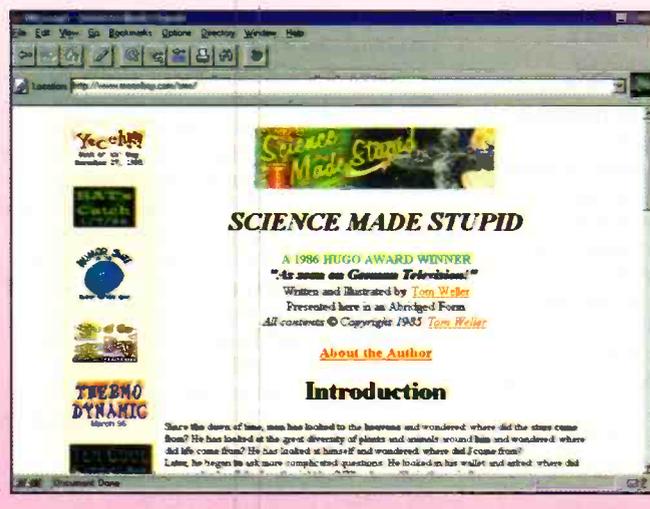
Cable modems real soon now

Cable modems promise ultra-high-speed Internet access for cable users around the country. However, the technology's not quite with us apart from a couple of test bed areas. Latest cable franchisee to have plans for cable modem introduction is ComTel, which has recently reached an agreement with @Home Network to provide a high-speed cable modem Internet service. First areas to have the service will be the Thames Valley and Oxford franchises early next year, and the rest of ComTel's franchises will follow later. The deal isn't exclusive, which means that other franchisees could use the same Internet service.

Shareware Central on the Web

If you are looking for a piece of software the Web is a great place to start. There are literally thousands of Web sites dedicated to the distribution of shareware and trial versions of commercial packages.

Psion reckons that there are now over 3,000 third party application available over the Web for its personal digital assistant (PDA). So if you want to store a list of whiskeys, select numbers for the national lottery or teach yourself Morse code check out www.psionking.com, www.palmscape.com, www.ukonline.com and info.brts.ac.uk.

The availability of software for the Psion is only surpassed by the quantity and quality you'll find online for the PalmPilot, demonstrating the fact that the Web is a superb medium for software distribution. A list of Web links for commercial third party software and shareware for the PalmPilot is available at www.palmpilot.com.

Finally if you own a PC and are stuck for a particular piece of software direct your browser to www.shareware.com. Here you'll find a searchable library of free software including many applications for electronics engineers.

A matrix for schools

While network computers (NCs) are finding their way gradually into businesses and industry, a new development is set to make them more popular in schools. Network computers are often known by their other name, thin-clients - and it's this name that really helps differentiate them from their bigger (and more expensive) personal computer cousins. Effectively, network computers are computers without most of the internal gubbins such as hard, floppy, and CD-ROM drives. They work because they are connected to a network, where a central NC server holds all the required programs and operating system. As a result, they can be significantly cheaper in hardware terms than full personal computers. Couple this fact with a secure working environment that users can't alter or tamper and you have a cost-effective solution to providing more computers for more users.

As far as schools are concerned, anything that's cheaper is good. School budgets are always restrictive, and the cost of computers is a significant part. Few network computer providers so far have addressed education satisfactorily, but Xemplar Education has recently launched its Matrix NC system which aims to provide network computers specifically for schools, at a launch price of only £575 per user for a 20-user system, into which further machines can be added at £419 each.

Apart from the thin client aspects of the network computer, one of the other beauties about the concept is that it's very much cross-platform. Existing and older computers such as 386 or 486 computers, along with Acorn A7000 machines that schools already own and are effectively past their sell-by date can be upgraded with a Matrix NC client to make them function again. Also, much existing software from those older machines is usable, although the system is pre-installed with a works package including word processor, spreadsheet, database, graphing, drawing and paint packages, together with a Web browser.

Apple Acquires Technology from Macromedia

Apple has acquired technology from Macromedia to enhance future versions of its QuickTime software. The move is part of Apple's efforts to make QuickTime the industry standard for digital video authoring and playback on personal computers and over the Internet.

QuickTime 3 can play back over 30 different video and audio file formats and offers real-time streaming of digital content over the Internet. The International Organisation for Standardisation (ISO) recently chose QuickTime's file format as the starting point for their MPEG-4 Intermedia Format.

Ticket Seller Goes Live on Web

Tickets for many events in the UK are now for sale, in real time, over the Internet after the launch of a new site from retailer Ticketmaster. The site at **www.ticketmaster.co.uk** is modelled on its US predecessor, which began selling tickets last year and claims to have moved more than a million tickets so far.

Its owners promise high security for credit card transactions and no customer details are stored on the host server. The site should have sufficient bandwidth for 6,000 visits and 200 transactions simultaneously. As well as an index of events, visitors can browse by venue and download other information, such as transport details.

ICL Supports Apple Store

Apple has awarded ICL, the IT systems and services company, a three year customer service contract, to support its new on-line Apple Store, an e-commerce site that allows customers to order Apple hardware and software products direct via the Internet. The agreement follows the launch of the company's first Apple Store in Europe, in the at **www.apple.com/ukstore.**

As part of the contract, ICL will assist Apple customers in placing orders through Apple Store, and provide information on the progress of their order. ICL will also be running a marketing campaigns desk, known as the Apple Information Centre, involving pre-sales enquiry handling, and telesales activity to follow up leads generated by Apple marketing campaigns.

Dan Adds Online Ordering to Web Site

London-based direct PC vendor Dan Technology has expanded its Web site at **www.dan.co.uk** to incorporate online ordering and 24-hours-a-day technical support. Visitors to the site have for some time had the facility to put together a Dan PC configuration that suits their exact requirements and to obtain an instant on-line price quotation.
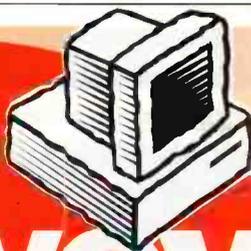
The month's destinations

Take control of a microscope over the Internet at Leica's online microscope, at `<http://www.leica.co.uk/microscope/>`, where you can zoom and focus to your heart's content. For other sites offering telemicroscopy at long-distance try also `<http://www.telemicroscopy.org/>`.

If mechanical control via the Internet isn't enough, now you can try your hand at animal training over the ether-so talk to a parrot and watch it real-time, at `<http://www.badgirl.co.jp/blue>`. However, the parrot (called Little Blue if you want to be informal) is located in Japan, so take into account the time difference, or you'll be staring at a dark screen. By emailing a message to Little Blue's email address `<blue@badgirl.co.jp>`, you can have the message spoken automatically by Little Blue's computer. Oh, and try to think of something a little more original than "Pretty Polly": this bird's smart, it's on the Internet, remember!

Join the buzz - chat long-distance to your worldwide friends on their telephones using a standard Internet connection. Vocaltec's Internet Phone is a package that allows Internet users to speak to other Internet users - or
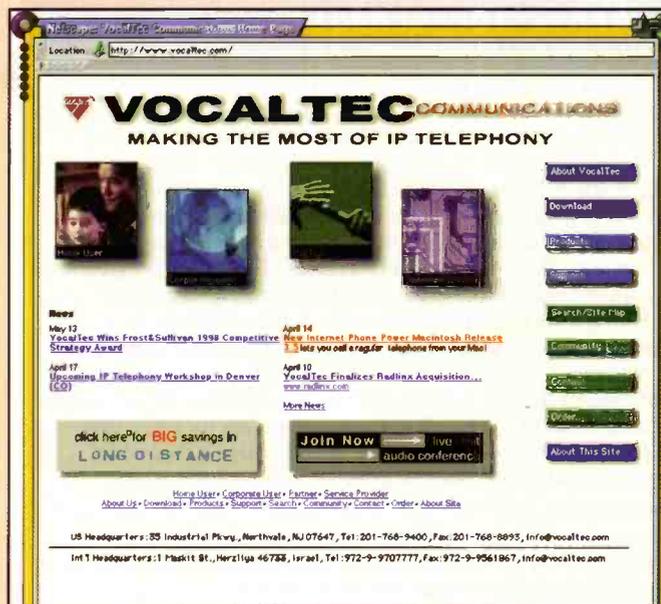
(better still) to ordinary telephone users - over the Internet, in a process that's commonly called IP telephony where IP stands for Internet Protocol. The advantage of doing this is pretty obvious - an Internet phone connection is usually local and costs only a few pence, while worldwide international telephone connections are long-distance and cost very much more. Understandably, British Telecom is getting worried about the proliferation of people using the Internet for

international calls, so try it yourself (download it from `<http://www.vocaltec.com>`) and give BT some more to worry about.

Teachers and other educators who need to teach about the Internet - how to use it, what it is and so on - would do little better than starting with surfing to `<http://www.capecod.net/schrockguide/begin97/index.htm>`. Kathy Schrock's guide to the Internet is a good, complete general-purpose introduction to the many facets of the Internet, and will provide a ready-built course that teachers can use as the basis of their teaching. It's also a good way to brush up on your own knowledge, as even those who feel at home on the Internet will find information that's of use.

Example of FTP Archive
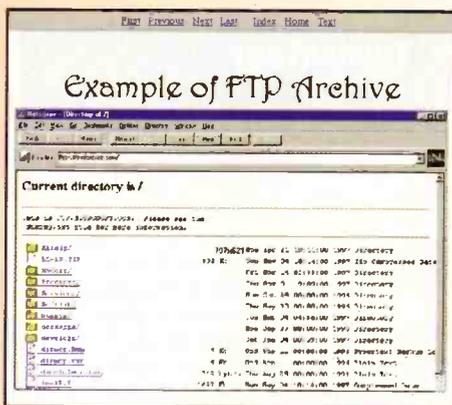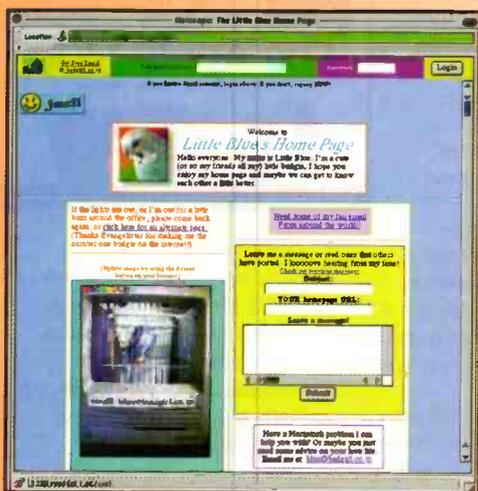
Call Waiting on the Internet

Lucent Technologies at `www.lucent.com` has developed software that enables users to receive a call-waiting message on their computer screens while they're using the phone line for data access or the Internet. If a call comes in, a message pops up on the screen and the user can choose to ignore it or log off and take the call.
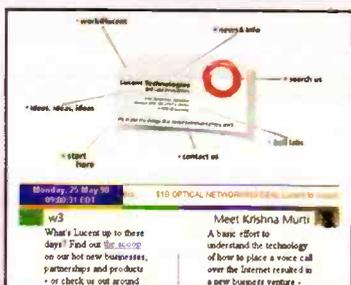
The software will be available this summer.

Excite in Deal With Netscape

Online directory service Excite at `www.excite.com` is set to pay Netscape at `www.netscape.com` almost £44 million for the privilege of providing some of the search services that Netscape plans to make available to users of its home page. Excite hopes to recoup the investment through advertising on the pages it delivers to people using its search engine.

The alliance between the two companies is aimed at unseating Yahoo!, which ranks as the most popular site on the Web. At the end of the two-year deal, Netscape and Excite could revert to full-fledged competitors, as both of them number among the top five most heavily trafficked sites on the Web.

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