THE MAPLIN MAGAZINE

ELECTRONICS and Beyond

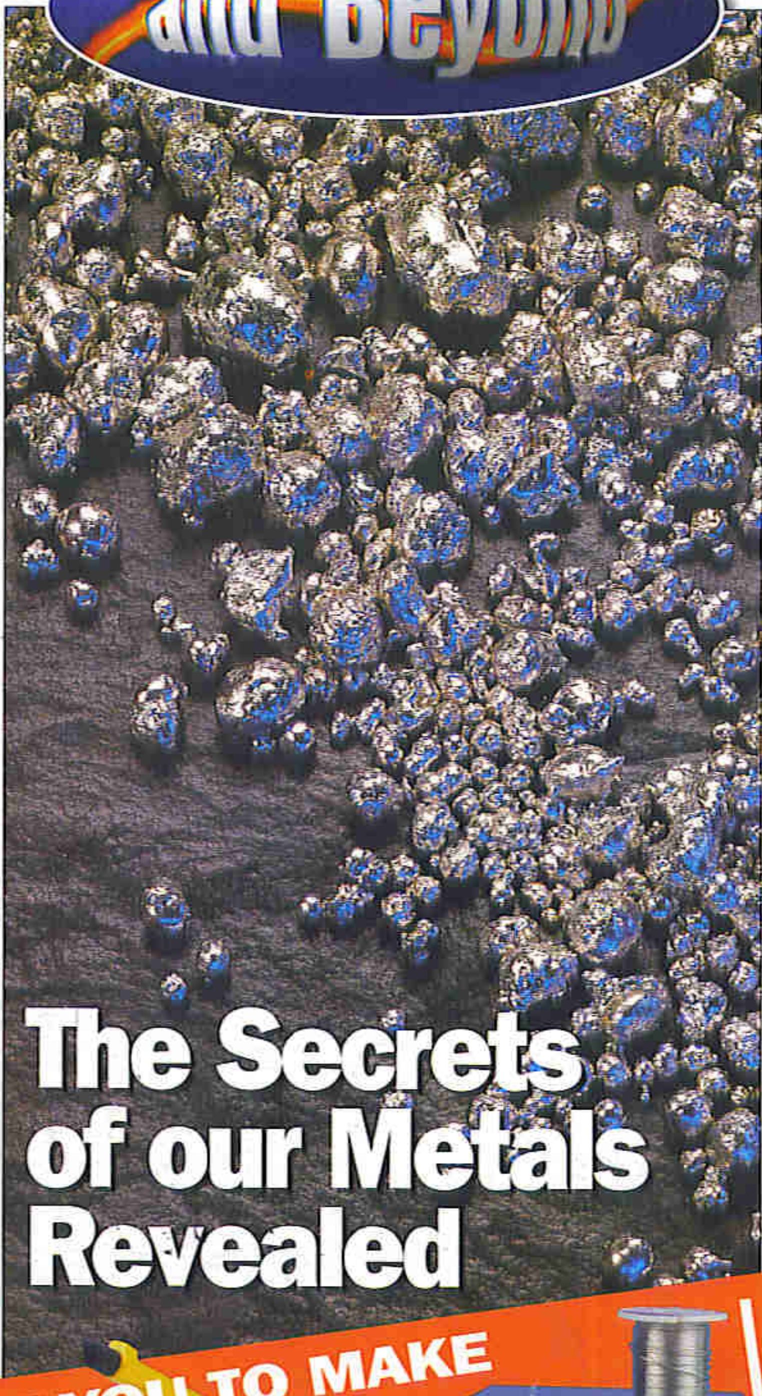
AUGUST 1997 NO. 116 £2.65

http://www.maplin.co.uk

Mars Pathfinder Expedition

A Giant LEP for Mankind?

A Look at Light Emitting Polymers



The Secrets of our Metals Revealed

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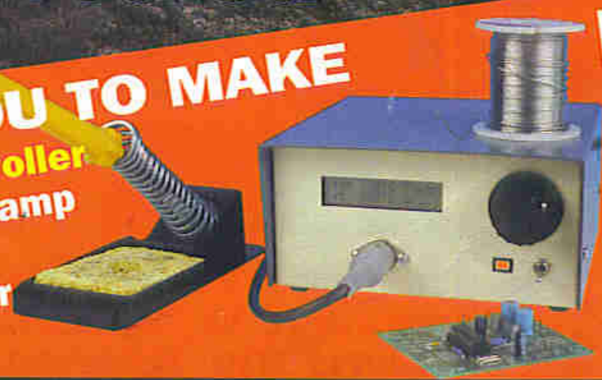

WIN A TEKTRONIX DIGITAL MULTIMETER

See inside for details

Britain's most widely circulated magazine for electronics!

THE MAPLIN MAGAZINE
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Regulars

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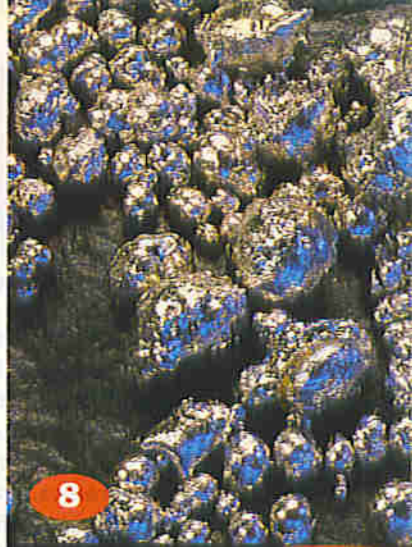
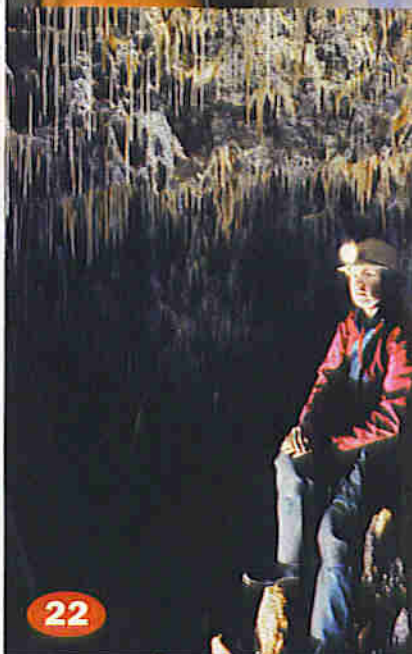




ELECTRONICS and Beyond

It's time once again to research the views of readers of Electronics and Beyond and others interested in electronics, science and technology. We have put together some questions within the centre pages that will hopefully find out the trends and changes in electronics. Magazines have to live and change with the times and the popular requirements of its readers and potential readers need to be taken into account. Please do fill in this brief questionnaire and as a bonus when you return it to us completed (no stamp required) you will be entered for a prize draw. You could win a Tektronix DMM916 Digital Multimeter for your efforts. Ten runners up will each win a subscription or subscription renewal to the magazine.

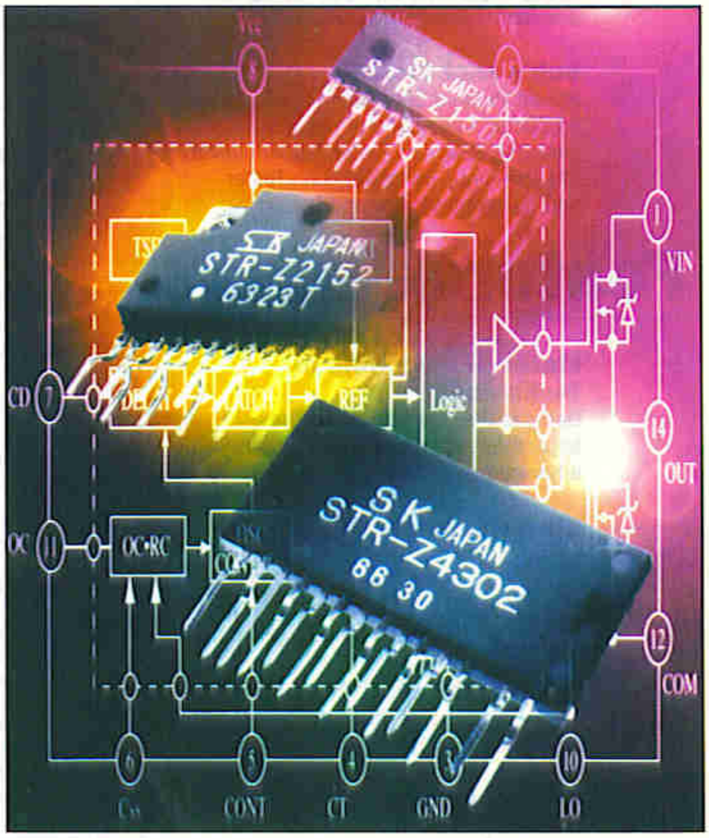
Competition

Finally, our congratulations go out to the following 10 winners who will each receive a copy of Short Wave Listeners Guide by Ian Poole, they are: G Sterling of Mitcham, J Ault of Bournemouth, W Anderson of Welwyn, N Tree of Bristol, I Clarke of Ellesmere Port, D Fricker from Maldon, E Guizzetti from Penrith, P Meinertzhagen of Sevenoaks, K Howard from Ashford and K Wanza from Ealing, London.

Paul Freeman-Sear, Publishing Manager

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT



Low Side Driver IC for Automotive Applications

A quad low-side driver IC from Allegro has been designed to provide a solution for driving relays and solenoids in automotive applications. The device, which can also be used for driving low-current incandescent lamps, has four outputs, each fully protected up to minimum sustaining voltage of 40V and capable of sinking 300mA in the 'on' state. Contact: Allegro, Tel: (01932) 253355.

Digital Radio Timetable

The Radio Authority has published the timetable for digital commercial radio, which is set to bring a new generation of up to 20 radio services on-air by 1999. In a letter to the Commercial Radio Companies Association (CRCA), the Radio Authority outlined the likely timings for its plans.

The Radio Authority has also announced funding of £100,000 for further 'field trials' of the new technology to heighten the accuracy of frequency planning for the new services across the country.

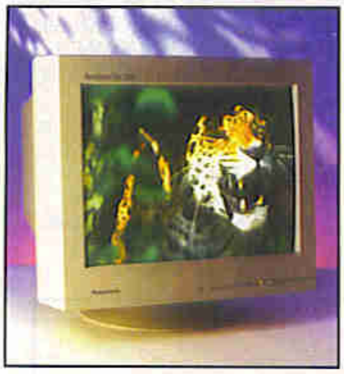
Contact: Radio Authority, Tel: (0171) 430 2724.

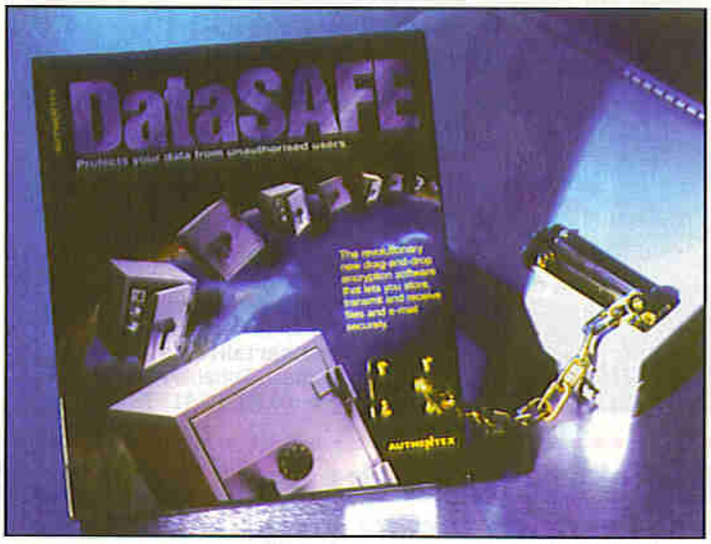
NEWS BYTES

Monitors Matter

The Computing Suppliers Federation (CSF) has launched a booklet entitled *The Definitive Guide to a Healthy Monitor*. It explains the key elements that determine display quality and the factors that impact users. The booklet is bundled with a software utility called CheckScreen that enables individuals to test an existing monitor or a prospective purchase. For a copy of the booklet, contact the CSF direct.

For further details, check: **www.csf.org.uk.**
Contact: CSF, Tel: (01905) 613236.





Desktop Security

Authentex-DataSAFE from Cross Atlantic enables users to store, receive or transmit information over the Internet and secure it on a PC or LAN server. As with a real safe or vault, users can place locked safety deposit boxes containing different files inside the safe, and then give people access to just one or more of the safety deposit boxes within the safe. The effect is like having secure subdirectories on a hard disk. Authentex-DataSAFE carries a recommended price of £59.99.

For further details, check: **www.crossatlantic.co.uk.**
Contact: Cross Atlantic, Tel: (0171) 228 7036.

Digital VHS Due Soon

VCRs capable of recording digital signals transmitted from direct-broadcast satellites and other digital sources should be available by the end of the year according to JVC, the company that developed the original VHS format. The D-VHS format will enable up to seven hours of TV programming to be recorded on a tape similar to a regular VHS tape, and will also record conventional analogue television.

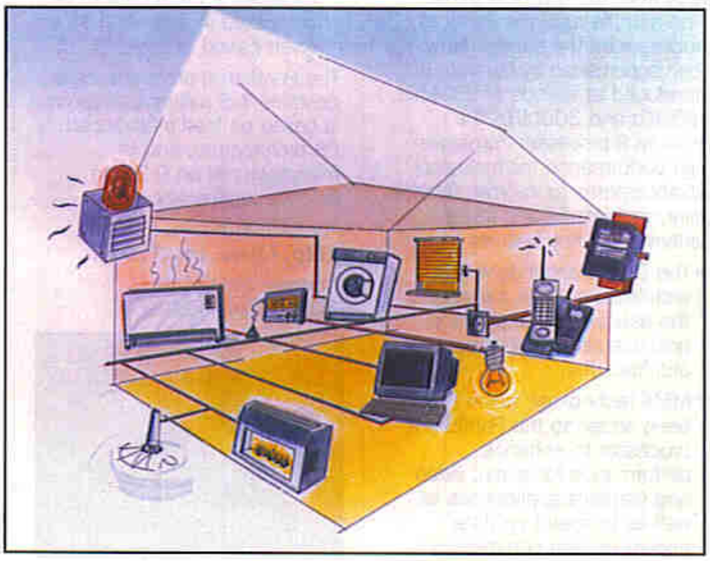
For further details, check: **www.jvc-america.com.**
Contact: JVC, Tel: +1 800 252 5722.

Online Home Control

A new integrated power line modem from Philips Semiconductors allows household electrical appliances to be controlled from anywhere within the home via the mains wiring system. The TDA5051 Home Automation Modem is designed for the transmission of digital signals on power lines or any two-wire DC or AC network.

Envisaged application areas for the TDA5052 include the control of light dimmers, washing machines and dishwashers as well as security/fire alarms and heating control systems.

For further details, check: **www.semiconductors.philips.com.**
Contact: Philips Semiconductors, Tel: +31 40 272 20 91.



Legal Suit Claims Intel Infringed Digital Patent

It can be no coincidence that Digital timed the announcement of a legal suit against Intel for the alleged infringement of ten Digital patents to coincide with Intel's launch of the Pentium II.

Digital alleges that Intel's patent infringement has caused it economic injury and, if not stopped, would cause irreparable harm. If passed, the injunction would prohibit Intel from using Digital's patented technology in its present and future microprocessor products.

The patents cited in Digital's lawsuit protect Digital's innovations in high-performance computing architecture and microprocessor technology. The patents relate to technologies – cache management, branch prediction and high-speed instruction processing – which are vital to state-of-the-art microprocessor design.

For further details, check: www.digital.com.
Contact: Digital, Tel: (01189) 868711.

PC Sales Show Modest Growth

European PC sale showed a steady growth of 11·6% in the fourth quarter of 1996, following the third quarter's rate of 12·4%, according to Dataquest.

Julio Abella, analyst for Dataquest's Personal Computers Europe program, told *Electronics and Beyond*, "This growth was modest compared with 20·5% in the fourth quarter of 1995. While Germany was strong, the UK was weaker, growing only 11·1% – just below the Western European average".

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

Shrinking Chip Circuitry

Chip manufacturer, VLSI, has developed a way to make computer chips with lines of circuitry just 0·2μm in width. The announcement catapults VLSI to the top of the pile in the ongoing competition to pack more circuitry onto an integrated circuit. VLSI's previous best effort was 0·35μm, and even the most advanced competitors, such as Intel and Motorola, are just now shifting to 0·25μm production.

For further details, check: www.vlsi.com.
Contact: VLSI, Tel: (01908) 667595.

NEWS BYTES

3D Simulation Brings San Francisco Bridge Designs to Life

With help from real-time 3D graphics technology developed by Silicon Graphics and Coryphaeus Software, transportation engineers are able to view the intricacies of a handful of proposed designs for the new San Francisco Bay Bridge.

Three new designs for the Bay Bridge – which was severely damaged by an earthquake in 1989 – have been recreated digitally using a 3D urban simulation solution from Coryphaeus and running on Silicon Graphics systems.

The bridge simulations allow civil engineers and government officials to actually 'fly through' three designs under consideration for the proposed $1·3 billion reconstruction of the landmark bridge's Eastern Span, which stretches from Oakland to Yerba Buena Island.

Developed using Coryphaeus Software's new MetroSim urban simulation software and a Silicon Graphics Onyx2 InfiniteReality high-end graphics system, the immersive and realistic simulations are more powerful than precreated animations, because viewers can go wherever they want and see the bridge and its surroundings from any angle.

For further details, check: www.sgi.com.

Contact: Silicon Graphics, Tel: (07000) 745 4266.

Mobile Communications Users Benefit from Changes to Mobile Rates

Ovum is warning telecommunications operators globally that interconnect arrangements between fixed and mobile networks are set to change dramatically. A combination of forces will bring about these changes – the growing interest of regulators in cost-based interconnect, a fall in mobile prices as mobile moves centre stage, and increased competition between mobile and fixed services. However, Ovum predicts that customers of mobile and fixed networks will benefit most from these changes as prices drop.

Robert Hall, head of Ovum's Competition and Regulation Group, told *Electronics and Beyond*, "The mobile industry has experienced explosive growth over the last three years and services have commanded significant premiums over fixed networks. A typical mobile call can cost up to three times that of the equivalent long-distance call on the fixed network. This has meant that mobile is the highest value and most profitable part of the total telecomms market."

For further details, check: www.ovum.com.

Contact: Ovum, Tel: (0171) 312 7238.

Upgrade PC Cards across Networking Range

Portable Add-ons has upgraded its network and combined modem products to handle 33·6k-bps. The three new products are the combined Net Mobile and TR Mobile network adapter/modem PC Cards and the Ethernet+ Full Duplex network adapter PC Card.

For further details, check: **www.portable.co.uk.**

Contact: Portable Add-ons, Tel: (01483) 241333.

Bank of America and Visa Launch Test of Visa Cash Internet Payments

Giving consumers and vendors an online equivalent to cash and coins for small purchases, Bank of America and Visa International is to conduct a comprehensive test of stored-value chip card transactions on the Internet beginning this summer.

Several hundred employees of Bank of America and Visa will participate in the pilot program, using reloadable Visa Cash stored-value chip cards and their PCs to purchase goods from participating vendors on the Web.

Virtual or online purchases with a Visa Cash card will operate similarly to those made with the stored-value card at physical merchant locations. After adding value to the Visa Cash card, a cardholder browsing Web sites can insert a Visa Cash card into a card reader attached to the PC, and with a click of the mouse, approve the transaction after reviewing the cards balance and purchase amount. The transaction amount is deducted from the card's chip, and then captured by the merchant's payment server for settlement.

The Bank of America and Visa electronic commerce trial for chip-based micro-payments is the first of three Internet-related chip-card programs scheduled by Visa this year. Smart Commerce Japan, a government- sponsored initiative involving Toshiba and financial institutions, is expected to commence in Tokyo this fall. In France, Project e-COMM, a consortium co-founded by Visa, will test Internet payments with chip cards and the Secure Electronic Transaction (SET) protocol later this year.

For further details, check: **http://www.bankamerica.com.**

Contact: Bank of America, Tel: (0171) 634 4770.

Business Wire Commercial Photo

Intel Launches Second Generation Pentium

Product life cycles are becoming ridiculously short. The next best thing is only ever a few months away from the last best thing. Nine months ago, the Pentium processor hit the streets. Now, it's been superseded by Pentium II. Introduced at speeds of 233MHz, 266MHz and 300MHz, the Pentium II processor combines high performance technological advancements to improve floating point, multimedia and integer performance. Key features include:

- The Dual Independent Bus architecture which addresses the bandwidth limitations of previous-generation processor architectures.
- MMX technology, which has been added to the Pentium II processor to enhance performance for audio, video and graphics applications as well as to speed up data encryption and compression.
- Dynamic Execution technology, which extends the raw performance of the processor by allowing more data to be processed in parallel in a given period of time.

The Pentium II processor core contains 7·5 million transistors, is based on Intel's advanced P6 architecture, and is manufactured on 0·35μm process technology.

For further details, check: **http://www.intel.com.**

Contact: Intel, Tel: (01734) 403000.

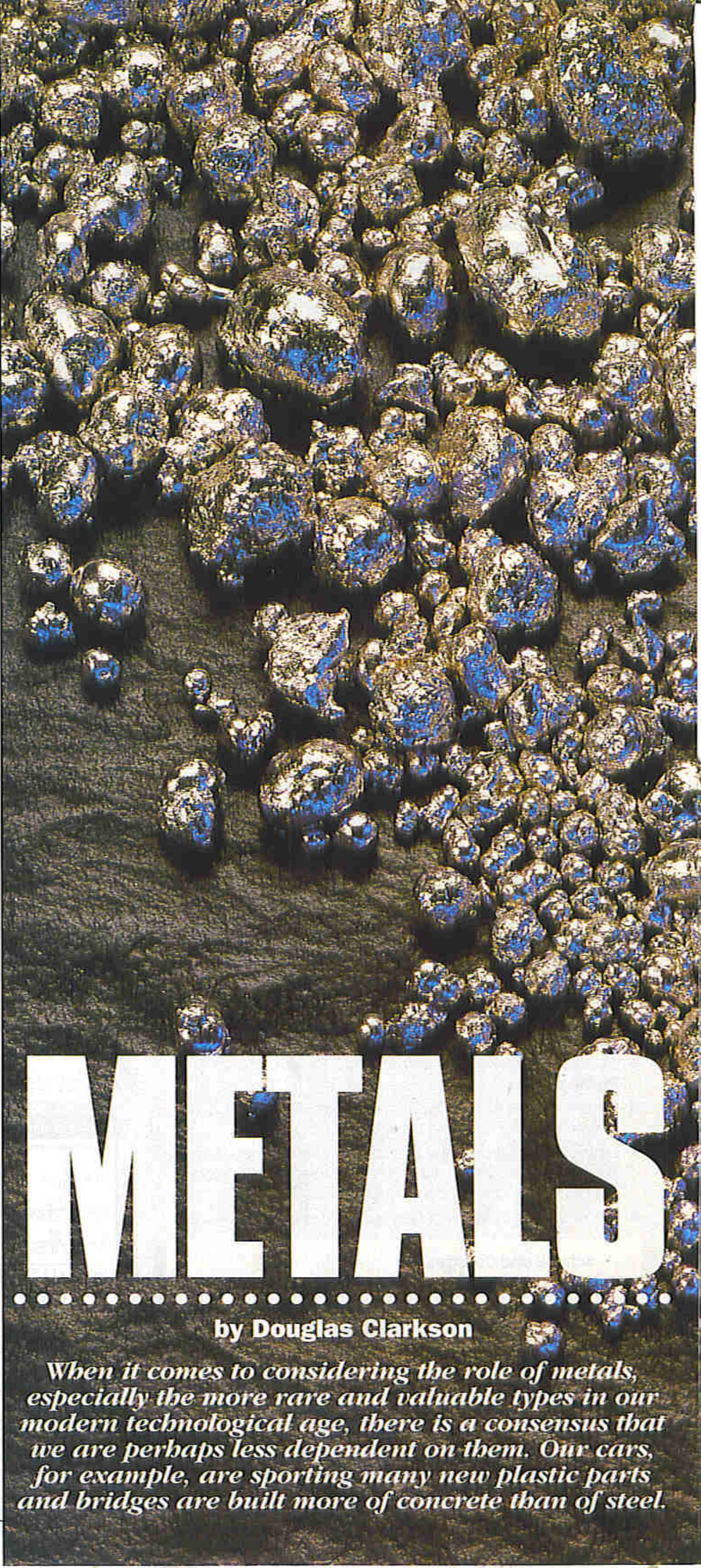
VidModem Sends Two-way TV over Phone Lines

US-based Objective Communications has patented a signal-processing technology called VidModem that can accommodate simultaneous two-way video, voice and data over the standard copper telephone lines already found in homes and businesses.

VidModem transmits via an FM signal rather than the AM signals used to transmit most television programmes over the airwaves or via cable. The technique uses compression technology to squeeze the 24MHz FM signal into the 20MHz bandwidth that the phone wires can handle. The company plans to start shipping a commercial system by the end of the year.

For further details, check: **www.objectivecom.com.**

Contact: VidModem, Tel: +1 800 403 2787.



METALS

by Douglas Clarkson

When it comes to considering the role of metals, especially the more rare and valuable types in our modern technological age, there is a consensus that we are perhaps less dependent on them. Our cars, for example, are sporting many new plastic parts and bridges are built more of concrete than of steel.

As the range of technologies continue to expand, in particular, those of optical and semiconductor technology, new metal elements find key and novel applications. These tend to be hidden within the product, however, so that their use goes unannounced.

Key elements are very much in evidence in the rapidly developing electronic and optical technologies where, for example, the Platinum group metals are finding increasing application in manufacture of surface mount technology and Rare Earth metals as components of lasers and specialist optical fibre amplifiers for use in telecommunications.

It is useful, therefore, to call up details of a selection of metal elements – some familiar and some certainly not familiar – and to briefly relate these to applications.

Elements are typically described by position in the periodic table of the elements. This gives a systematic classification of elements using periods – basically in a horizontal arrangement of 7 periods and of 16 groups configured vertically. In addition, elements can be referred to by groups such as the Carbon group and Zinc group, etc., where sets of elements are grouped as having similar chemistry.

Beryllium (Be)

This metal has been used as a filament material for lamps and ion lasers such as argon and krypton. The metal can also be used as an alloy, principally with copper with between 0·5 and 2·0% of the Beryllium to produce an alloy as strong as mild steel. Beryllium, however, is highly toxic and has to be worked with great care.

Copper Beryllium (Cu98/Be2) is used in tubing where corrosion resistance is required. The oxide of Beryllium (BeO), called Beryllia, is used in specialist applications where high thermal conductivity and high volume resistivity are required. One specific use is for thermocouple tubes.

Cadmium (Cd)

Cadmium, discovered by Friedrich Stromeyer in Gottingen, Germany in 1817, is mainly extracted from Zinc ores. The use of more environmentally acceptable Ni-MH rechargeable batteries (higher capacity but at greater cost), may in time see a reduction in use of Cadmium for this application. Cadmium, however, is a fairly rare metal, with an occurrence of 0·011ppm in the Earth's crust. If battery vehicles mature, they will not be based on Cadmium technology. Nickel Cadmium batteries utilise electrodes of Nickel Hydroxide and Cadmium using an aqueous solution of Potassium Hydroxide. Nickel, however, is around five times as expensive as Manganese, lead, zinc and other materials used for existing battery technology.

Cadmium sulphide is used as a photoresistive material in a range of components. Typical resistances vary from around 5kΩ at light levels around 10,000 lux (fairly bright sun) to around 1MΩ at light levels around 10 lux. This material is principally sensitive to the wavelength range 480 to 690nm.

In the early days of power distribution, alloys of copper containing about 0·8% of Cadmium were used for long span overhead power lines. This resulted in a reduction in conductivity of around 10% but with a significantly increased tensile strength. Steel-reinforced Aluminium, however, is now the preferred material for such cables. Copper-cadmium alloys, however, still find

Photo 1. Grains of Palladium (Courtesy Johnson Matthey).

application where high structural strength and high current carrying capacity is required, e.g., in railway electrification.

Cobalt (Co)

Cobalt, discovered by G. Brandt in 1735 in Sweden, finds a wide range of uses, principally as an component in the composition of alloys.

One important application of this metal is its alloying with the rare earth metal, Preseodymium. Such alloys find ready application in motors of all types. Zaire in central Africa is a major producer of this metal but fluctuations in its world commodity price have had a destabilising influence on the country. Kovar (Fe54/Ni29/Co17) is used as a glass sealing alloy for sealing to hard borosilicate glasses.

Gallium (Ga)

This soft silvery white metal, discovered in 1875 by P. E. Lecoq de Boisbaudran in Paris, has found widespread application in semiconductor fabrication and in production of optical components such as LEDs and miniature electroluminescent displays. The metal is also used in formulation GaP (Gallium Phosphide) and GAsP (Gallium Arsenide Phosphide) as a photodetector material.

Early LEDs were constructed from GaAsP for 655nm red light. Subsequently, GaP green and red and GaAsP orange/yellow and high efficiency red were developed, followed by GaAlAs high efficiency types. Blue lasers and photodiodes are being developed using Indium Gallium Nitride and also Gallium Nitride. Such technology will be used to increase the density of storage of a wide range of mass storage devices.

With the advent of blue LEDs, work is underway to generate 'white' light sources using a mix of red, green and blue LEDs. Could this be the light source of the future? In theory, an array of miniature light sources could be controlled in sophisticated ways which conventional Tungsten filament lamps never made possible.

The metal is a liquid over a wide temperature range between 30 and 2,070°C. In exotic research applications, liquid Gallium has been used as a detector of solar neutrinos.

Lithium (Li)

This metal, with a density of only 0·534g/cm^3 – approximately only half that of water, is a soft, silvery metal. As the first member of the alkali group of metals which include Sodium and Potassium, it is only mildly reactive in air and water – forming a coating of black oxide. Lithium is used as an alloying agent with Aluminium and Magnesium for the production of light, ductile alloys. An alloy of Aluminium containing 2·5% lithium, 2·4% copper and 0·75% Magnesium provides a 10% reduction in weight and a 10% increase in structural strength – providing a 15% weight saving in replacement of aluminium of standard characteristics. Such savings are critical factors is the design of all aspects of air and space technology. The metal is generally stable under oil to prevent oxidation.

For the long term, rechargeable Lithium batteries are showing promise, following the launch by Sony Energytec of a rechargeable Lithium 'rocking chair' battery for portable electronic equipment. Being a light element, these batteries tend to have a good value of watt-hours per kg, though the relatively low conductivities of Lithium ions tends to be reflected in lower levels of peak power.

In the Lithium cell, one electrode is formed from Manganese oxide while the other is made of carbon. Current discharge follows the natural migration of Lithium ions to bind more strongly in the current collector electrode made of Manganese oxide. Essentially in this design, there is no chemical reaction taking place, so the number of potential charge/discharge cycles is relatively great. The open circuit voltage of a Lithium cell tends to be around 3V. Such cells demonstrate low levels of self-discharge – typically less than 1% loss per year.

While most Lithium consists of the isotope of mass number 7 (at 92·5%), Lithium 6 has a large cross-section for absorption of neutrons and consequently is used for control rods in nuclear reactors.

Manganese (Mn)

This metal is extensively used in the production of steel but is also a key component of alkaline batteries, where the cathode is composed of Manganese Dioxide and the anode is made of Zinc powder. It is never well explained why there is such a great price range in alkaline cells – even for the same package size. With a nominal voltage of 1·5V, these cells have a self-discharge rate of approximately 3% per year.

Mercury (Hg)

Mercury has been extensively used in scientific instruments such as thermometers, barometers, blood pressure measurement units, discharge lamps and vacuum pumps. Mercury tilt switches are still manufactured. The chemical symbol Hg is derived from the Latin 'hydragyrum' meaning liquid silver. One of the most widely used application of mercury today is in fluorescent light tubes. The use, however, of Mercury in other areas has reduced significantly due to the general level of toxicity. The usefulness of Mercury in thermometers, etc., is due to its relatively large coefficient of expansion – 61 parts per million per degree centigrade. In the Mercuric oxide battery, the cathode is composed of Mercuric oxide and the anode of zinc powder. With a nominal voltage of 1·35V and a self-discharge rate of around 2%, care has to be taken in the disposal of these cells.

Niobium (Nb)

Initially discovered by C. Hatchett in London in 1801 from a sample of ore from Connecticut and initially named Columbium, Niobium is a silver coloured metal which is found generally together with Tantalum. The pure metal is very reactive and forms a stable oxide which enhances its corrosion resistance. The greatest use of Niobium is as an alloy for use in apparatus at high temperatures, on account of its high melting point of 2,468°C. When combined with compounds of Tin and Zirconium, the resulting alloy demonstrates a high degree of superconductivity.

Niobium Titanium alloys have established themselves as the superconductor of choice in the 1960s.

Osmium (Os)

No list of metals would be complete without reference to the metal Osmium, the heaviest of all elements with a specific gravity of 22·5g/cm^3. A cube the side of 35·5cm would weigh a metric tonne (1,000kg).

Osmium, however, is highly reactive in air and forms a pungent metal due to the formation of a volatile oxide – Osmium Tetroxide. Osmium forms naturally occurring alloys with Iridium (Osmiridium) which are extremely hard and used for tips of pen nibs. Osmium was discovered by the chemist, Smithson Tennant, in London in 1803.

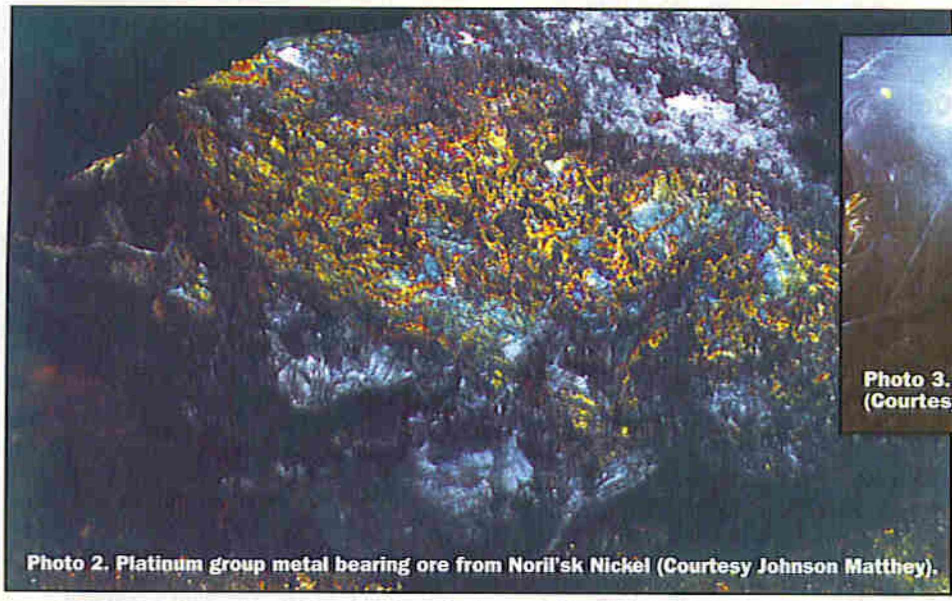


Photo 2. Platinum group metal bearing ore from Noril'sk Nickel (Courtesy Johnson Matthey).

Photo 3. Underground drilling at Lonrho Platinum Division (Courtesy Johnson Matthey).

Plutonium (Pu)

Whether we like it or not, Plutonium is a product of our modern technological age. If there ever was a time, several billions of years ago, when new matter was created in the Universe and Plutonium was then created, then with a half life of 26,000 years and more than a million half lives later, there would be in all probability no atoms of the element left. In 1941, however, Plutonium was created by bombarding Uranium atoms in a cyclotron, in order to create a fissile material. Today, in the aftermath of the Cold War, the world has a growing stockpile of the metal as warheads are decommissioned. Just as the metal is difficult to create, it is also difficult to get rid of and remains a liability due to a host of associated dangers.

Selenium (Se)

Selenium, discovered by J. J. Berzelius of Sweden in 1817, demonstrates strong photoelectric properties. It is not a very robust element, however, with a melting point of only 180°C. Early work of Alexander Graham Bell with his 'phonophone' used Selenium cells to transmit audio signals using modulation of light. Various discrete electronic components contain Selenium and are provided with appropriate safety warnings.

Zinc Selenide compounds have been investigated by Toshiba for generation of blue light, though Gallium Nitride technology looks more promising. Zinc selenide is used as a material for transmission of wavelengths between about 0·8 and 10μm.

Tantalum (Ta)

This metal has widespread applications in the electronics industry. The metal was first discovered in 1802 by A. G. Ekeberg in Upsalla, Sweden, though pure samples were first isolated by the German scientist, Verner von Bolton, in 1903.

The initial application of Tantalum was as a material for filament lamps, though the highly stable, non-corrosive metal has also been used for many medical implants such as pacemakers and bone screws.

The ability of Tantalum to survive corrosive environments at high temperatures has resulted in the metal being used extensively in the chemical and pharmaceutical industry. The use of Tantalum in thin foil form has allowed capacitances to be made around one fifth the size of conventional Aluminium foil types.

Tungsten (W)

Tungsten was first isolated by J. J. and F. Ehuijar in Vergana, Sweden, in 1783, though it was not until 1870 that Robert Musket, an associate of Henry Bessemer, became aware of the metal's ability to form alloys capable of cutting hard materials at speed.

The high melting point of Tungsten renders it valuable as a material for electron filaments. The pure metal is lustrous and silvery white in colour. The melting point of 3,410°C implies a natural limit to the spectral 'temperature' of lamps using such filaments. In particular, it means that such material cannot be used to directly simulate the solar spectrum, which has an equivalent 'spectral temperature' of around 6,000K.

Rare and Valuable Metals

Palladium (Pd)

This interesting metal, discovered by W. H. Woolaston in London in 1803 is a member of the Platinum group of metals. The properties of Palladium are still being extensively studied across a range of emerging technologies. Palladium was very much the metal centre stage of the scientific controversy of Cold Fusion.

Palladium demonstrates good corrosion resistance but not as good as Platinum. The most important property of Palladium is its ability to absorb Hydrogen – up to 900 times its own volume. In industry, it is extensively used as a catalyst for hydrogenation. One of the current uses of Palladium is as a super purity filter for Hydrogen gas, where a diaphragm of heated Palladium will act to exclude gas molecules of greater diameter. To purchase in samples for scientific investigations, Palladium is apparently just as expensive as Platinum. Photo 1 shows grains of Palladium, which is the typical way in which the metal is shipped.

Platinum (Pt)

A key feature of Platinum is its resistance to corrosion and its high melting point. Platinum was known to early South American cultures and was introduced to Europe around 1750. Photo 2 indicates Platinum group metal bearing ore from Noril'sk Nickel. The mineral is generally mined at deep level, as indicated in Photo 3 of the Lonrho Platinum Division.

Platinum is used in the electronics industry extensively, where electrical contacts are likely to be exposed to high temperatures. Presently, Platinum is extensively used as a catalyst to reduce the emissions of car exhausts.

There is also significant interest in the use of Platinum in Proton Exchange Membrane fuel cells, with Johnson Matthey providing technology to Ballard Fuel Cells of Vancouver, Canada. Work entails dealing with primary hydrogen systems and also with systems where methanol is reduced to hydrogen using specialist 'hot spot' catalysts. Photo 4 indicates the fuel cell 'engine' of the Ballard Bus.

Johnson Matthey are also expanding the range of technologies that utilise Platinum. The orally administered Platinum anti-cancer drug, JM216, developed by Johnson Matthey's Biomedical Products group, is proceeding through multinational clinical trials.

Photo 4. The fuel cell 'engine' of the Ballard Bus which utilises Proton Exchange Membrane technology incorporating Platinum catalyst supplied by Johnson Matthey. (Courtesy Ballard Power Systems, Vancouver, Canada.)

Rhodium (Rh)

Rhodium, discovered by William Woolason in 1803 in London, has properties very similar to that of Platinum and in some ways, demonstrates superior performance, being lighter and with a higher melting point. Thermocouples for measuring up to 1,800°C are made from Platinum-Rhodium alloy. The name Rhodium is derived from the reddish colour of compounds which the metal forms. Rhodium is one of the easiest Platinum group metals to electroplate and is used on high duty electrical contacts, plugs and sockets. Rhodium, however, is approximately some 5 times rarer in occurrence than Platinum. Rhodium is used in the manufacture of high quality glass for LCDs on PCs.

Ruthenium (Ru)

This rare member of the Platinum group of metals was initially discovered by J. A. Sniadecki in Poland in 1808. Apparently, the use of Ruthenium is largely related to the demand for Chlorine and its products. Ruthenium is extensively used for coating electrodes used for the electrolysis of solutions for chlorine. Chlorine itself is widely used in the chemicals and plastics industry for chlorinated polymer products such as PVC.

Ruthenium is also used as a metal in the manufacture of resistors for PCSs and mobile phones.

Silver (Ag)

Silver is a metal known to ancient civilisations and has the highest electrical conductivity of all metals. The pure metal is stable in water and oxygen but is attacked by sulphur-containing compounds in the air such as sulphur dioxide, which leave a characteristic black layer of silver sulphide. Each time this discolouration is removed, therefore, some of the silver is lost. Silver is used extensively in the manufacture of electrical contacts and in the silvering of glass and other materials for mirror fabrication. Silver has the highest reflectivity to light in the optical spectrum. The active silver layer is typically sealed under a thin layer of Iconel alloy or copper. Silver finds extensive application in the manufacture of photographic film through the use of the salts AgI, AgCl and AgBr.

Silver oxide batteries are used extensively for quartz watches and have a nominal voltage of 1·55V. In its structure, it has a Silver Oxide cathode and a Zinc powder anode. It is interesting to note that these cells have a self-discharge rate of 5% at 20°C. Could it be that the very act of wearing a watch in intimate contact with the skin raises its temperature and hence that of the battery – causing it to lose its charge faster? Silvered mica capacitances are used in circuits requiring highly stable performance.

Metal	Electrical Resistivity μΩ/cm	Corrosion Resistance (relative)	Melting Point °C	Density g/cm3	Thermal Conduct. W/J/cm2	Occurrence in crust ppm
Gold	2·2	+++	1,064	19·3	318	0·0011
Silver	1·63	++	962	10·5	429	–
Platinum	10·58	+++	1,772	21·5	71·6	0·001
Rhodium	4·7	+++	1,965	12·4	150	0·0002
Palladium	10·8	++	1,554	12·0	71·8	6
Iridium	5·1	++++	2,410	22·4	147	0·000003
Ruthenium	7·7	++++	2,310	12·2	–	0·001

Table 1. Summary of precious and semi-precious metal characteristics.

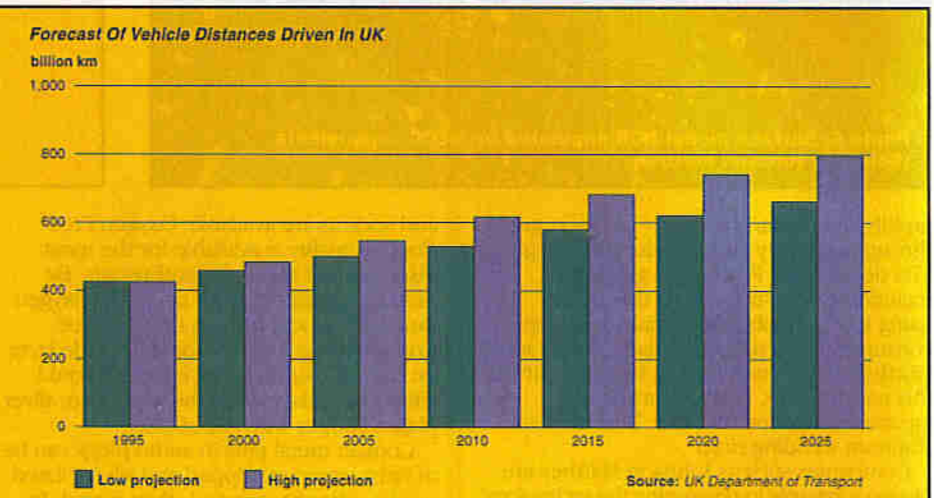


Figure 1. Forecast of vehicle distances driven in the UK (Courtesy Johnson Matthey).

Gold (Au)

This metal, used since the dawn of history to denote wealth, has a unique role in the manufacture of electronic components, especially for contacts of circuit boards and connectors. Gold also has applications in optics, where it is used for mirror coatings for the near, middle and far infra-red. The use of gold provides long lifetime properties, especially in components that are used in satellites. Gold in thin conductive film has been used in laminated glass in windows in aircraft for demisting applications. Gold has a relatively low melting point which makes it relatively easy to 'splutter' onto surfaces.

Iridium (Ir)

This member of the Platinum group of metals has a density of 22·4, second only to the heavyweight Osmium. Applications of Iridium are akin to those of Platinum and include electrodes. Spark plugs of aero engines are now being coated with the metal to provide improved corrosion resistance.

The Voyager space crafts, Voyager 1 and Voyager 2, used Iridium as an ultra-stable shield to contain ceramic spheres of Plutonium Dioxide whose heat of radioactive decay was used to power the crafts. Standard weights also tend to be made from Platinum-Iridium alloy, on account of their ultra low chemical activity.

Crucibles of Iridium are used to grow crystals for electronics applications. The metal does not apparently contaminate the melt material being produced. Platinum-iridium alloys are used in biomedical applications such as heart pacemakers and catheters. Table 1 summarises the key characteristics of this set of metals.

Applications

The use of precious metals for improving performance of contacts is very much a compromise of cost over performance. Silver has the best electrical and heat conductivity, while gold has relatively better corrosion resistance. Platinum has a relatively high resistivity and poorer thermal conductivity, so it is not an obvious choice for high current contacts. Silver contacts can be superior in a sealed environment, e.g., in an enclosed switch. However, with a high level of sulphur dioxide pollution in our air environment, exposed silver contacts may be susceptible to build up of oxide film.

The mining and utilisation of Platinum Group metals is influenced by a wide range of factors. Being a global market, price fluctuations arise from non-uniformity of release of supplies onto the market and changing preferences in range of uses of such materials. As technologies change

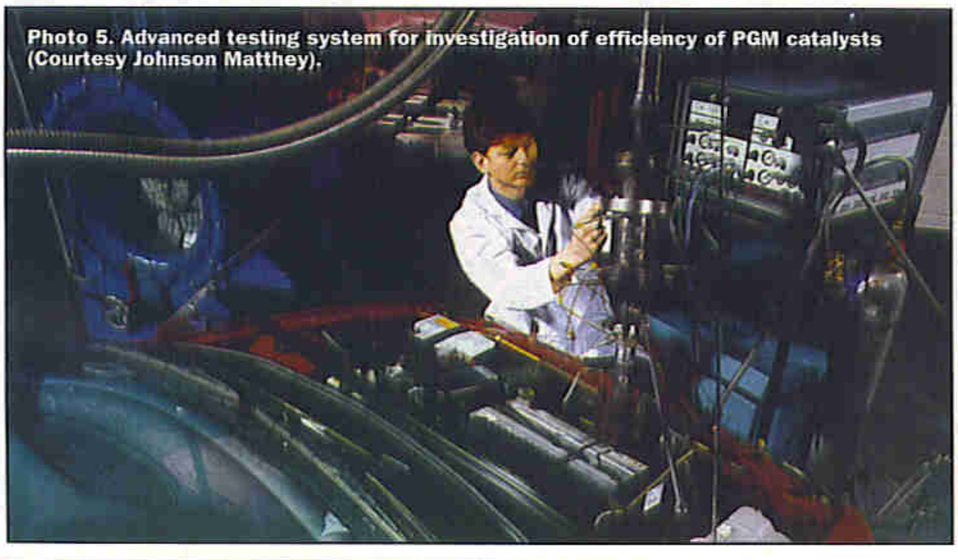


Photo 5. Advanced testing system for investigation of efficiency of PGM catalysts (Courtesy Johnson Matthey).

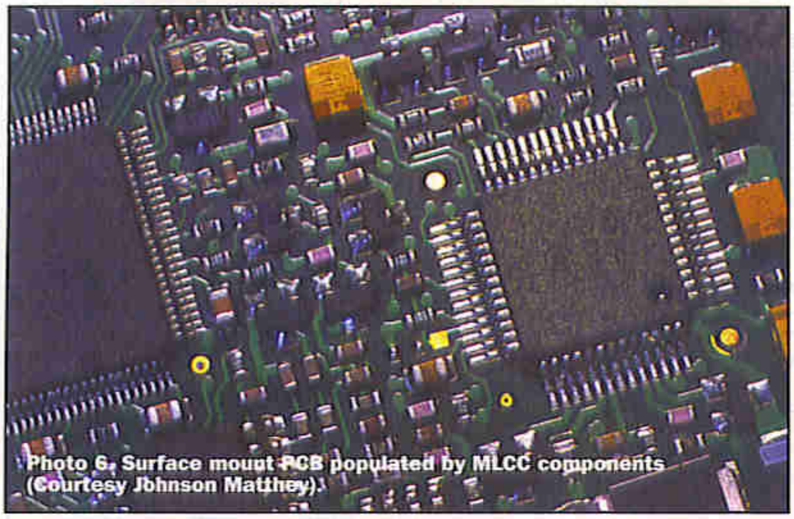
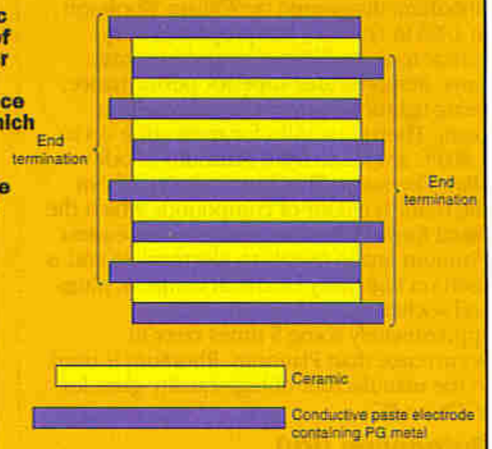


Photo 6. Surface mount PCB populated by MLCC components (Courtesy Johnson Matthey).

Figure 2. Schematic diagram of multi layer ceramic capacitance (MLCC) which typically utilises conductive Palladium pastes.



rapidly, the demand for such products goes through relatively sharp peaks and troughs. The demand for Platinum is generally maintained at a strong level due to the rising level of global industrialisation. Japan consumes more platinum than Europe and North America combined. A large amount of this requirement, however, meets the Japanese whim for Platinum 1000 or pure Platinum wedding rings.

Companies such as Johnson Matthey are playing a key role in developing the technology of Platinum Group Metal catalysts. Figure 1 shows an advanced testing system for investigation of efficiency of such catalysts.

Palladium is certainly a metal reflecting increasing world demand from a range of sources, principally that of electrical components and circuits.

Iridium, having in some ways the best corrosion resistance and the highest melting point, is relatively difficult to work with and is also considerably rarer than gold or platinum.

A key part of the perception of the use of Platinum group metals is that where possible, products containing these metals need to be recycled. With around 20 million ounces of Platinum being used since 1975 for auto catalysts, by the end of 1995, only around 2 million ounces had been recovered. Europe is, however, only slowly establishing a PGM recovery system, with Germany being further advanced in its establishment than any other European country.

The trend is to use Palladium-rich catalysts for petrol cars instead of Platinum rich types and this has significantly increased the demand for Palladium for the autocatalyst sector. Palladium maintains its efficiency at high temperatures – e.g., when engines are run at high speeds on small, fuel efficient cars. In the USA, Ford has introduced Palladium-Rhodium and Palladium on a number of its North American models.

Projections of driven vehicle distances in the UK, shown in Photo 5, confirm almost a doubling in value between 1995 and 2025 at the high end of estimations. This is presumably arising due to an increase in the number of vehicles on the road. Without use of catalysts, the levels of air pollution would certainly become a hazard, although presently levels of pollution are already dangerously high for significant periods of time during the year.

Applications: Everyday Electronics

In many ways, the most demanding contacts are produced for the discerning audio marketplace. A wide range of types of pins and sockets are available. Oxygen Free Copper quality is available for the most discerning of the audio enthusiasts. By preventing copper from taking up oxygen during production, such Oxygen Free Copper is less liable to form an oxide layer on the wire surface which in turn could affect the resistance of the wire. Also, silver plated copper wire is available.

Contact metal pins in audio plugs can be of brass, mercury dipped and silver plated or phosphor bronze and silver plated. In jack plugs, contacts can be of nickel silver. BNC connector bodies tend to be of nickel plated brass. For coax plugs, the body of the plug can be of aluminium in economy option and with nickel plated brass in more upmarket options.

Mains plugs tend to be made of brass with mains sockets in equipment (IEC connector) tin plated brass. Eurocard connectors tend to be gold plated phosphor bronze. A range of metals are used with D connectors, including copper alloy or gold plating over nickel. Grounding posts tend to be chrome plated brass. Wire-wrap wire tends to be silver plated copper. Fuse holder contacts can be nickel plated or tinned brass. Wafer switches can utilise silver plated electrodes.

Specialist Wires

The resistance wire, Constantine, contains typically 55 to 60% Copper and 40 to 45% of Nickel and is the material used in the manufacture of wire-wound resistances. The coefficient of resistance with temperature tends to be +0·00002/°C (20ppm/°C).

The alloy Manganan (Cu86/Mn12/Ni2) is also used as a resistance alloy. Its temperature coefficient tends to be + 0·00001/°C, though its value is not as flat as that of the Constantin alloys and its corrosion resistance is not as good. Manganin, however, tends to be cheaper than Constantin.

Toasters and domestic irons utilise specialist resistance heating alloys that are highly resistant to oxidation. Chromalloy (Fe75/Cr20/Al5), Fecralloy (Fe72·6/Cr22Al4·8/Si03/Y0·3) and Aluchrom (Fe70/Cr25/Al5) are typically used.

Optical Assemblies

Invar (FE64/Ni36) is used where minimum expansion of material is required, for example, in laser assembly systems where optical alignments are required to be maintained. Typical value for coefficient of expansion is around 2×10^{-6}/°C. Typically, Aluminium will have a coefficient of expansion of $23{\cdot}5\times10^{-6}$/°C.

Advanced Optic Systems

Potassium Lithium Tantalum Niobate (KLTN) is being investigated as a photorefractive crystal for electro holography where holograms can be reconstructed by applying voltage signals to a crystal structure. Such technology is being developed for applications which include very large scale optical memory and artificial neural networks.

Surface Mount Technology

A key component of surface mount component technology is the multi layer ceramic capacitance (MLCC), indicated in Figure 2. Typically, a modern PC or digital

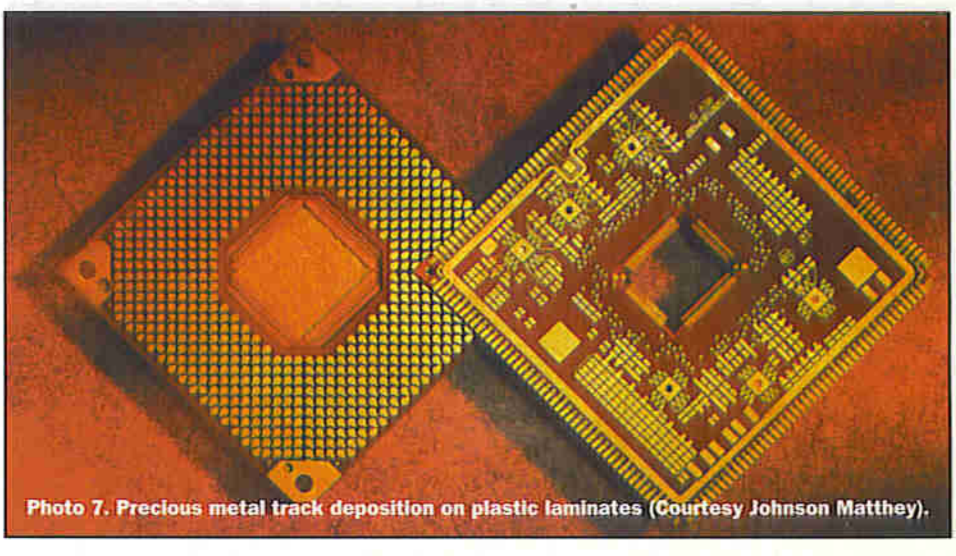


Photo 7. Precious metal track deposition on plastic laminates (Courtesy Johnson Matthey).

Element	Symbol	Atomic Number	Density g/cm3	Melting Point (°C)	Relative Abundance ppm in crust
Cerium	Ce	58	6·75	799	68
Dysprosium	Dy	66	8·54	1412	6
Erbium	Er	68	9·05	1529	3·8
Europium	Eu	63	5·24	822	2·1
Gadolinium	Gd	64	7·90	1313	7·7
Holmium	Ho	67	8·80	1474	1·4
Lanthanum	La	57	6·17	921	32
Lutetium	Lu	71	9·84	1633	0·51
Neodymium	Nd	60	7·00	1021	38
Preseodymium	Pr	59	6·78	931	9·5
Samarium	Sm	62	7·54	1077	7·9
Terbium	Tb	65	8·27	1356	1·1
Thulium	Tm	69	9·32	1545	-
Ytterbium	Yb	70	6·98	819	3·3
Yttrium	Y	39	4·49	1522	30

Table 2. Table of elements of the Lanthanide or Rare Earth group of elements.

mobile phone will contain at least 150 MLCC devices. Photo 6 indicates a typical surface mount PCB with an assortment of MLCC devices.

The device typically consists of between 10 and 50 layers of ceramic sandwiched between ceramic layers. A wide range of conducting pastes are presently used, with higher quality devices using pastes containing 100% Palladium of Palladium-Silver. The high content Palladium pastes are preferred in Japanese 'high fire' soldering techniques, though attempts are being made to introduce cheaper pastes with cheaper metals such as nickel.

This use for MLCC devices of Palladium requires typically around 75% of the annual current world demand of around 3 million ounces.

Hybrid Integrated Ceramics (HIC)

These devices consist of a ceramic substrate on which is mounted various electronic components linked by conductive silver Palladium tracks. These HIC devices prove more rugged than conventional PCBs, since they can safely dissipate more heat and are used in telecommunications, military hardware and engine management systems of vehicles.

Developments in electroplating are contributing to a rapid rise in the use of Palladium nickel alloys with plate thicknesses of around 1μm typically being deposited. The main advantage of this process is the reduction in cost, and the use of Palladium for this application is expected to increase rapidly. Also, Palladium plating is likely to increase as an alternative to traditional solder plating methods.

Precious metal track deposition on plastic laminates, as shown in Photo 7, is a standard feature of high precision, high volume manufacture.

Rare Earths

The Lanthanide series or 'Rare Earths' is a series of metal elements which, for many years, assumed only the status of scientific curiosities. With the advent of developments in modern semiconductor and optical technology, many of these once obscure elements are key constituents of new devices in lasers and fibre optics. Many of the elements in this series were, in fact, identified by Scientists in Sweden and Finland, due largely to the occurrence of minerals bearing these elements being found in this region. The UK is not really a focus of Nordic history and culture, so the significant scientific input of the set of Swedish scientists is not widely known but no doubt, provides an absorbing story.

The chemical properties of the Lanthanides or Rare Earths was for many years a great puzzle, as minerals and derived compounds were, in fact, complex mixtures of Rare Earth metal oxides. The use of the spectroscope from 1859 helped identify elements from specific output of incandescent samples.

Even today, however, there is considerable range in values quoted for a range of parameters of these elements. This is due mainly to variation in purity of samples and the environmental conditions when measurements are made. The key properties of this series are indicated in Table 2.

Various metals of the Lanthanide group find highly specialised applications in the developing fields of solid-state laser crystals and fibre optics. The mineral Gadolinite, containing Gadolinium, was named after the Finnish chemist, Johann Gadolin. The metal was discovered in 1880 by J. C. Galissard in Geneva, Switzerland, and isolated by P. E. Lecu de Boisbaudran in 1886 in Paris. The element presents a silvery white metal which is stable in a dry atmosphere. Gadolinium finds application for its magnetic properties, with magnets containing this element being used in recording heads and various electrical components. Due to methods of production, Gadolinium will typically contain up to 2% of Tantalum. Gadolinium has a very large cross-section for thermal neutrons and is consequently used in the control rods of nuclear reactors.

Ytterbium is named after the Swedish district of Ytterby in the arcipeligo of islands near Stockholm. At the site where the famous rare earth minerals were discovered, mining has taken place for china clay and feldspar. The source of these rare earths would appear to be rocks such as granite that cooled deep in the crust and have subsequently been exposed and weathered. The metal was itself discovered by J. C. G. de Morignac in Geneva in 1878.

The metal Erbium, discovered by C. G. Mosander in 1842 in Stockholm, finds increasing application in laser and fibre optic technology. The metal is itself of silver grey appearance, has a relatively high electrical resistivity and is used in the production of infra-red absorbing glass.

Rare earth elements such as Ytterbium and Erbium are being used to develop specialist phosphors which absorb infra-red radiation and re-emit visible light. While initial applications include tagging of explosives, other potential uses include medical diagnostic use.

Hopefully, the metal Europium, discovered by the Frenchman, E. A. Demarcay in 1901, does not faithfully describe the characteristics of the emerging European Power block. The metal of silvery appearance readily reacts with air and water and so the pure metal has few, if any, applications. The metal has, however, been used to produce thin film superconducting alloys. Its large cross-section for absorption of thermal neutrons has led to its use in control rods of nuclear power stations.

Terbium was discovered by C. G. Mosander in Stockholm in 1843 and also named after the Swedish district of Ytterby. The metal reacts slowly with air and water. Its principal use is as a dopant in the semiconductor industry.

Holmium was discovered in 1878 by P. T. Cleve in Upsalla, Sweden and named after Stockholm. The metal is soft and malleable and is slowly attacked by oxygen and water. The principal use of this Lanthanide is in solid-state laser and fibre optic technology. The Holmium laser, with a characteristic wavelength of 2·4nm, is used in the medical field for the treatment of knee injuries.

While significant use is currently being made of various members of the Lanthanide series, it is entirely possible that other members of the family, as yet largely unused, are pressed into service in the laser/fibre optic technology of the future.

Samarium was isolated for the first time by P. E. Lecoq in 1879 and called after the mineral Samarskite, which in turn was named after the Russian mine officer, Colonel V. E. Samarsky. The metal has a narrow range of uses within the glass, ceramics and electronics industry and especially in the manufacture of permanent magnets as an alloy of Cobalt. Samarium cobalt magnets provide a material of choice for small, high performance devices between 175 and 350°C.

Cerium is a relatively abundant member of the Lanthanides and is also the most reactive – oxidising in air and igniting when heated. It also reacts violently with water. The element, which was discovered by J. J. Berzelius in Sweden in 1803, was named after the asteroid Ceres which was itself discovered in 1801. Cerium is now widely used in fibre optic technology where, in particular, it has been extensively studied as an in-line signal amplifier.

The element Dysprosium, meaning 'hard to get at', was discovered by P. E. Lecoq de Boisbaudran in Paris in 1886. This silvery metal, relatively stable in air, reacts violently with water and dissolves in acids. Its main use is as a component in the manufacture of magnets. Dysprosium has been added as a component to Erbium doped Barium Chloride for visible fluorescence triggered by infra-red radiation.

Lanthanum (the Hidden One), a relatively abundant member of the Lanthanides, discovered by C. G. Mossander, Sweden in 1839, is one of the most reactive of the group. It reacts with water to generate hydrogen gas. In air, the soft white metal oxidises rapidly. Superconducting below 6K, the metal is used to manufacture special grades of optical glass with specific properties relating to refractive index.

Lutetium, named after Leutetia, the Latin name for Paris, demonstrates properties of high density and significant hardness, but is one of the rarest in the Lanthanide group.

Neodymium was discovered by Baron Auer von Weisbach in 1885. Its name means 'new twin' and is linked with the fact that the element was extracted from a material which also contained the metal Praeseodymium (also discovered by the Baron). Neodymium now finds wide application as a material for solid-state lasers and in fibre optic technology. Alloys of boron-iron-neodymium have been developed which demonstrate excellent magnetic properties. Praeseodymium can also be used with neodymium as a component of optical filters of high optical density, e.g., for use with arc welding. Neodymium/Iron/Boron has become a popular if not expensive choice for specialist rare earth magnets.

The Lanthanide Yttrium, discovered by J. Gadolin in Finland in 1794, finds applications as a phosphor to produce the red colour on TV screens and monitors. The element is also a component of solid-state laser crystals in the form of Yttrium Aluminium Garnet (YAG) – see Photo 8. The solid-state laser is typically used to produce a wavelength of 1,032nm, in the near infra-red. Often, this wavelength is used as an input into non-linear crystals in order to achieve frequency doubling and tripling to generate 532nm and 355nm, respectively.

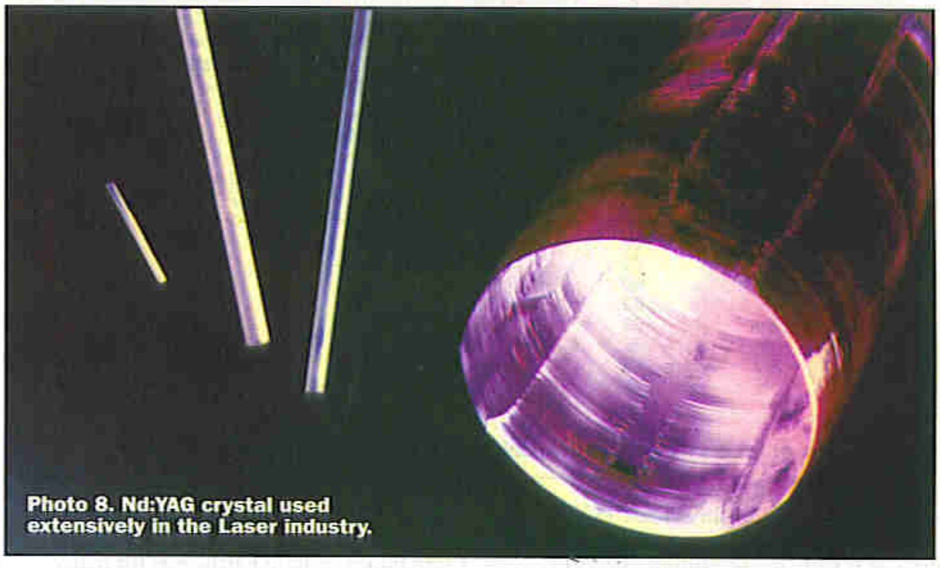


Photo 8. Nd:YAG crystal used extensively in the Laser industry.

Rare Earths in Optics and Magnets

Samarium has been used to dope silica fibres to produce a laser wavelength of 651nm with Erbium, principally 980nm and 1,490nm. Thulium has been used to produce wavelengths around 2,000nm. Holmium has been used to produce wavelengths beyond 2,000nm.

There is very significant interest in the use of the Rare Earth metals in optical technology – especially as dopants for optical fibres for the telecommunications industry. Dopants tend to be added to high purity silica fibres at levels between 500 and 1,000ppm. Thulium has been used to produce laser outputs at around 2,000nm, Erbium principally 980nm and 1,490nm, Samarium at 651nm and Holmium wavelengths greater than 2,000nm. Since, however, energy levels within such doped compounds can accommodate many photonic transitions, a much wider set of wavelengths can be demonstrated though the efficiency of many of these will be low.

The main interest is in the use of repeater 'in-line' amplifiers around the communications window of 1,550nm – the 'long haul' communication wavelength of choice. Erbium has tended to be more widely used since wavelength transitions in this region using Erbium have been easiest to initiate. The key usefulness of the Rare Earths in such optical technology is the great number of energy levels possible in their electron shell distributions.

Commercial interest, however, is centred on transitions that utilise the 1,550nm 'communications window' – the wavelength of choice for transmission through fibre with minimum losses.

Cerium oxide is used as a polishing agent for glass, with large quantities being consumed in the polishing of all types of lenses and also television screens. Glasses containing Lanthanum oxide produce glasses with the attractive properties of high refractive index but low dispersion and are used in the manufacture of high quality optical components of cameras, binoculars and microscopes of all types. The quality of TV screen images has been enhanced due to the use of the phosphor of the oxides of Europium and Yttrium to produce red wavelengths. Rare earths are also used in mercury lamps which produce a radiation similar to daylight. This is in part due to the large number of energy level transitions which excited atoms can relax to compared with Mercury.

Figure 3 summarises the paramagnetic properties of the Rare Earth elements. These elements have no residual magnetic field in the pure element state but randomly aligned magnetic dipoles align up with the establishment of an external magnetic field. The susceptibility term is an expression of the relative ability of the element to demonstrate this process. Elements such as Iron, Cobalt and Nickel are ferromagnetic – i.e., magnetic domains can align without addition of any external magnetic field. The strongest permanent magnets tend to be alloys of these ferromagnetic materials and the elements of the Rare Earth elements.

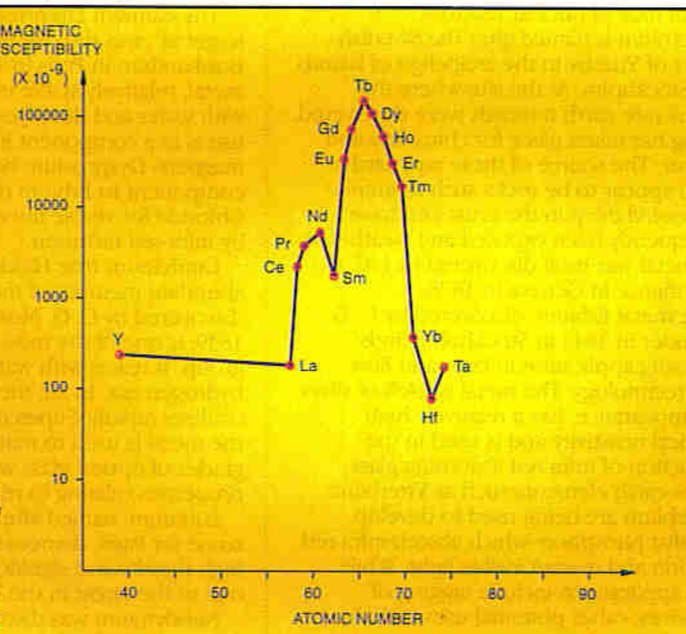


Figure 3. Detail of paramagnetism of Rare Earth elements: values of susceptibility relate to kilogram mole of elements.

Summary

Elements which had been known for over 150 years and came to be regarded as diversions of Nature have been found to exhibit specialist properties in semiconductor and optical technologies. Also, rare metals known to civilisations for thousands of years are increasingly being used to deliver increasing performance from today's electronic technology. Thus, materials science is very much at the cutting edge of new processes and technology. Can anyone spot now the emergent element of the new millennium? Answers please on a postcard to the dealers in the London Futures market.

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Global emissions management, February, 1997, Johnson Matthey, February 1997.
Goodfellow Catalogue 1996/1997.

Points of Contact

Johnson Matthey, 2-4 Cockspur Street, Trafalgar Square, London, SW1Y 5BQ.
Tel: (0171) 269 8400.
Goodfellow Cambridge Ltd., Cambridge Science Park, Cambridge, CB4 4DJ.
Tel: (01223) 568 068
http://www.goodfellow.com.

Diary Dates

Every possible effort has been made to ensure that information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments, please contact event organisations to confirm details.

July 1997

3 July. Year 2000, Bloor Research, The Commonwealth Institute, London. Tel: (01908) 373311.

7 July. European Computer Trade Show, Olympia Conference & Exhibition Centre, London. Tel: (0181) 742 2828.

7 July. Seventh International Conference on HF Radio Systems and Techniques, IEE, East Midlands Conference Centre, Nottingham, Tel: (0171) 344 5469.

11 July. Fifth International Conference on Holographic Systems, Components and Applications, University of Bath, Tel: (0171) 344 5467.

14 July. Summer Social Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

28 July. Construction Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

August 1997

3 August. RSGB National Mobil Rally, Woburn, Bedfordshire. Tel: (01707) 659015.

31 August. Radio Rally, Telford, Shropshire. Tel: (01707) 659015.

September 1997

1 to 3 September. Tenth International Conference on Electromagnetic Compatibility, University of Warwick, Tel: (0171) 344 5467.

2 to 4 September. International Conference on Genetic Algorithms in Engineering Systems: Innovations and Applications, University of Strathclyde, Tel: (0171) 344 5467.

7 September. Document 97, NEC, Birmingham. Tel: (0181) 742 2828.

7 September. GIS 97, NEC, Birmingham. Tel: (0181) 742 2828.

7 September. Voice Europe, Olympia 2, London. Tel: (01244) 378888.

17 September. InControl 97, Olympia Exhibition Centre, London. Tel: (01799) 528292.

17 September. OnBoard ,Olympia Exhibition Centre, London. Tel: (01799) 528292.

17 September. Time 97, Earls Court Exhibition Centre, London. Tel: (01799) 582292.

22 September. European Exhibition on Optical Communications, Edinburgh International Conference Centre, Edinburgh. Tel: (01322) 660070.

22 to 25 September. 11th International Integrated Optical Fibre Communications Conference, ICC, Edinburgh. Tel: (0171) 344 5478.

22 to 25 September. 23rd European Optical Fibre Communications Conference, ICC, Edinburgh. Tel: (0171) 344 5478.

26 to 28 September. RSGB International HF Convention, Windsor, Berkshire. Tel: (01707) 659015.

27 September. The Internet 97 Show, NEC, Birmingham. Tel: (01923) 261663.

30 September. Microwaves, RF & Technologies 97, Wembley Conference & Exhibition Centre, Tel: (01322) 660070.

Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics and Beyond*, P.O. Box 3, Rayleigh, Essex SS6 8LR or e-mail to swaddington@cix.compulink.co.uk.

What's On?

UKCMG Claims Network Computing is Immature

Network-centric computing was the key issue debated at UKCMG's 12th annual conference and exhibition at the Riviera Centre, Torquay from June 3 to 6. During the keynote debate on the last day of the conference, UKCMG chairman, Alan Knight, argued that although network computers are being hyped as a panacea, they are just another immature technology.

"Network-centric computing is just the latest flavour of the month, it will not radically reduce the total cost of ownership of IT-based business systems. If managed correctly, it might produce savings of around 10 to 20%", said Knight.

For further details, check: www.ukcmg.org.uk/ukcmg

Contact: UKCMG, Tel: (0181) 643 7783.

Commission Conducts Secret Investigation

The European Commission has decided that its study into the cost and impact of the proposed Directive on the Sale of Consumer Goods and associated Guarantees should be carried out in secret.

The Personal Computer Association (PCA) believe that there is no real justification for doing this, other than for the Commission to have a better chance of pushing through a damaging, costly and unwanted piece of bureaucratic nonsense. The UK's House of Lords has already rejected the need for the directive while the Department of Trade and Industry has expressed concern that the secrecy decision is not in the spirit of transparency.

The proposed directive would apply to all consumer transactions. It would, among other things, give the consumer the right to select from a menu of remedies in the event of product failure, including money back or retrospective discount, free repair or free replacement up to a year after purchase, and free repair or retrospective discount in the second year. Additionally, the burden of proof would be reversed so that vendors would have to prove there is no fault with the product.

The DTI's provisional compliance cost assessment indicates that there would be non-recurring costs in the UK of approximately £30 million, with annual costs to industry thereafter of £775 million, representing 0·5% of consumer expenditure on consumer goods – excluding motor vehicles. The Confederation of British Industry (CBI) evidence to the House of Lords Committee indicated a figure closer to 2%.

Although the UK's House of Lords has endorsed European industry's view and rejected the need for a directive, the Commission seems hell-bent on ensuring that the legislation is pushed through, which can be done by majority vote – being a 'harmonisation' directive aiding implementation of the common market. The Commission has repeatedly been asked to produce quantified justification of the need for a directive, but has failed to produce meaningful figures. Instead, the Commission has stated that consumers are unsure of their guarantee rights when purchasing from other countries and that this was a major obstacle to cross border sales.

The Personal Computer Association is rightly concerned for its own sector, as there is very little reliable data available, and the estimated cost impact of the Directive on consumer prices will be a massive increase of 50% onto the price of a PC bought for home use.

Contact: Personal Computer Association, Tel: (01763) 262987.

Loughborough Hosts Maze Mouse Final

The 1997 World Micromouse Championship will be held on 5 July at Loughborough University. Mice from around the world will compete for the coveted Brass Cheese Trophies and cash prizes. Time trials will be held during the day to select the most promising mice for the finals.

Micromouse are small electronic robot vehicles able to run in a maze of alleyways. They have the task of exploring, navigating and solving the maze to find the fastest route to the centre, within a 15-minute time limit.

There are three categories in the competition: teenage, intermediate, and advanced. In addition, in 1997, the IEE has launched a new simplified Micromouse competition targeted at schools.

For further details, check: www.iee.org.uk.

Contact: IEE, Tel: (0171) 344 8419.

IBM Launches New Era of Distributed Computing

Flanked by customers and business partners, IBM has announced a breakthrough in enterprise computing, which could extend the life of the estimated $5 trillion worth of software which the world's largest companies rely upon.

The new IBM software uses component technology to untangle, manage and link the maze of disparate computing systems that have mushroomed with enterprise growth.

At its Technical Interchange 97 Conference, IBM unveiled Component Broker Connector (CBConnector) and Component Broker Toolkit (CBToolkit), which allow companies to capture information from mission-critical systems, such as databases, transaction processing systems, and applications, as highly manageable, mix and match components.

These reusable parts, ranging from payroll and order entry to inventory tracking and accounts payable, can be combined to add new capabilities to traditional backend systems, or be used to create new 'killer' applications for the Internet, intranets or extranets.

An estimated 70% of all code written today consists of interfaces, protocols and other procedures to establish linkages among various systems. CBConnector and CBToolkit include the facilities needed to process information requests and make connections, enabling application developers to use their time more productively, to solve business problems.

Charles Schwab, Ford Motor Company, France Telecom, Swiss Bank, and Volvo are among the IBM customers that will be participating in an early installation program.

Swiss Bank, which has more than 300 distributed systems, plans to use CBConnector and CBToolkit for a re-engineering project, Millennium Banking. The bank processes millions of transactions a day. In the next two years, Swiss Bank will migrate banking systems for its domestic operations, including branch banking, into the new system.

Volvo is integrating its different information technology (IT) environments through the Volvo Extended Enterprise (VEE). The company has a long tradition of using, buying, and developing state-of-the-art software to integrate enterprise information needs.

For further details, check: www.software.ibm.com/ad/cb.

Contact: IBM, Tel: (0181) 818 5086.

Digital SOLDERING IRON CONTROLLER

PROJECT

by Dr Mike Roberts

This project provides the opportunity to build a top quality, low voltage soldering iron controller at a fraction of the cost of a commercial unit, with the added features of showing you the measured temperature and the power being applied as well as the set temperature.

FEATURES & SPECIFICATION

- Close temperature control in range 60 to 450°C.
- 50W power available when needed.
- Digital display of set temperature, measured temperature and level of power being applied.
- Low noise circuit.
- Very fast warm up time (30 to 40 seconds).
- Temperature can be adjusted for the solder/task being performed.
- Able to tackle larger jobs.
- Iron can be used for melting/sealing plastics or other low temperature duties.
- Iron element and bits last longer.

Once you have used a temperature controlled iron, you will never want to use a conventional iron again! The fast warm-up and consistent temperature control is fantastic. When you want to do a job, just switch on the controller and by the time you have got the solder out and the wires prepared, the iron is ready to use. If you have a large job, this controller can push out 50W of power, so you can tackle a job needing the equivalent of two 25W XS irons. If you have something more delicate to do like cutting/joining bubble-wrap or applying heatshrink film to tight corners on a model aircraft, just turn the temperature down to what you need.

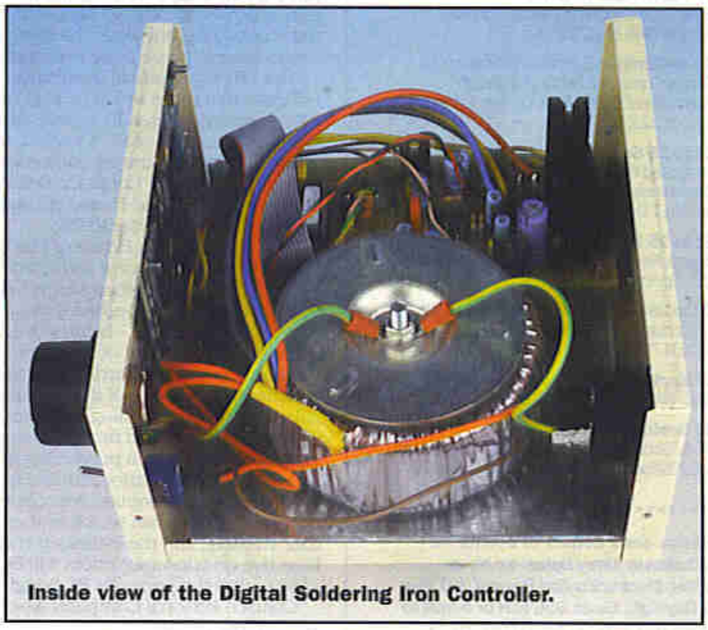
This controller is designed for the Antex TC50 low voltage (24V 50W) iron. It drives the iron with 24V 50Hz power using a zero-crossing switch to apply full half cycles of power with minimum noise.

How it Works

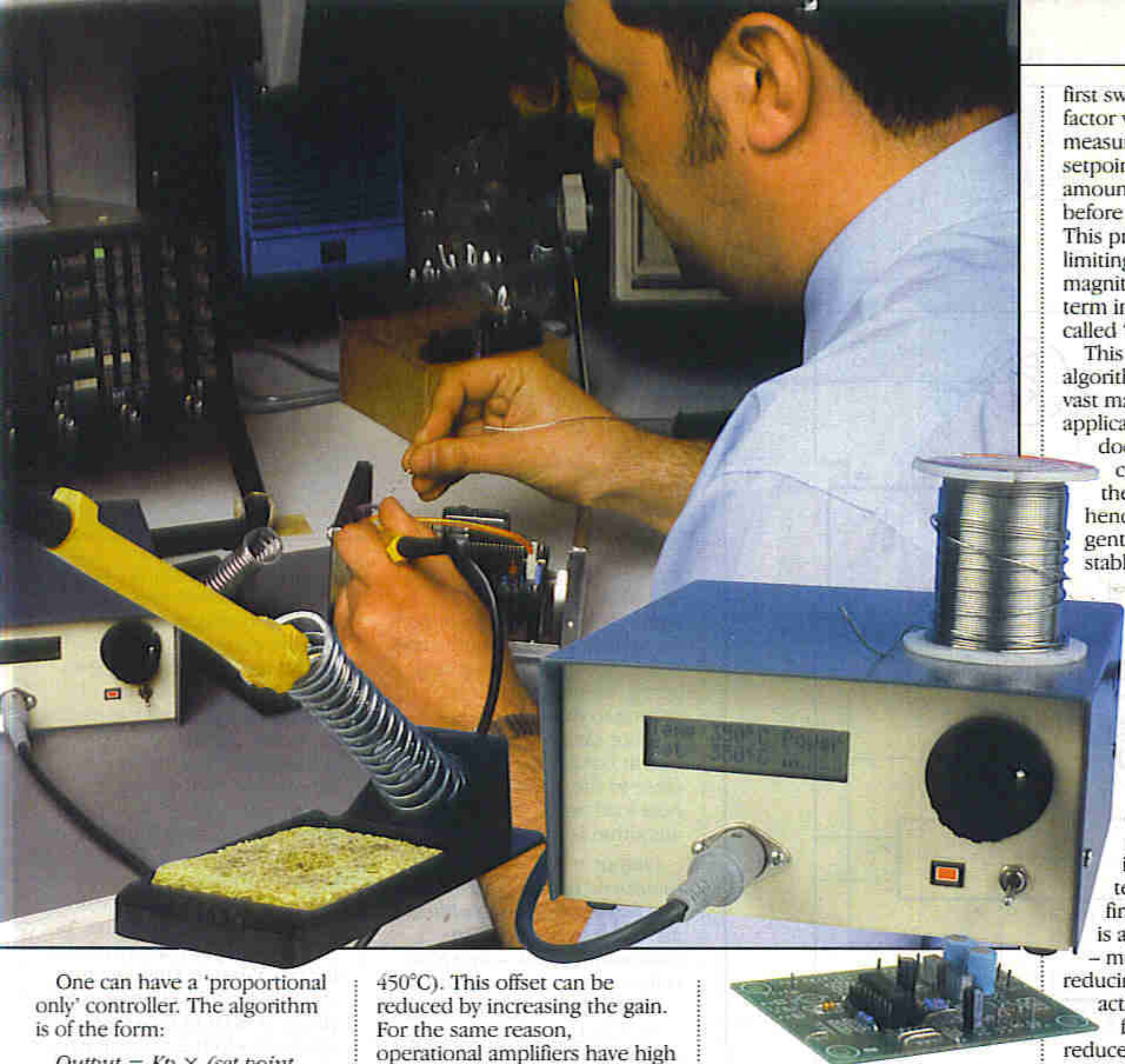
The principle of operation is simple. The iron has a thermocouple in the tip in addition to the heating element. Hence, power can be applied until the measured temperature reaches the desired temperature.

This principle is used in simple temperature controllers such as the Maplin Project from Issue 59 of *Electronics* in November 1992. A limitation, however, with these basic controllers is that the power is either full on or off. With the delay in heat getting to the sensor, the bit temperature continues to rise after the set temperature has been reached and then does the same in the other direction when the power is turned off. The net effect is a temperature which oscillates over about 20-30°C.

The route to close temperature control is to use a range of output powers and to continuously apply the level of power needed for the current situation. The controller then needs an algorithm to decide what level of power is needed. Industrial plant controllers typically use what are called 2- or 3-term proportional controllers. The same technology is applied here as a sophisticated 3-term controller (proportional, integral and derivative action with integral desaturation). These terms are much simpler to understand than they sound, so please read on.



Inside view of the Digital Soldering Iron Controller.



One can have a 'proportional only' controller. The algorithm is of the form:

Output = Kp × (set point – measured value)

Where 'Kp' is the proportional gain.

This will work to a degree (no pun intended). Take, for example, a case where the output and the set point/measured values are in the range 0 to 1·0 and the value of 'Kp' is, say, 10. You will see that in order to apply a full output of 1·0, the value of the (set point – measured value) will be 0·1, i.e., 10% of the range. In our temperature controller case, this would lead to an offset of up to 45°C (range 450°C). This offset can be reduced by increasing the gain. For the same reason, operational amplifiers have high gain. Unfortunately, we cannot make the gain too high as the system has a low frequency response due to the thermal lags. With too high a gain, the system will oscillate. Again, there is an analogy with operational amplifiers which also need high frequency response or they too will oscillate. So, proportional only control will not meet our needs.

Integral action to the rescue. All this does is add up the offsets (set point – measured value) and adds this sum to the proportional factor. The effect is to gently add more power until the offset is driven to zero. The algorithm is:

Output = Kp × (set point – measured value) + Ki × sum (set point – measured value)

Where 'Ki' is the integral gain.

The integral action gain, Ki, has to be tuned to give the best control. If it is a low value, it is slow to bring the offset to zero. If it is too high, it makes the system unstable. Integral action can also cause problems when the difference between the set point and measured values is large for some period of time, for example, when the iron is first switched on. The integral factor would try to drive the measured value above the setpoint for about the same amount of time as it was below before settling to zero offset. This problem is solved by limiting the maximum magnitude of the integral action term in the algorithm. This is called 'integral desaturation'.

This '2-term' control algorithm is satisfactory for the vast majority of control applications. Unfortunately, it does not do anything to compensate for the thermal lag in the iron and hence, has to be a slow gentle control in order to be stable. The fastest and tightest control is achieved by adding 'derivative action'. This looks at the rate of change of the difference (set point – measured value), hence its name. It works by adding a compensation into the algorithm based on how fast the (set point – measured value) is changing. In practical terms, when the iron is first turned on, full power is applied and the (set point – measured value) is reducing fast. The derivative action recognises this and forces the power to be reduced before the set point is reached. Derivative action enables the controller to predict how much the temperature will increase after the power is removed, hence compensating for the thermal lag. With good tuning, it will turn the power off completely about 20°C before the setpoint is reached and as the heat dissipates, the measured temperature comes up close to the set value leaving the integral action to finish off the job.

The derivative action also speeds up the response when you tackle a heavy heat load. When it sees the temperature falling rapidly, it compensates

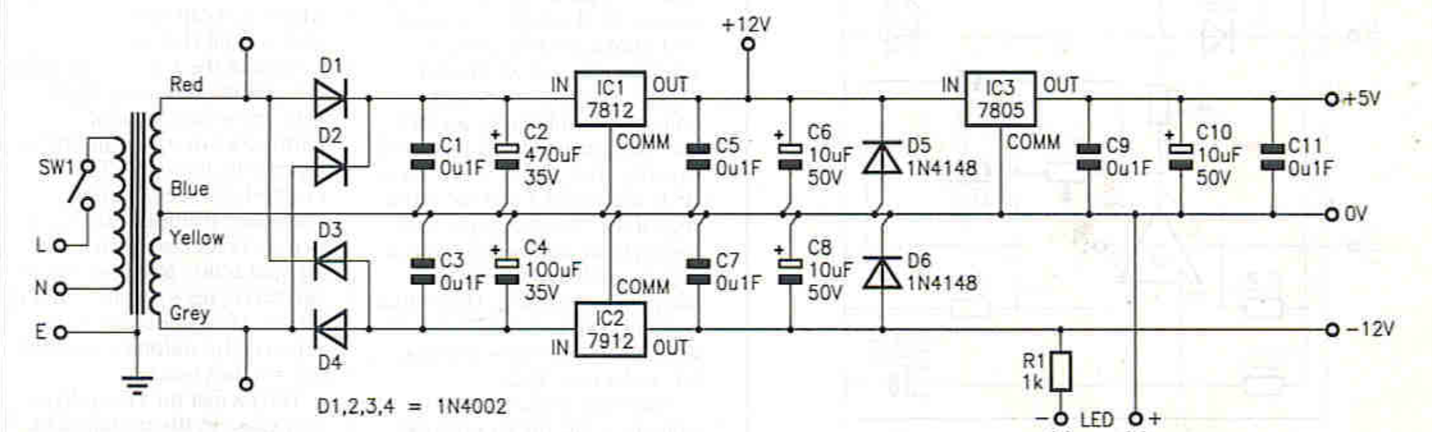


Figure 1. Circuit diagram – Power supply section.

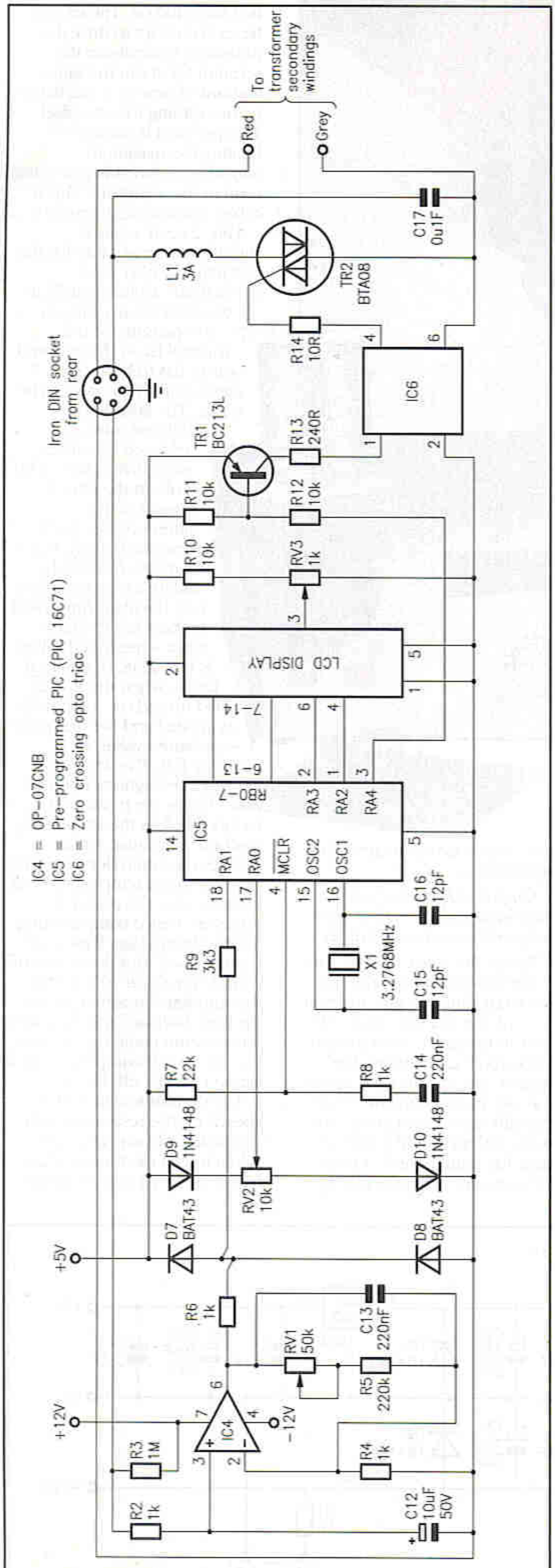
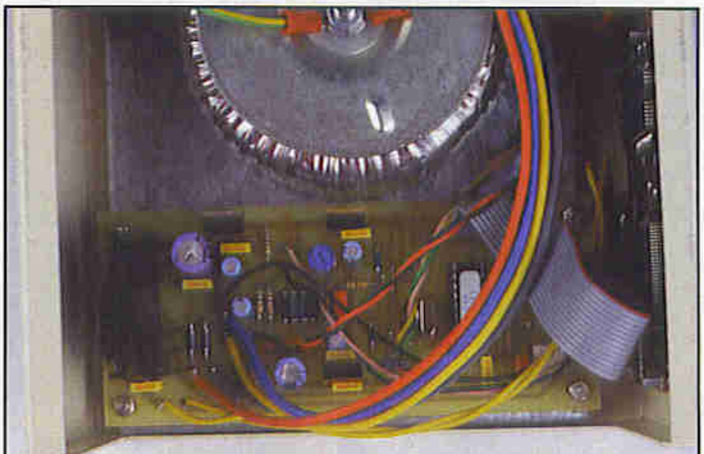


Figure 2. Circuit diagram – Control section.



Close-up of the assembled PCB.

by applying more power than would be applied by proportional action alone. So, the derivative action anticipates where the measured value is going. This helps both in getting to the setpoint fast without excessive overshoot and in holding the temperature close to the setpoint when the heat load varies. The full algorithm is then:

Output = Kp × (set point – measured value) + Ki × sum (set point – measured value) + Kd × [current (set point – measured value) – previous (set point – measured value)]

Where 'Kd' = derivative gain.

The soldering iron controller uses this 3-term algorithm. The values of Kp, Ki & Kd have been tuned to give fast stable control. The controller calculates what output power to apply 10 times per second. This is convenient as there are 100 half cycles per second, so it can apply somewhere between 0 and 10 half cycles of power in every tenth of a second.

The controller also has a software safety trip. If the measured temperature exceeds 460°C, it will shut off all power. This can only be reset by switching the controller off.

Circuit Description

Refer to Figures 1 & 2, showing the circuit diagram. The input and output circuits are very similar to the earlier Maplin design. The thermocouple voltage is amplified by an OP07 precision instrumentation grade op-amp. The gain is set by RV1. R3 is included to pull the input high if the thermocouple fails open circuit and hence force a trip-through giving a high temperature reading. The output is via an opto-isolator IC6, which does the clever zero-crossing bit, and a triac TR2.

The work in the middle is done by a PIC microcontroller. Sorry, I have said the dreaded 'PIC' word. One just cannot get away from these things. I guess the control could have been done with analogue circuitry – but the output conversion would require an analogue-to-digital converter (ADC) and associated logic, and the display of set and measured temperature would require two more ADCs, and then you need display drivers, and so on. I am afraid the PIC simply provides the most elegant and cost-effective solution.

The PIC16C71 has provision for up to 4 analogue inputs. In this case, just two are used, one for the measured temperature and one for the set temperature (RV2). PORTB (8 digital lines) sends data to the alphanumeric display with two of the unused PORTA pins for the display control logic. The last available PORTA pin drives the output. The programme uses the principles described in the earlier 'Putting PICs to Work' article in Issue 113. A 3·2768MHz crystal is divided down to give interrupts at 100Hz. The code executed at the interrupt is used to drive the output and collect the analogue data. Every 10 interrupts, it evaluates the control algorithm and updates the display. The power is shown on the display as a mini bargraph. This is achieved using the feature on the Hitachi displays where you can download your own special characters.

Most of the control algorithm is implemented using single byte 'twos complement' arithmetic (most significant bit represents the sign). This enabled the use of simpler arithmetic routines than those in the Microchip manual. The integral action term needed to use two bytes to avoid rounding errors. All multiplication was achieved by shifting. One shift left = times two.

The format for PIC code is very close to the examples in the Issue 113 'Putting PICs to Work' article. An additional

```
        bsf         STATUS,RP0          ;bank 1
        movlw b'00000010'
        movwf ADCON1                    ;porta 0,1 analogue rest digital
        movlw b'00000011'
        movwf TRISA                     ;porta bits 2-4 out, bits 0,1 in
        bcf         STATUS,RP0          ;bank 0
```

Listing 1. Additional code on the start-up routine.

```
        incf        csec,F              ;increment counter
        movlw d'10'
        subwf       csec,W              ;w=csec-10
        btfsc       STATUS,Z            ;skip if csec<>10
        clrf        csec                ;csec=0
        movlw d'7'
        subwf       csec,W              ;w=csec-7
        btfsc       STATUS,Z            ;skip if csec<>7
        goto        gset
        movlw d'8'
        subwf       csec,W              ;w=csec-8
        btfsc       STATUS,Z            ;skip if csec<>8
        goto        gtemp
        movlw d'9'
        subwf       csec,W              ;w=csec-9
        btfsc       STATUS,Z            ;skip if csec<>9
        goto        calc
        retfie
gset    movlw b'11000001'
        movwf ADCON0                    ;start adc sample, ch0 (set), RC osc
        call        DELAY
        bsf         ADCON0,adgo         ;start new sample
        bsf         STATUS,Z
        retfie
gtemp   movf        ADRES,W             ;w= result = setp
        movwf setp
        movlw b'11001001'
        movwf ADCON0                    ;start adc sample, ch1 (temp), RC osc
        call        DELAY
        bsf         ADCON0,adgo         ;start new sample
        bsf         STATUS,Z
        retfie
calc    movf        ADRES,W             ;w= result = temp
        movwf temp
        code for controller calculation
        retfie
                                        ; sample delay
DELAY   movlw d'3'
        movwf temprl
del     decfsz      temprl,F
        goto del
        return
```

Listing 2. Interrupt routine key code.

feature used here is the analogue-to-digital converter, which is available in the PIC16C71. One can take advantage of the interrupt routine which runs every 10ms to simplify the code. An analogue-to-digital conversion will be easily complete in the time from one interrupt to the next. The controller only needs to measure the set point and the temperature once each tenth of a second or every 10 interrupts. It uses a software counter which is incremented every interrupt (100 per second) and reset to zero when it reaches ten (10 times each second). Between counts 7 and 8, it measures the set point from RV2, between counts 8 and 9, it measures the temperature and between 9 and 10 (0), it evaluates the control algorithm to set the power required. The additional code on the start-up routine is shown in Listing 1 and the code in the interrupt routine is shown in Listing 2. I hope that with the comments, the code is self explanatory: 'csec' is the counter of centi-seconds; 'temprl' is a temporary register used in the 'DELAY' subroutine which allows time for the input voltage to settle before starting the analogue-to-digital conversion; 'setp' holds the value of the setpoint and 'temp' holds the value of the temperature.

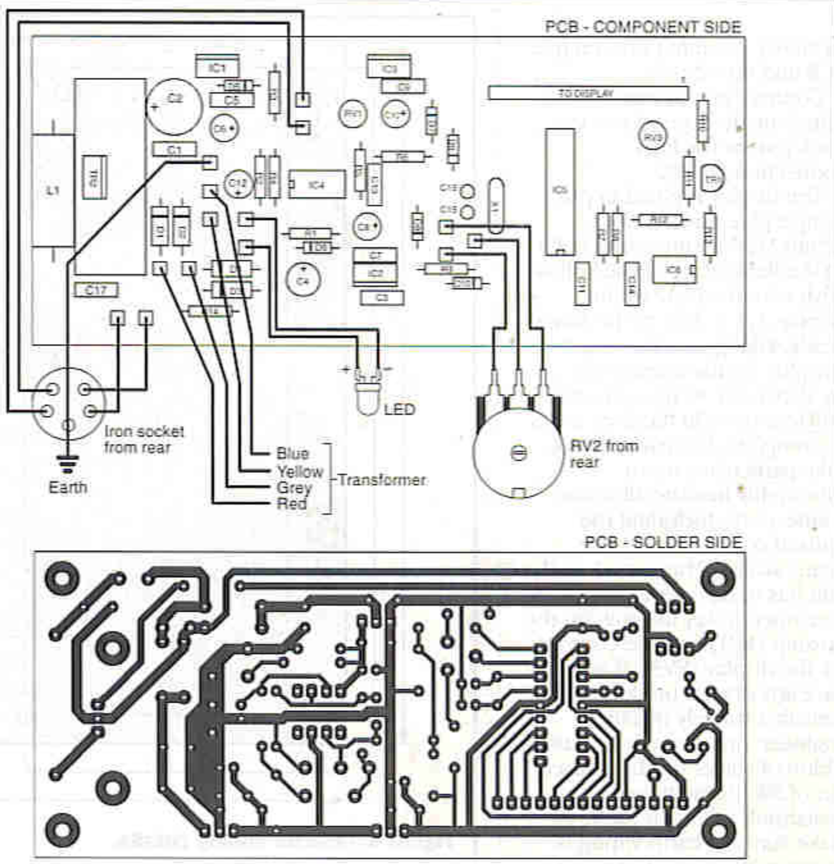
Construction

The PCB layout is shown in Figure 3. I suggest starting with the lower profile components first (resistors and diodes) and work up to the IC socket, with capacitors, voltage regulators and triac last. Please take particular care with the orientation of the diodes, capacitors, ICs and voltage regulators.

With the board complete (before installing the PIC or connecting any of the leads), it is no harm to test the current consumption (if you have a bench power supply). First, apply +18V to D1 with respect to earth. The consumption should be 11mA. Then apply -18V to D3 with respect to earth. The consumption should be 7mA. If these measurements are widely out, check again for component orientation and PCB shorts. If you don't have a PSU, just do the checks anyway.

Next, connect the display, the setpoint potentiometer RV2, the LED, the socket for the iron and install the PIC. Use 3A hook-up wire for the power to the iron. Again, check the power consumptions. These now should be 28mA and 18mA, respectively. Also, with power

Figure 3. PCB legend, track and wiring.



applied to the positive rail, the display should function and the set temperature should change in response to RV2. The measured temperature will not be correct as IC4 needs the negative rail.

The box drilling requirements for the display, RV2, SW1, PCB mounts, transformer, and mains inlet are shown in Figures 4 to 6. The PCB holes in the chassis are best marked using the PCB as a template. It is also necessary to move the chassis rearwards 5mm to give space for the iron socket. The new hole locations are best marked using the case as the template. The chassis self-tapping screws need 2mm diameter holes.

Mount the PCB using 12mm M2·5 bolts fed from underside the chassis, using either a spacer or two nuts 6mm apart to give a clearance of 6mm between the PCB and the chassis.

Connect up the transformer. This is made easier if you use track pins at the PCB connection points.

The display is glued in place using a glue gun. Set four 12mm M2·5 countersunk bolts so the flat surface of the bolt is flush with the front of the display. Apply glue to the screw heads, taking care not to get any glue on the display face. As an alternative to this, you can drill four holes in the front panel.

Complete the mains wiring. Take particular care to thoroughly insulate all mains connections, including the unused connection on the mains switch. This is vital, as the unit has to be operated with the case open to set the gain on the op-amp (RV1) and the contrast for the display (RV3). If you have any doubts on doing this, consult a suitably qualified engineer. I recommend putting a blob of solder on the unused pin of SW1 to help keep the heatshrink tubing in place. Make sure the earth wiring is secure with connections using 10A cable both to the bolt on the transformer and to the panel on one of the bolts on the iron socket. Additional earth wires are needed both to the middle pin of the iron socket and to the 0V connection on the PCB.

Check that the bolt holding the transformer does not touch the top of the case. This would provide a short round the transformer.

With the construction complete, double-check all the wiring, set RV1 & 2 midrange, plug in the iron, and turn on. The display should show the measured temperature, rising from 20°C with the power

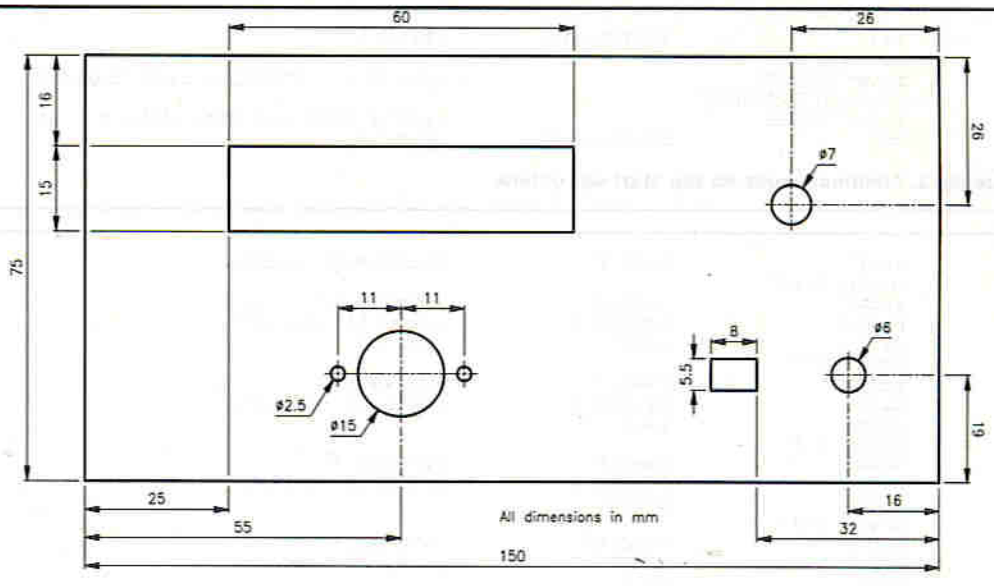


Figure 4. Front panel preparation.

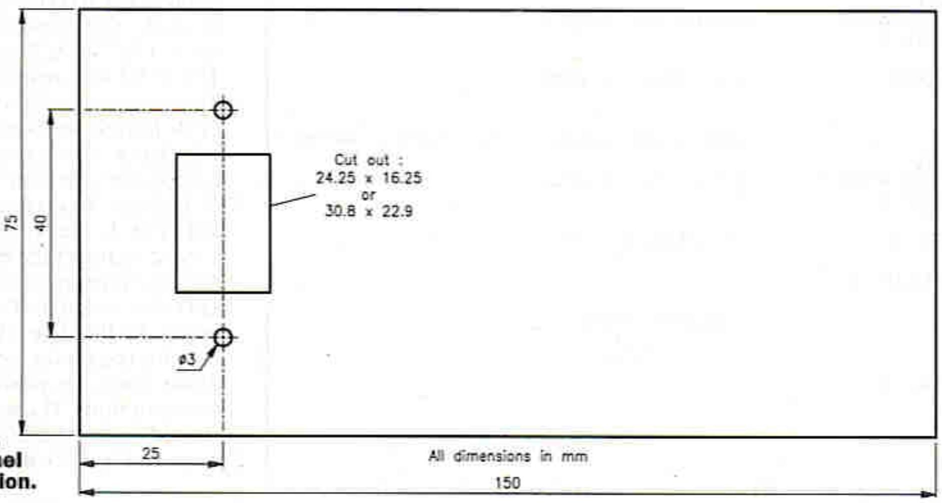


Figure 5. Rear panel preparation.

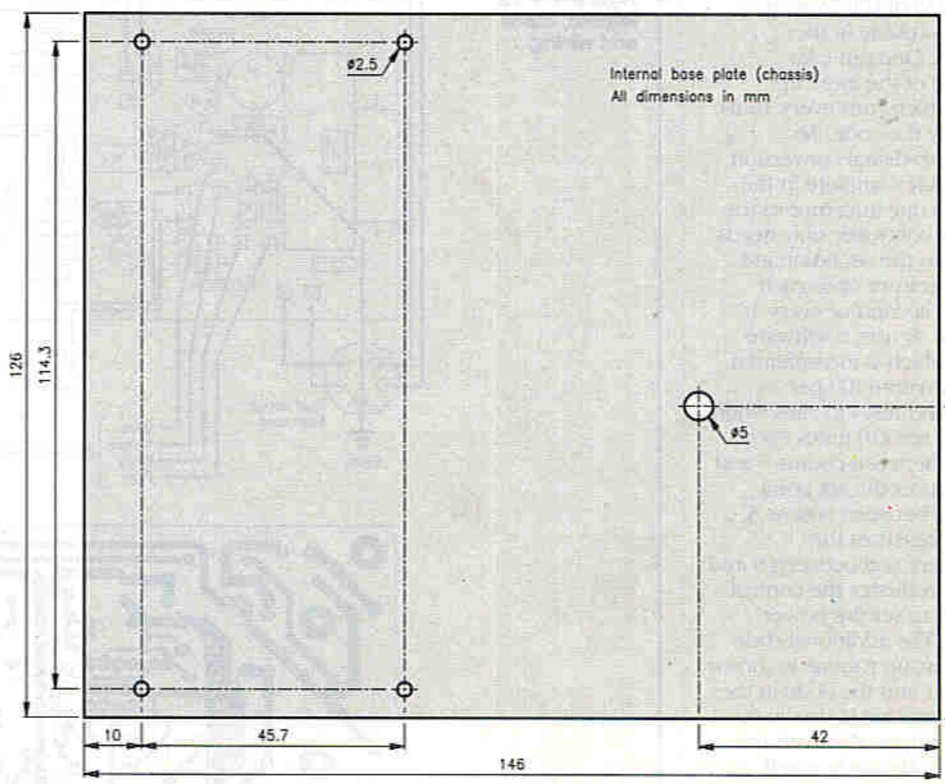
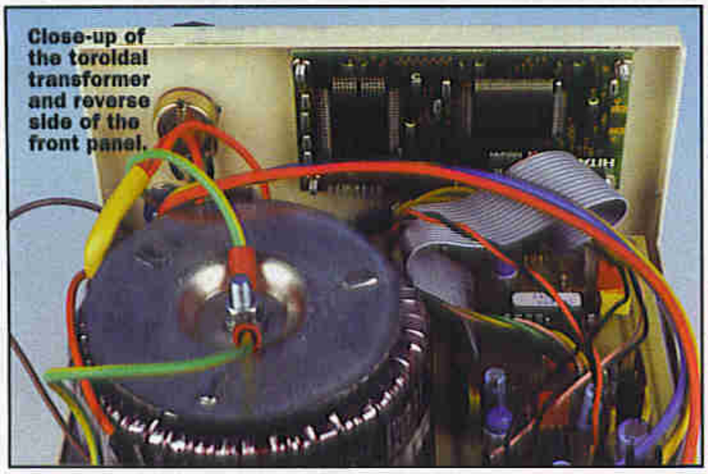


Figure 6. Chassis drilling details.



Close-up of the toroidal transformer and reverse side of the front panel.

View of the front panel/display. Note bargraph power indicator at the right-hand side of the display.

bargraph at full power. As the set temperature is reached, the power should be reduced. If there is any deviation from this, switch off immediately, disconnect from the mains and start looking for faults.

Important Safety Note

It is important to note that mains voltage is potentially lethal. Details of mains wiring connections are shown in this article, and every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit, which should never be operated with the box lid removed (with exception of during the initial setting-up – see below). Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article. If you are in any doubt as to the correct way to proceed, consult a suitably qualified engineer.

Operation and Calibration

The power required to keep the iron at a typical 370°C is about 10W (two bars showing in the power bargraph). You can see the power increase as you tackle a big job.

Calibration is not essential as the key thing is to find the temperature setting that suits each job. I calibrated the prototype using Aluminium solder (FY71N), which melts at 270°C. I adjusted RV1 until the solder went mushy with this temperature setting. Please take extreme care when making these adjustments, even with all your mains wiring insulated. Use one hand to adjust RV1 and only use an insulated adjuster.

Adjust RV3 to give the best contrast for the display, again observing the precautions above.

The display shows 'TRIP' to indicate a fault condition exists, in this case, caused by the soldering iron being disconnected from the unit.

Printed Circuit Board and Pre-programmed PIC

A PCB and Programmed PIC are available from the author at £20 including postage.

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

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Stated)

R1,2,4,6,8	1kΩ	5	(M1K0)
R3	1MΩ	1	(M1M0)
R5	220kΩ	1	(M220K)
R7	22kΩ	1	(M22K)
R9	3k3Ω	1	(M3K3)
R10-12	10kΩ	3	(M10K)
R13	240Ω	1	(M240R)
R14	10Ω	1	(M10R)
RV1	50kΩ	1	(WR43W)
RV2	10kΩ	1	(JM71N)
RV3	1kΩ	1	(WR40T)

CAPACITORS

C1,3,5,7,9,11,17	0·1µF	7	(CX21X)
C2	470µF 35V	1	(VH47B)
C4	100µF 35V	1	(VH38R)
C6,8,10,12	10µF 50V	4	(VH22Y)
C13,14	220nF	2	(CX22Y)
C15,16	12pF	2	(WX45Y)

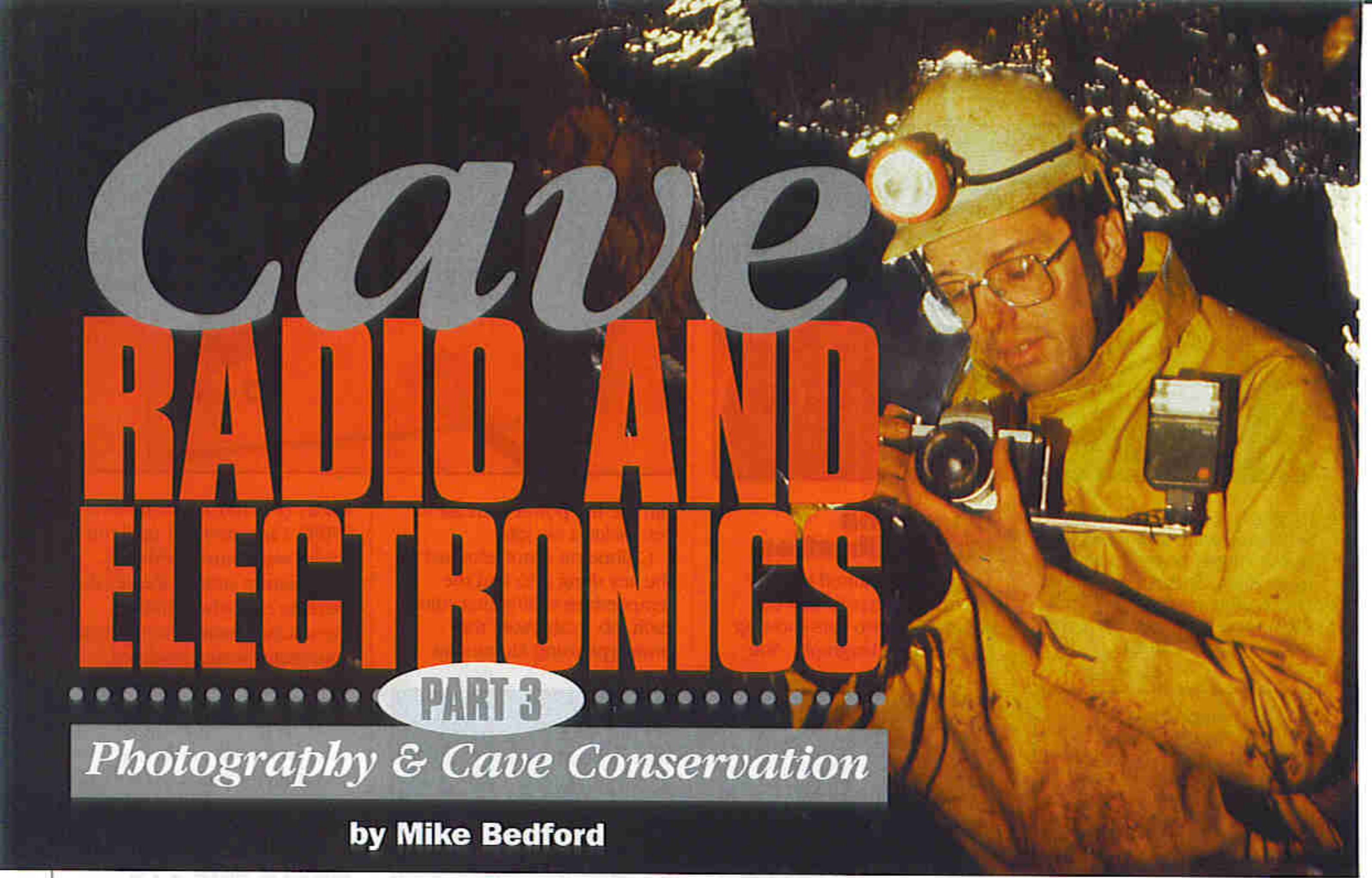
SEMICONDUCTORS

D1-4	1N4002	4	(QL74R)
D5,6,9,10	1N4148	4	(QL80B)
D7,8	BAT43	2	(VR19V)
IC1	7812	1	(QL32K)
IC2	7912	1	(WQ93B)
IC3	7805	1	(QL31J)
IC4	OP-07CNB	1	(RA73Q)
IC5	Pre-programmed PIC16C71	1	* See Text *
IC6	Zero-crossing Opto Triac	1	(RA56L)
TR1	BC213L	1	(QB61R)
TR2	BTA08-600B Triac	1	(UK54J)

MISCELLANEOUS

Display	16 × 2-line LCD Module	1	(DK53T)
X1	3·2768MHz crystal	1	(FY86T)
L1	3A Choke	1	(HW06G)
	Heatsink	1	(AX95D)
	Heatsink Clip	1	(AX97F)
	1mm PCB Pins	1	(FL24B)
T1	Toroidal 50VA 12V Transformer	1	(YK15R)
	LED	1	(QW96E)
	LED Clip	1	(HY62S)
SW1	Sub-Miniature Toggle Switch	1	(FH00A)
	2·4mm Heat-shrink Sleeving	1	(BF87U)
	Earth Cable	1	(XR38R)
	Cable – Live to SW1	1	(FA28F)
	DIN Socket B	1	(HH35Q)
	Knob	1	(FK41U)
	Mains Chassis Plug	1	(HL15R)
	Cover for Mains Chassis Plug	1	(JK66W)
	Mains Lead	1	(MK41U)
	PCB	1	* See Text *
	Case	1	(XY44X)
	M2·5 12mm Screw	1	(BF40T)
	M2·5 12mm Countersunk Screw	1	(JY31J)
	M2·5 Nuts	3	(JD62S)
	2BA Solder Tag	1	(BF27E)
	6BA Solder Tag	1	(LR02C)
	Soldering Iron TC50	1	(DQ01B)

The Maplin 'Get-You-Working' Service is not available for this project.
The above items are not available as a kit.



Cave Radio and Electronics

Part 3

Photography & Cave Conservation

by Mike Bedford

Let's face it, potholers are a strange bunch of people. If I didn't count myself amongst their ranks, I'd probably have to question how crawling along on your hands and knees in two feet of glutinous mud or walking up to your neck in freezing cold water could possibly be thought of as fun. But if it's hard to appreciate the motivation for the sporting caver, you'll probably find it even harder to understand why some cavers will even want to risk taking a camera into this environment. The sporting caver will probably express a sentiment on the lines of "no pain, no gain", and it's no different for the cave photographer. Yes, I might be risking hundreds of pounds worth of equipment, but I can testify to the sense of achievement when I return from a caving trip with a particularly good photograph. Cave photography is one of the specialist interests which some cavers undertake, and it's also another area in which electronics is becoming increasingly important.

So far, in this series which investigates the strange link-up between the world of electronics and the world of the potholer, we've looked at those applications which concern all cavers. So, for example, in the first article, we looked at cave communications, and specifically, its application in cave rescue. OK, most cavers never have to be rescued but the rescue groups do, nevertheless, provide a service to the whole caving community. And last month, we looked at how electronics and computing are coming to the fore in cave exploration and cave surveying – once again, of interest to a large number of cavers. In this third and final part of the series, however, we're turning our attention to the application of electronics to a couple of the rather more specialised interests within caving.

Photography

At one time or another, most cavers have taken a camera underground with them. Most of these cavers wouldn't call themselves cave photographers, and if you were to look at their results, neither would you. The fact is, it's very easy to take some appalling cave photographs. With no special photographic skills and a cheap camera, most people can take half-decent holiday snaps. Not so when you venture underground. The major snag, of course, is that there's no light underground, so you end up relying on flash.

For the expert cave photographer, this difficulty can be turned to advantage. If there's no natural light, the lighting is entirely under the photographer's control and some stunning effects can be achieved. For the snapshot photographer, however, things are quite different. The first problem relates to the fact that point-and-shoot cameras have very small flash tubes. So, if your subject is more than a few metres from the camera, the image ends up being underexposed. And if you want to photograph a huge cave chamber – forget it.

The second problem is that the flash tube is mounted right next to the lens. So, even if the subject is correctly exposed, the photograph will be devoid of shadows – basically, it'll look flat and boring. And the other problem with a flash tube mounted on the camera is that your photographs will end up fogged. Why? Because cavers breathe out steamy air which the flash will then illuminate.

All of these problems can be overcome simply by using a more powerful flashgun and separating it from the camera. The larger flashgun means that your subject will be correctly exposed, and if you hold the flashgun at arm's length, the shadows will add depth to your photograph, and you won't illuminate the steamy cloud of air you've just exhaled. The end result of this is that your photographs will be perfectly adequate, albeit probably not especially exciting or artistic.

So, the progression from a total failure to a perfectly adequate photograph involved a simple step. Perhaps, the progression from this stage to the next level of competence might be effected as easily. Unfortunately, it can't. We're not going to talk about basic photographic skills here, after all, this is an electronics magazine, not a photography magazine. Nevertheless, you're certainly going to need to own a decent camera, understand the basics, have an eye for picture composition, and a good measure of flair, imagination and originality.

However, these alone are not enough. You're also going to need various bits of equipment which you probably won't be able to buy from a photographic shop. So, cave photographers often have to be prepared to spend a good deal of time in the workshop before going underground, and this can require as much imagination as the picture composition. Certainly, some pieces of kit are a fundamental part of every cave photographer's armoury. However, there are times when a piece of equipment is built up with a single photograph in mind, and clearly, much of this kit has an electronic element. Let's investigate this in a bit more detail.

Photo 1. Photo taken with a single flash – OK, but not particularly exciting.

Photo 2. Photo taken with two flashes, the rear flash being triggered using a slave flash unit – much more dramatic.

Flashgun Slaves

Perhaps the single most important technique in cave photography is the use of multiple light sources. To photograph a very large chamber, for example, you might need half a dozen flashguns scattered around, each one illuminating a different part of the scene. But the technique needn't be restricted to large chambers, even a close-up of a caver will often be enhanced no end by the addition of a second flash to provide backlighting. This is illustrated in Photos 1 & 2. The first photograph is an example of what I've referred to as an adequate photograph. It was taken using a single electronic flash about 3 feet from the camera.

OK, you can see what's going on – the caver is experimenting with induction radio – but it's not exactly the most exciting photograph. The second photograph was taken in the same location, but now there's a couple of light sources – one near to the camera as before, and the other one behind the caver. The advantage of this technique speaks for itself, but it's pertinent to question how the additional flashguns are synchronised to the camera.

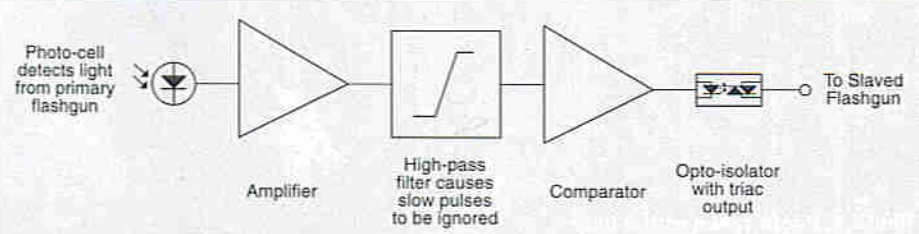


Figure 1. Block diagram of a caving flashgun slave unit.

Certainly, with a still subject, you can place the camera on a tripod, open the shutter on its 'B' setting, and get people to activate the flashguns manually. However, this means that you've got to carry a tripod and it's totally unsuitable for moving subjects. More common, therefore, is to use a flashgun slave. This attaches to a remote flashgun and is triggered whenever it sees a pulse of light from the main flashgun which is triggered directly from the camera. OK, this isn't unique to cave photography, but those slave units intended for caving are quite different from ones intended for general-purpose use. Figure 1 shows the block diagram of a slave unit, while Figure 2 indicates its use within a cave.

Perhaps the most important feature of a

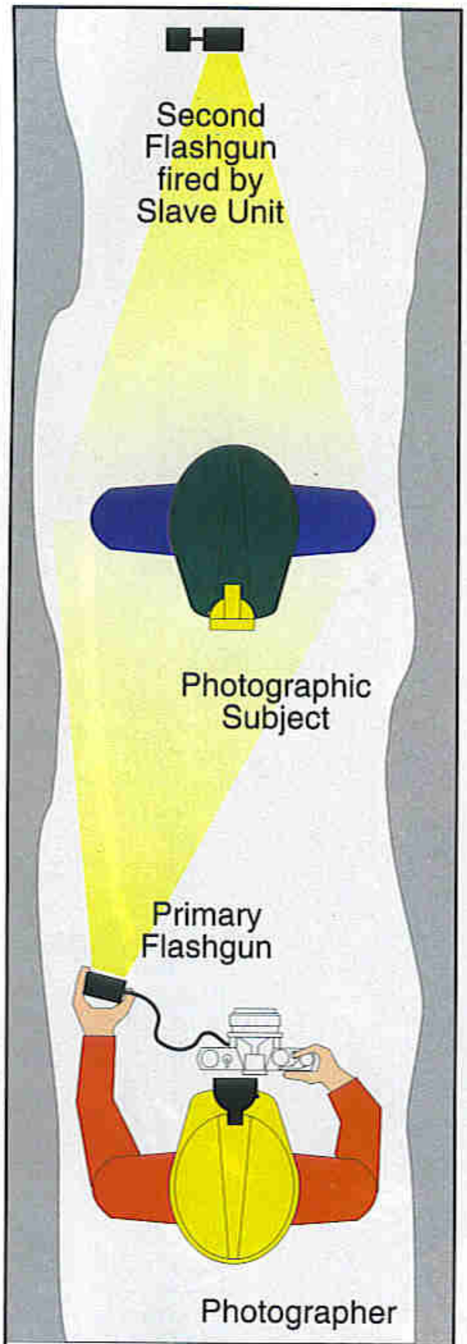


Figure 2. Using a flashgun slave in cave photography.

caving slave unit is that it needs to be very sensitive. In a large chamber, a slave could be quite some distance from the primary flashgun, and even for closer work, it could easily be located round a corner. However, sensitivity alone is not enough, indeed, ultra-sensitive slaves can bring their own problem – false triggering. The problem lies in the fact that cavers wear lamps on their helmets, and as they move around, flashes of light trigger the slave units. The answer, therefore, is for the slave to respond only to the very short duration pulse which is typical of an electronic flashgun.

The third feature is sensitivity to infrared. This way, you can place an infrared filter over the primary flashgun – the one which is triggered directly from the camera – and so trigger a slaved flashgun without the primary flashgun illuminating the photograph. This may seem an odd requirement, but interesting effects can be achieved using a single flashgun well away from the cameras, as the Photo 3 shows.

Keep that Water Moving

Photographing moving water using a flashgun is not a common requirement for most photographers, but in cave photography, it's extremely common. Now, a bit of background information about electronic flashguns – the pulse of light which is generated is extremely short. Normally, most of the light output will occur within 0·5-2ms, depending on the flashgun. Water doesn't move very far in this sort of period, so moving water ends up looking very unnatural. Spray will look like a few silver dots suspended in the air, and cascades can look as if they're frozen. Actually, there's a very simple solution which requires no electronics at all – use an old-fashioned flash bulb rather than an electronic flashgun.

Flashbulbs burn for about 25ms, and are used extensively by cave photographers. In addition to imparting a sense of movement to water, they are also far more powerful than all but the most expensive flashguns. If you're not a cave photographer, you're probably surprised that flashbulbs are still available. For years now, cavers have bemoaned the impending withdrawal of flashbulbs but as yet, supplies have held up. Obviously, this situation isn't going to last forever though, and electronics enthusiasts are already working on replacements.

Solution number one, developed by Ian Drummond in Canada, is a box of tricks

Figure 3. Block diagram of a flash cascade unit.

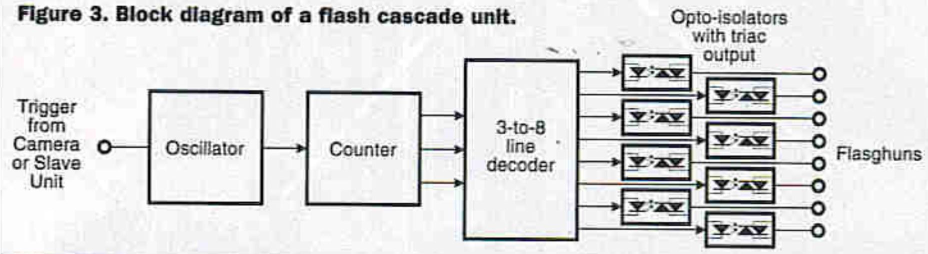


Photo 3. Photo taken with a back light only. Explains why a slave unit needs to be sensitive to infrared.

Photo 4. Photo taken with a single electronic flash – water is 'frozen'.

which fires small electronic flashguns, one after another in rapid succession – see Figure 3. Cascading flashguns in this way, light is generated over a much longer period of time and movement can be imparted to moving water. To approach the burn time of a flashbulb, however, a very large number of flashguns would be needed and this would be both unwieldy and expensive (see Figure 4). Nevertheless, useful results have been achieved with as few as six small flashguns, as you can see in the pair of Photos 4 & 5. Photo 4 was taken

Figure 4. Comparing the light output of a flashgun, a flashbulb and eight cascaded flashguns.

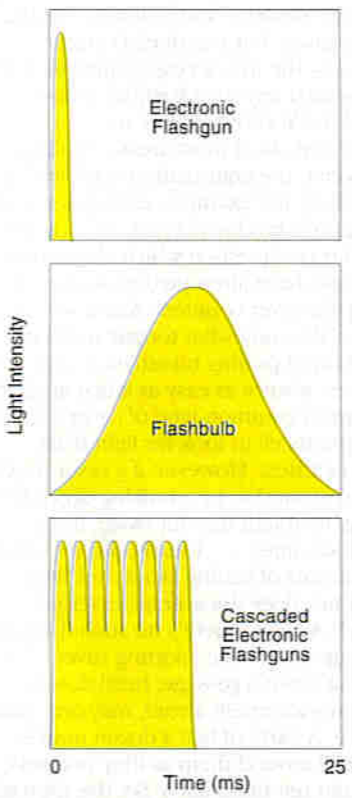


Photo 5. Photo taken with six cascaded flashes – movement is starting to be imparted to the water, although more flashes would have been better.

with a single electronic flashgun, and Photo 5 with a bank of six units triggered at 2ms intervals. Photo 6 shows six flash guns and a cascade unit.

Although more flashguns would have been better, we can already see the 'glass sculpture' effect disappear, to be replaced by the blur of moving water. As an aside, both these photographs were taken with just a single flash (or bank of flashes) close to the camera. This photograph would have been improved by an additional light source behind the caver but the choice of a single light source was made to better illustrate the advantage of cascading flashguns.

Solution number two is to design a purpose-built electronic flashgun, specifically for cave photography. There's been much talk about this, but so far, nothing has come off the drawing board. One solution may be to include lots of flash tubes, effectively producing a more compact version of the multiple flashguns plus cascade unit. Alternatively, it may prove possible to repeatedly trigger a single flash tube to produce the necessary burn time. So, what else might be incorporated into a caver's flashgun? Lots of possibilities come to mind. High power and a wide angle of illumination, both advantages of flashbulbs, come to mind. And what about making a slave unit an integral part of the unit? Plus, it would be good to make it waterproof – underwater illumination can produce some very interesting effects.

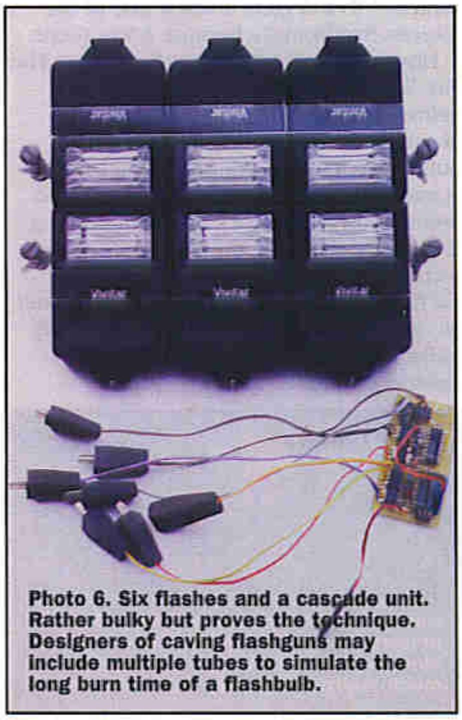


Photo 6. Six flashes and a cascade unit. Rather bulky but proves the technique. Designers of caving flashguns may include multiple tubes to simulate the long burn time of a flashbulb.

Well, that's the dedicated caver's flashgun, and as I've already indicated, it doesn't exist. So, what's the point in talking about it? Simply to illustrate the fact that cave electronics enthusiasts don't yet have all the answers. There's still plenty of scope for innovation in this fascinating field, and if you like an interesting and unusual technical challenge, you'll find lots to fascinate you in cave radio and electronics.

Photography & Radio

You'll probably notice that we keep coming back to the subject of cave radio throughout this series, and this article will be no exception. But how on earth do you turn the topic of cave photography to include cave radio? Let's start our story 9,000 miles away in the Caves of Thunder in Irian Jaya, Indonesia. Discovered in 1990, this series of caves contains the world's largest underground river and was the destination of a 1992 expedition from the UK. Obviously, photography would be an important element of the expedition, indeed, the team included Gavin Newman, the well-known cave photographer. But photographing a noisy river cave would bring its own peculiar challenges. "Angle the flashgun to your right – no your right – right – right – right". Clearly, communications between photographer and assistants would be a major problem when speech is inaudible over much more than a few metres.

Recognising this, Gavin Newman (see Photo 7) had turned to electronics and equipped the team with radios which would be used to orchestrate the photography. These weren't cave radios like the ones we discussed earlier in the series, after all, they

Photo 7. Gavin Newman photographing the Caves of Thunder, aided and abetted by specially-adapted CB radios. (Courtesy Gavin Newman: Kev Senior pushed the button!)

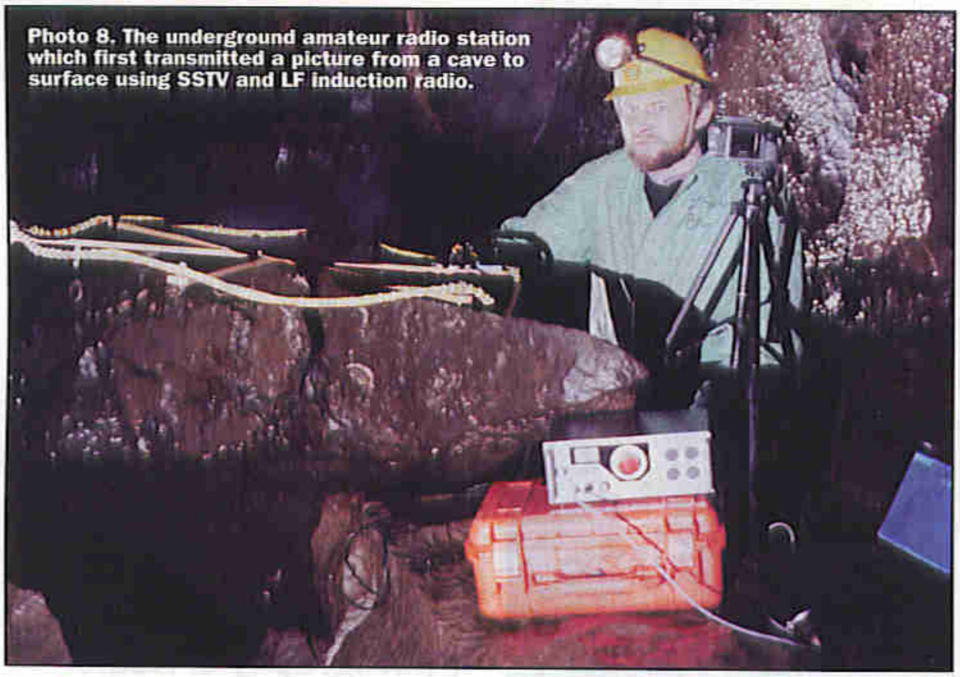


Photo 8. The underground amateur radio station which first transmitted a picture from a cave to surface using SSTV and LF induction radio.

only had to achieve line-of-sight communication – the signal didn't have to penetrate the rock. So, CB radio was used but ordinary radios would have been useless for a number of reasons, so a degree of innovation was called for. Specifically, the CB rigs were re-housed in rugged waterproof housings, hands-free operation was provided, and ear defender headsets with noise cancelling microphones were provided to cope with the noisy environment.

In practice, these units made possible photographs which just couldn't have been achieved by shouting. But, as the following extract from Gavin Newman's article on the expedition, published in *Descent* magazine 110 (February/March 1993) demonstrates, they were also invaluable in flood conditions. "With team members stationed at various points with radios, watching water levels, we commenced our photography. Literally walking backwards as the water advanced up the walls at a metre a minute, we photographed and filmed the awesome onslaught."

"Suddenly, over the radio came a shout to get out as water was in danger of flooding our exit. With minutes to spare, we retreated through the crawl which soon filled up with water. Between us, as a group, we'd seen most of the world's great caves and seen floods before, but this was something different. The sheer volume of the water and its speed was just breathtaking."

Closer to home, and to see a quite different link-up between cave photography and cave radio, we need to go to Birkwith Cave in the Yorkshire Dales. The date was 22nd March this year, and the occasion was a joint field meeting of the Cave Radio & Electronics Group and cave photographers. Let's set the scene underground. The location was a boulder-filled chamber with a sizeable cascade entering from the passage beyond. On a precariously balanced tripod, was mounted a Casio QV10A digital camera. This was connected to a Fieldworks FW7600 rugged laptop PC to which a 73kHz induction radio was also attached via a special modem. A loop antenna and a super-bright dichroic lamp in a waterproof housing completed the setup (see Photo 8).

The purpose of this strange assortment of equipment was to transmit photographs from the cave to the surface using slow-scan television (SSTV). Unlike ordinary television, SSTV occupies a bandwidth of just 3kHz, the same as speech. So, whereas standard TV can only be transmitted at VHF or UHF, SSTV can be transmitted at shortwave or even in the LF band used for through-rock cave radio. Of course, you don't get something for nothing and the drawback of using such a narrow bandwidth is that images take a few seconds to transmit. So, SSTV is used for the transmission of still photographs rather than moving pictures.

To cut a long story short, contact was established with a similar station on the surface, and a picture transmitted from Birkwith Cave to the wind-swept moorland above – through 30m of solid rock (see Photo 9). OK, this was the first time anyone had done this, and it involved overcoming a number of technical and organisational challenges, but what was the point of the exercise? To a degree, it was a case of the 'Everest Syndrome' – because it was there.

However, there are potential benefits. The Fire Service is now experimenting with helmet-mounted cameras which allow images to be transmitted from a burning building to a rescue controller. On coming across a tricky situation, suitably equipped firemen can call for backup without having to describe the situation verbally. The same scenario could be applied to cave rescue. We might assume that the ability to transmit pictures to the surface would be especially valuable in the event that a badly injured casualty is found.

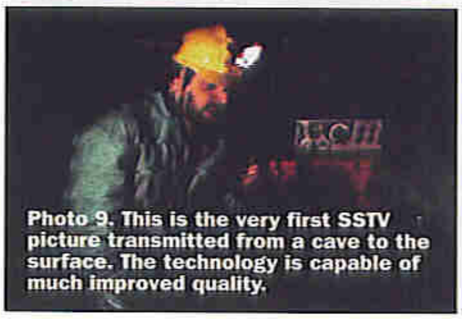


Photo 9. This is the very first SSTV picture transmitted from a cave to the surface. The technology is capable of much improved quality.

Cave Conservation

When cavers think about specialist interests, cave conservation doesn't normally come to mind. However, the underground environment is a remarkably fragile one, which can easily be destroyed be malicious or careless cavers. Straw stalactites (see Photo 10), for example, a hallmark of many of the potholes in the Yorkshire Dales, are perhaps only 5mm in diameter, can grow to a couple of metres in length, and as their name suggests, are hollow. Breathe on one of the longer straw stalactites and it will blow in the wind. Brush up on it, and thousands of years of growth are destroyed in an instant. It's a sobering thought to visit Easter Grotto in the Lancaster Hole system, see the broken straws littering its floor and understand why, less than 50 years after it's discovery, some cavers have been prompted to dub it Easter Grot.

In a way, cave conservation is one of the most important special interests within caving. Last month, we looked at the subject of cave exploration, but many of the more responsible cavers are going to ask themselves whether it's really worthwhile discovering a new cave if the end result of their discovery is that their less responsible colleagues end up destroying it. The bulk of this month's article has been concerned with cave photography, but how much enjoyment can there be in photographing the muddied, broken-off stumps of stalactites and stalagmites? All the electronic gizmos in the world aren't going to restore them to their former glory.

But cave conservation is also a very controversial subject. One obvious way of protecting a cave is to place a locked gate on the entrance and ban all cavers. Slightly less draconian is to allow cavers only in organised parties or, perhaps, only under the supervision of a competent leader who can ensure that the party causes no damage. This is the situation with a number of the Mendip caves. But this doesn't suit everyone – the free-access contingent will argue against any such barriers, indeed, most of the Yorkshire caves are unprotected. As in most areas of political controversy, the arguments are fuelled by a lack of facts. For example, exactly how many potholers do go down a particular cave in a year? This is a question which electronics enthusiasts have attempted to answer by developing caver counters. And if we discount the somewhat tongue-in-cheek suggestion of putting turnstiles at cave entrances, it's not as easy as it first appears.

The most common type of caver counter uses a photocell to look for light from cavers' headsets. However, if a caver moves his head around as he's walking down the passage, he might register twice, three times, four times. . . . Clearly, there's a need for some sort of scaling factor, but how many times does the average caver get counted? Actually, there's no such thing as an average caver. The sporting caver marching down a passage, head down, intent on excitement ahead, may only count the once. A party of half a dozen novices, looking all around them as they progress, may count ten times each. So, the approach taken by most designers of caver counters is to count parties rather than individual cavers. To do this, as soon as you register a caver, you start a timer and disable counting until the pre-set interval has expired. So long as you don't place the counter in a place such as the top of a pitch where people are likely to hang around for some time, the party will be well out of range before the counter is re-armed.

Perhaps the other major problem with caver counters is that they disappear. I guess this is no great surprise. After all, if some cavers are prepared to destroy the calcite formations, why should they have any more compunction about stealing a caver counter? In most cases, I'm sure that people who remove these devices don't know what they're taking – it just looks interesting. So, a philosophy employed by Stuart France of the South Wales Caving Club is that of the 'stealth' caver counter.

Step number one is to separate the counting circuitry from the photocell and attach the two using an umbilical. Now, the box of tricks can be located for minimum visibility – buried in mud, for example – and the tiny photocell for an optimum 'view' of the passage. Step number two is to make the counter as boring as possible so that, in the event of its discovery, it will be ignored. This involves removing switches, LCD displays, and so forth. All these components are put in a separate box which is only connected up when someone visits the cave to obtain the data.

Other Applications

Throughout this series, we've concentrated on those caving applications of electronics which will most appeal to those with a general interest in electronics. We could have looked at the development of data-logging kit for measuring water levels, pH, air temperature and pressure, but unless you have a particular interest in cave hydrology, this would probably be as fascinating as watching paint dry.

We could have looked at equipment for detecting bats, but this would really only appeal to speleo-biologists. Or we could have gone on at great length about lighting and battery charging. This latter topic is one which regularly exercises the minds of cavers but except for discussions about the applicability of new components like white LEDs or lithium-ion batteries, isn't exactly high tech. As we come to a close, though, please bear in mind that the equipment and techniques we've discussed over the last three months are little more than a representative sample of the sorts of things electronic engineers get up to underground. If you want to know more, see the contact details below.

Don't Forget

If you've read all three articles in this series, you'll have seen this warning before. But I make no apologies for that – caves are dangerous places if you're not an experienced caver. So, if you want to find out what caving is all about, or if you want to try your latest electronic creation underground, please find an experienced caver to take you underground. And if you want to find like-minded people, try making contact with the Cave Radio & Electronics Group (CREG) of the British Cave Research Association (BCRA). The Group's twice-yearly field meetings could provide a safe introduction to caving and would allow you to see cave electronics in action. CREG also publishes a quarterly journal which contains a broad mix of practical and theoretic articles. For details and an order form, please send an SAE to Bill Purvis, 35 Chapel Road, Penketh, Warrington, WA5 2NG. Also check out the CREG Web site at **http://www.sat.dundee.ac.uk/~arb/creg.** If the more general aspects of cave photography appeal to you, you might be interested in the magazine *Underground Photographer.* Contact the Editor, Underground Photographer, 40 Buckingham Road, Petersfield, Hants. GU32 3AZ. Their Web site is at **http://www.dhios.demon.co.uk.**

Student Projects

For the last couple of years, electronic engineering students at a number of universities in the UK have undertaken projects concerned with cave radio and electronics. Industrial design students, mindful of the unique challenges posed by equipment intended for use underground, have also worked on cave-related projects. Some students have designed caver counters for use in environmentally sensitive caves, some have worked on pagers for transmitting messages to underground parties, and others have looked at ways of improving cave radios.

Nearly all these students have found their projects challenging and have been motivated by the opportunity to work on a rather unusual application. If you're a student or a lecturer and have been inspired by this series of articles, why don't you contact the Cave Radio & Electronics Group to discuss some ideas? CREG maintains a list of project proposals which are technically challenging and represent an area of new research or development. Some could make a genuine contribution to the cave rescue organisations and may even help save lives. To progress this further, please write to Chris Trayner, Electronics & Electrical Engineering Department, The University of Leeds, Leeds LS2 9JT or e-mail **ct@elec-eng.leeds.ac.uk.**

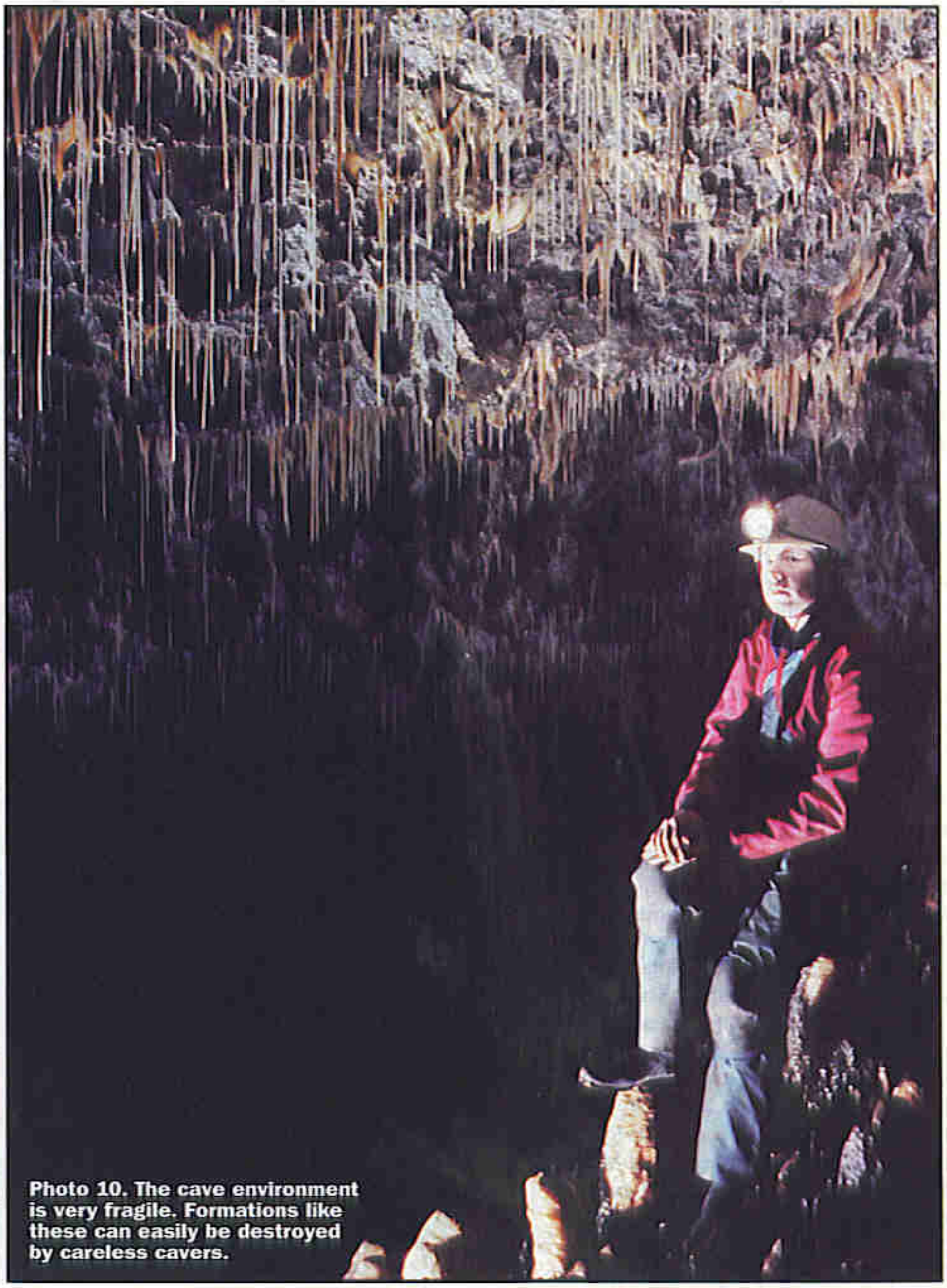


Photo 10. The cave environment is very fragile. Formations like these can easily be destroyed by careless cavers.

Mars – THE RETURN AND THE SEARCH FOR LIFE

by Dr Chris Lavers

Sometime before dawn on 4th July 1997, if all has gone according to plan, the Mars Pathfinder will descend onto an ancient Martian flood plain at the mouth of Ares Vallis (19·50N/32·80W), a mile deep canyon. This event will be the first US probe to land on Mars since the 1970s Viking missions, and heralds the beginning of NASA's long-term exploration of the Red Planet.

Mars has long held a fascination for man, it is the fourth planet from the Sun and is easily observable with its distinct red colour (Photo 1). The ancients associated Mars with violent upheaval and war and is one of a small group of 'wanderers' (Greek planetes), which do not remain fixed in the night sky, but cross the background of constellations. Popular interest in Mars developed with the observations of American astronomer, Percival Lowell, at the turn of the century. He believed that he saw canals on the Martian surface, which to him was unmistakable evidence of advanced intelligence.

Fantastic science fiction tales, including the notorious adaptation of H. G. Wells' The War of the Worlds by a young Orson Welles in October 1938 (which left much of America in panic), unfortunately eclipsed more serious discussions as to the likely nature of any martian life. However, the reality of the Martian surface was driven home by the first high-quality imagery of Mars taken by Mariner 4 in 1965. Mariner revealed a world more like our own Moon than expected, which combined with the Viking Missions, has lead to a very different view of Mars typified in popular novels such as Red Mars by Kim Stanley Robinson.

The first two attempts to reach Mars were made in 1960 from the Soviet Asian republic of Kazakhstan, but neither rocket succeeded in entering Earth orbit. It is a pity that after four decades of space rocket design, poor funding in part led to the loss of Mars 96. Mars 96 was launched from Baikonur cosmodrome in Kazakhstan on 16th November 1996 and ended when its Proton D2 rocket's 4th stage failed to reignite to transfer it from a circular low-earth parking orbit at 160km to a new apogee of about 100,000km. The rocket splashed down SE of Easter Island in the Pacific on 18th November, and is the 15th Russian Mars failure in 18 launches since 1960. The total lost mission cost is estimated at £300 million, and its failure has effectively cast the Russians out of the latest phase of Martian exploration.

This was also a disaster for Europe and the USA, who had placed a significant amount of electronic hardware (costing £40 million) aboard the 6-tonne craft. Some of the experiments had taken nearly a decade to design, and replacement in the short term is impossible. Coming as it did in the wake of the European Space Agency's (ESA) Cluster mission destruction on the new Ariane V rocket, the ESA's prestige has also been dented.

The result of these catastrophes is that NASA now has the field clear of competition for any Martian missions well into the next decade. NASA's track record is encouraging, in spite of the Mars Observer failure as it entered Martian orbit in August 1993. Under Daniel Goldin, the present Senior NASA administrator, this failure was used to underline the necessity of cheaper, more focused missions across the board if NASA is going to maintain steady funding levels under an increasingly thrifty Democrat regime.

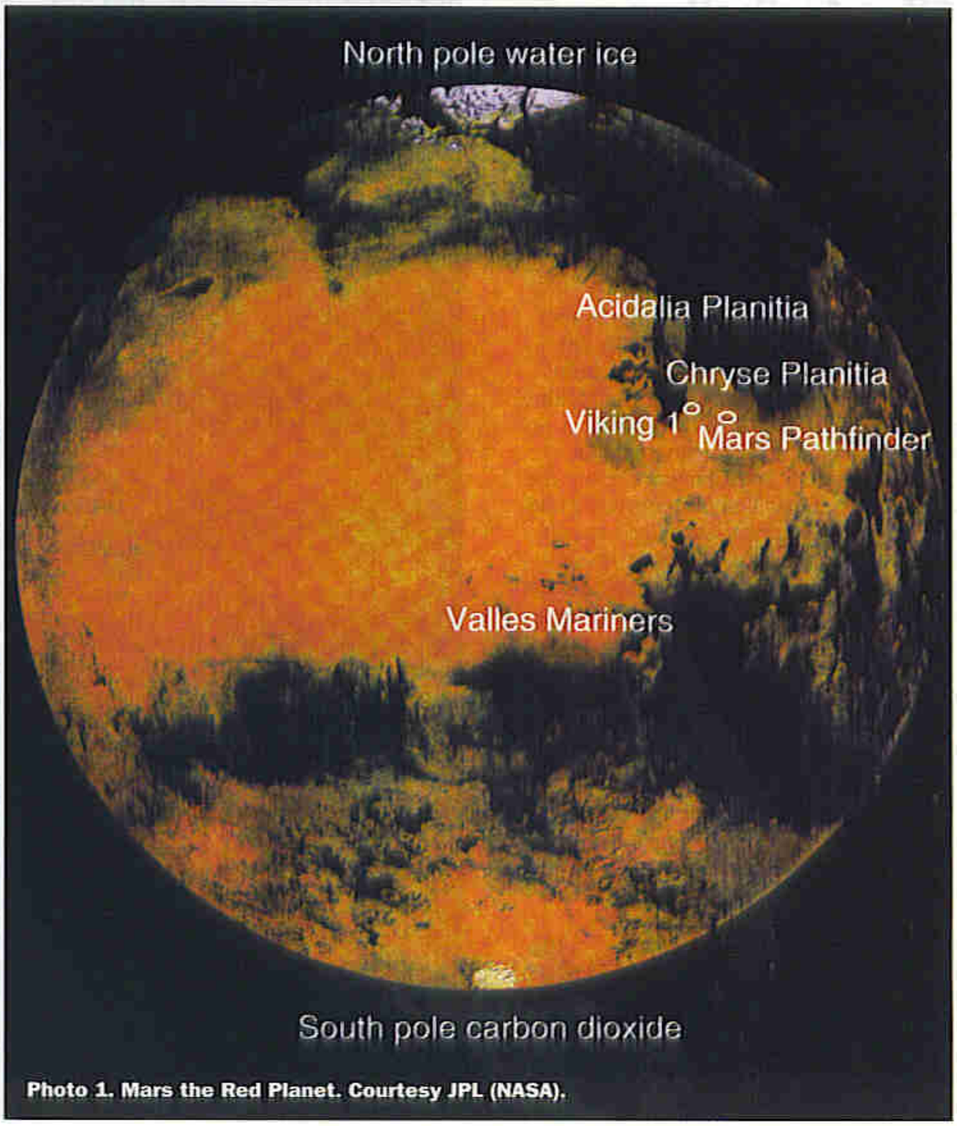


Photo 1. Mars the Red Planet. Courtesy JPL (NASA).

The Mars Pathfinder series will begin by deploying a small rover, Sojourner, launched on December 4th 1996 from Cape Canaveral on a McDonnell Douglas Delta 2 booster (7925A) and will explore the region around the lander, photographing terrain in a range of spectral energies. The overall mission aim is simple; to establish whether low-cost, soft landings are possible. This mission will be followed shortly after in September by the arrival of the Mars Global Surveyor (MGS) already launched, which will relay information from the Mars Pathfinder. MGS will enter Martian orbit using 'aerobraking' for the first time. Friction generated with the planet's tenuous atmosphere will decelerate it. MGS will scan the surface from a height of 400 miles with a resolution of 1m.

America intends to send Landers to Mars every 26 months from 1998 until 2005, and further Orbiters are planned for 1998 and 2003. A sample return mission will be launched in 2005 to hunt for speculated fossil bacteria found in meteorites such as ALH84001. A Lander will deploy a robotic rover to collect geological specimens and a return rocket will insert the samples into an Earth orbit, for initial analysis on the International Space Station (ISS). A permanent space station is one of Daniel Goldin's primary requirements for any future manned mission to Mars. The first Service Module for the ISS will be launched in April 1998 on a Russian Energia rocket, with a 3-man Russian/USA crew captained by William Shepherd, USA, in May 1998. However, the Russian-built Module is 8 months behind schedule, and if problems persist, the Module may either be fitted later or a US section inserted instead.

The ISS will play a key role in any manned Mars program in spite of recent claims of water ice at the Lunar South pole which could support a Moon Station. Dr Rich Lehner at the Pentagon announced that recent analysis of radar data from the Clementine Space probe, (launched from Vandenburg Airforce base, California in 1994) which mapped 99·99% of the moon's surface, had revealed water. The optical properties of water-ice cause radar echoes to be polarised quite differently from conventional rock echoes.

The Clementine mission was conceived in the Reagan StarWars initiative for tracking incoming intercontinental ballistic missiles and has taken nearly 2 million images, yielding the most complete radar analysis of our primarily satellite. Future surveys such as the NASA Lunar Prospector (launch date: September 24th 1997, designed for water detection at a cost of $63 million by Lockheed Martin) and the Japanese Lunar A in early 1998, are planned. Ice is believed to have been deposited by cometary impact at the Aitken South polar basin, which at 1,600 miles across and 8 miles deep, makes it the largest crater known in the solar system. ESA plans a preliminary lunar rover to explore the Moon's South pole in about 2005 and will travel up to 50km from the Lander to sample soil and ice.

A lunar station has some advantages over a space station, prolonged low gravity would be better physiologically than a microgravity (μg) environment. Analysis of the biological stresses upon plants, animals and people in low gravity and for specialist fabrication processes would complement μg work conducted by ESA and NASA. Astronauts to Mars can expect to spend 6-7 months in a μg environment. ESA has developed the Radius Programme (Research Associations for the Industrial Use of Space) to create commercial markets for the ISS. Radius offers customers the possible benefits of materials fabrication and processing in a μg environment.

Mission Name	Country	Launch Date	Mission	Results
Mariner 4	USA	28/11/64	Mars flyby 14/7/65	21 photos
Mariner 6	USA	24/2/69	Mars flyby 31/7/69	75 photos
Mariner 7	USA	27/3/69	Mars flyby 5/8/69	126 photos
Mars 2	USSR	19/5/71	1st orbiter/lander 27/11/71	No useful data
Mars 3	USSR	28/5/71	Orbiter/lander 3/12/71	Some data & a few photos
Mariner 9	USA	30/5/71	Orbiter 13/11/71	7,329 photos
Mars 5	USSR	7/5/73	Mars Orbiter 2/12/74	Lasted a few days
Mars 6	USSR	5/8/73	Orbiter/lander 12/3/74	Little data
Mars 7	USSR	9/8/73	Orbiter/lander 9/3/74	Little data
Viking 1	USA	20/8/75	Orbiter/lander 19/6/76	Combined the Viking orbiters
Viking 2	USA	9/9/75	Orbiter/lander 8/7/76	and landers,returned over 50,000 photos
MGS	USA	7/11/96	Orbiter	
Mars Pathfinder	USA	4/12/96	Lander and Rover	
Planet B	Japan	1/99	Orbiter	
1998 Surveyor	USA	12/98	Orbiter/lander	
2001 Surveyor	USA	3/01	Orbiter/lander	
2003 Surveyor	USA	5/03	2 Landers	
2005 Surveyor	USA	7/05	Sample Return	

Table 1. Successful and Planned Mars Missions.

So far, work has been in the areas of: biotechnology, pharmaceuticals, optoelectronics and metallurgy. Purification and crystallisation of proteins, semiconductor and electro-optic materials growth have already been tested in space. Radius will be incorporated in ESA's Manned Space Flight and Microgravity Programme to guarantee participants access to the ISS. Industry is beginning to discover the benefits of space in addition to a satellite communications industry worth several $US billion a year. Whether joint cooperation between commerce and governments can supply the necessary financial backing to support both a Space Station and Lunar base, even if directed towards a long term Martian Manned Mission, is unlikely. Some talk has been made of placing an observatory on the moon, but this could be achieved in space more easily with the Next Generation Space Telescope (NGST).

A Brief Review of Surveyed Martian Physical Features

Table 1 summarises past exploratory surveys and planned surveys. The first spacecraft to soft-land successfully on Mars was the Soviet Mars 3 in 1971. The Mariner space probe series helped to 'scout' out potential landing sites and paved the way for the Viking Missions of 1976. Viking heating and chemical experiments conducted on soil samples produced conflicting and ambiguous results, which was disappointing given the evidence of past massive water outflows across the surface. The surface has hostile extremes of pressure, temperature and radiation, the most harmful component of solar emissions being the high level of UV (100-400nm).

The Martian atmosphere is composed of 95·3% CO_2, 2·7% N_2 and 1·6% Ar, compared with 0·035% CO_2, 78% N_2, 0·93% Ar and 21% O_2 for the Earth. Surface temperature averages -23°C compared with 22°C on Earth, but may fall to -128°C during the polar night. Equatorial Martian diurnal temperature varies between -13 and 27°C, with a pressure 0·8% of the Earth. Mars has significantly more CO_2 than the Earth, and due to incomplete mixing of gases, some stratification in composition is expected.

Several physical and physiological features common to both Mars and Earth may help facilitate human exploration. The Martian axis is inclined at 25° to the orbital plane compared with 23·5° on Earth and as a result, well defined 'seasons' exist during the 687 Earth day Martian year. The Martian day is 37 minutes longer than the Earth day and adjustment to its diurnal cycle would not be too difficult. On a relative scale, Mars is smaller than the Earth, with an equatorial diameter of 6,795km, compared with the Earth's at 12,756km, resulting in gravitational accelerations of respectively $3{\cdot}73ms^{-2}$ (0·38go) and $9{\cdot}81ms^{-2}$. This is one reason why the Martian atmosphere is considerably thinner than the Earth's, although a breathable gas density could be supported within the Martian gravitational field. The solar flux is less than upon the Earth, due to the increased solar distance (228Mkm rather than 149Mkm or 1AU).

It is believed that the permanent Northern polar cap is composed primarily of water ice whilst the Southern pole is composed of frozen CO_2 and will be analysed by the Mars98 mission. The Southern hemisphere suffers greater extremes of temperature than the north due to axial tilt (similar to Earth). More CO_2 is effectively frozen out of the tenuous atmosphere in winter which fails to thermally shield Mars as on Earth.

During the Southern summer, CO_2 sublimes and increases the global atmospheric pressure. At the original Viking 1 lander site in Chryse Planitia, pressure varied between 6·7mb in Southern winter and 8·8mb in summer. The polar cap may cover as far North as 50°S in Southern winter. In spring, the CO_2 cap recedes 1° latitude every 5 days with the main cap breaking into several more stable CO_2 fields. In early autumn, CO_2 accretes again by sublimation and a large cloud layer called the 'polar hood' is visible.

The largest feature visible is Valles Marineris (Photo 1), which stretches over the planet for 5,000km, and in some places, canyons are 200km wide and 7km deep. The ultra-thin CO_2 dominated air causes fine dust or 'fines' to be convected by strong thermal gradients high up above the height of our terrestrial troposphere. The Southern hemisphere is crater strewn but the Northern hemisphere is more Earth-like in its geomorphological features. Large shield volcanoes such as Olympus Mons are present (similar to Mauna Loa in Hawaii). Life may exist in volcanically heated permafrost given new evidence of ancient archaic bacteria which live near deep ocean volcanic thermal vents and in permanently dark subterranean regions.

The Hunt for the Martians

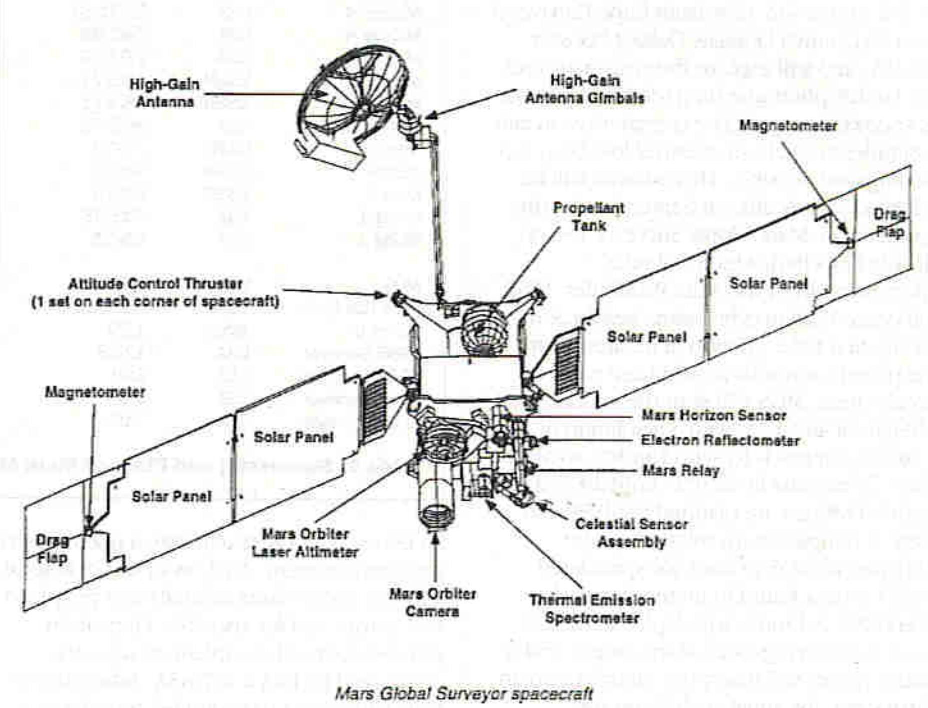
Meteorites like ALH84001 (found in the Allen Hills region of Antarctica) belong to the Shergottite-Nakhala-Chassingny (SNC) meteorite class, and contain trapped gas pockets with an identical composition to that measured by the Viking Landers. It is generally believed that these meteorites were expelled from Mars in planetary impacts and eventually captured by the Earth's gravity. The extreme stability of the Martian atmosphere over vast timescales needs further investigation.

Stable carbonate compounds suggests that the igneous meteorite was formed between 0 and 80°C, where water-based organisms can survive. Analysis of ALH84001 interprets possible traces of life on Mars by comparison with similar mechanisms on the Earth. After fresh surface fractures were made in the meteorite abundant polycyclic aromatic hydrocarbons (PAHs) were found. PAHs are often associated with biological activity and carbonate globules were identified resembling those known to be the result of terrestrial bacteria. The PAHs were found near regions rich in biological chemicals such as chysere and pyridine. The argument is that the random probability of all these probable evidences of life occurring together, giving an overall 'fingerprint' of life, is extremely unlikely. As far as scientists can tell, the PAHs were not caused by Earth contamination. Interestingly, the concentration of PAHs in the meteorite increases with increasing depth towards the meteorite core which clearly discounts any usual Diffusion-based contamination process from outside working in.

Photo 2. Possible fossilised Martian bacteria. Courtesy JPL (NASA).

Further analysis of the nanoscopic structure within the carbonate globules revealed elongated objects about 20nm (short-axis) to 100nm (long-axis) in size, much smaller than a human hair (Photo 2). Some similarity exists between these structures and those observed in calcite deposits formed in groundwater and are associated with nanobacteria. However, debate rages fiercely on these very small dimensions as they are on the fundamental limits for terrestrial bacterial. To resolve this problem and others, a dual approach will be taken; a search for fossilised Martian bacteria and also a search for life. The chance of detecting Martian fossils is not as remote as it may seem, as Mars possesses little or no plate tectonic activity which accounts for the continual reforming and consequent destruction of the Earth's fossil-rich sedimentary layers, instead, Mars appears to have a single layer of static crust.

Figure 1. Mars Global Surveyor spacecraft.



Mars Global Surveyor spacecraft

Mars Global Surveyor

The first Mars Global Surveyor (MGS) – see Figure 1 – was launched in November 1996 carrying 6 of the 8 scientific experiments carried by the failed Mars Observer in 1993 and will accomplish about 80% of the original mission objectives. The MGS has four main operational phases: launch, cruise, aerobraking and mapping. The transit flight, orbital capture and transference from an initial highly elliptical orbit to a stabilised circular geometry, is a complex process. The plan is to reduce the initial orbital period of 48 hours to a final orbit of 2 hours over 130 Earth days. Power is provided by gallium arsenide and silicon solar panels having 2·3kW peak power and 2 Nickel hydrogen batteries each with 20Ah capacity for occulted Martian operation. The main engine is powered by hydrazine and nitrogen tetroxide giving 596N thrust and 4·45N thrust from each of 12 hydrazine fuelled stabilising thrusters.

MGS Orbiter Sensors

An important mission objective, is detailed global mapping for geological and climate study. It will also give a better understanding of changes in climate history and an estimate of mineral resources that could be used to support a sustained human presence.

The Mars Orbiter Camera is two independent cameras mounted on a single optical assembly stage generating stripe images from 0·4 to 140° field of view (FOV) using adjustable optics and Charge Coupled Device (CCD) pixel detectors. Image resolution will range from 250m per pixel down to 1·4m per pixel (FOV = 0·4°) and will be updated daily to monitor geographical features; this is 35 times better than the Viking camera systems. Accurate high resolution monitoring of atmospheric and surface related phenomenon on a dynamic timescale will be possible for the first time.

The Mars Orbiter Laser Altimeter for Light Detection and Ranging (LIDAR) will measure heights above the Martian surface to pinpoint accuracy by timing returning reflected laser pulse echoes in an identical manner to the measurement of a ship's range at sea from timed radar echoes. A diode pumped Q-switched Nd:Yag laser (λ=1·064μm) will fire 10 pulses per second, with an error of 50cm, using a Cassegrain collecting mirror. Variations in surface reflectivity will indicate the presence of surface minerals. The discovery of valuable minerals such as significant deposits of gold or silver would open the commercial debate on viable space mining. This experiment is run by the Goddard Space Flight Centre.

Magnetometer and electron reflectometer 2 flux magnetometers will measure any residual magnetic field down to 16nT. An electron reflectometer will monitor the effect of the solar wind and its interaction with any Martian magnetic field. Mars is the only planet apart from Pluto whose magnetic field has yet to be measured. A radio system will observe distortions in Earthbound radio transmissions as they pass through the atmosphere, enabling temperature profiles to be recorded. Tiny changes in Doppler shift will allow accurate computer reconstruction of Mars' gravitational field. This project is also run by the Goddard Space Flight Centre.

Thermal Emission Spectrometer (TES)

All bodies above the absolute zero of temperature (OK) emit thermal energy. The significant amounts of heat radiated from the Martian surface, particularly in the Far Infra-Red (FIR) between 6-15μm, is utilised in thermal image mapping. Considerable intensity variation across the surface should be revealed during diurnal and seasonal cycles. The TES's Michelson Interferometer will operate between 6·25 and 50μm and is intended particularly for: dry ice and water ice measurements, information on polar cap growth and recessional dynamics, rock and grain size distributions, rock and sand dune mineral content, and for monitoring specific atmospheric molecules having vibrational bond energies corresponding to selective wavelengths of absorption. The principal investigator here is Dr Philip Cristensen, Arizona State University.

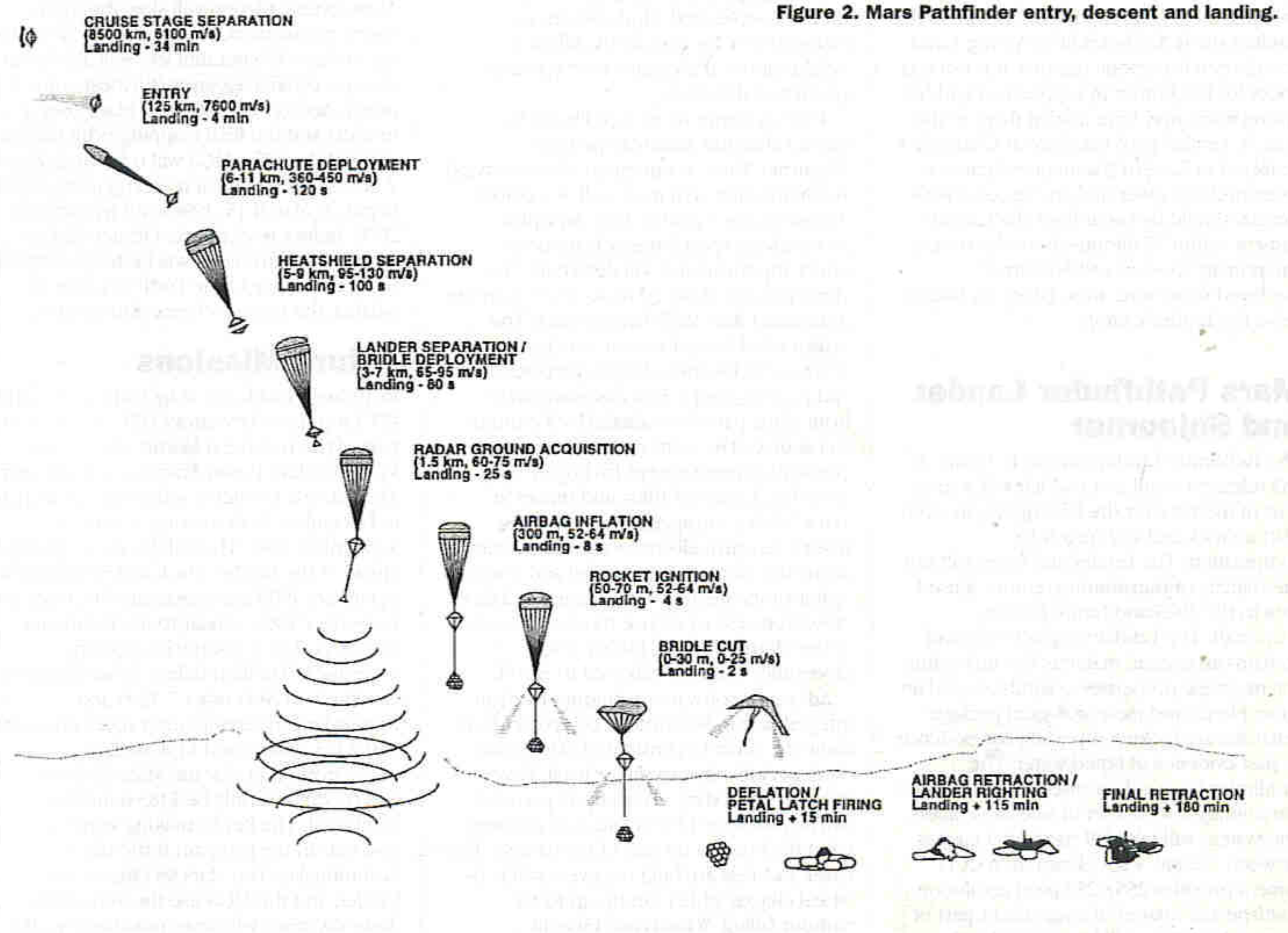
The Mars Relay will coordinate data from Pathfinder and the space transmission link. The Relay is a French designed module and will relay data from the lander sites to the Orbiter and from there back to the JPL database in Pasadena. A high gain antenna (1·5m diameter) is deployed at the end of a 2m long boom. The Madrid Deep Space Network's 70m antenna in Spain will support landing communications. Mission data will be received at 401·5 or 405·6MHz and orders transmitted to the land stations at 437·1MHz, from the high gain transmitter using only 1·3W of power!

Re-entry on Mars

Pathfinder uses an elaborate descent mode (see Figure 2). With 2 minutes to impact, the Lander will deploy a parachute reducing its speed from 360-450ms^{-1} at 6-11km height. After separation from its heatshield and from its backshell, the ground acquisition radar will operate. The thin Martian atmosphere makes the parachute only partially effective and a cluster of airbags will inflate when the Lander is travelling at 50-60ms^{-1} at only 300m above the surface and with 8 seconds before impact.

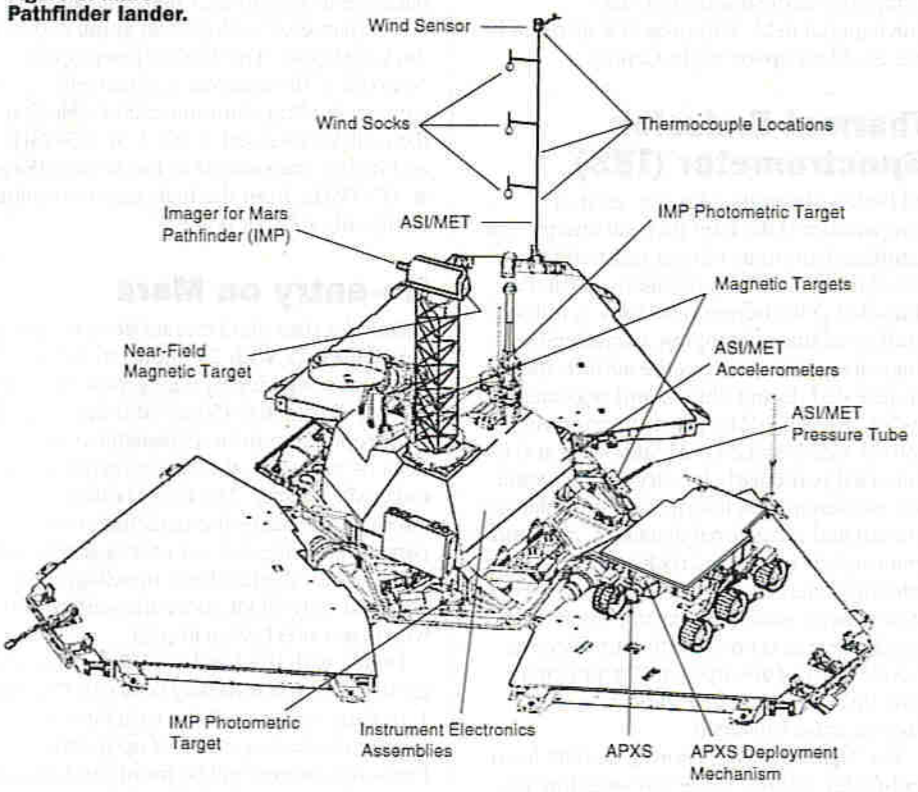
Finally, with the Lander 50-70m above the ground and still travelling between 50-60ms-1, braking rockets will fire to achieve a touchdown with a speed of up to 25ms^{-1}. Pressure readings will be monitored during Lander descent and after its airbag-cushioned landing. Sensitive accelerometers

Figure 2. Mars Pathfinder entry, descent and landing.



Mars Pathfinder entry, descent and landing

Figure 3. Mars Pathfinder lander.



will be used in the re-entry phase to monitor the 30-50g expected. The Ares Vallis landing site is 527 miles SE of Viking 1 and was chosen for several reasons: it is not too rocky for the Lander to topple over and hot spring water may have flowed there in the past. A 'similar' geological site at Channeled Scabland in Eastern Washington State was examined and rover mobility tested. Visual images should be taken from the Lander's camera within 35 minutes from the start of the primary mission and Sojourner deployed some time after, taking an hour to leave the Lander's ramp.

Mars Pathfinder Lander and Sojourner

The Pathfinder Lander (shown in Figure 3) will release a small rover which will wander tens of metres over the landing site to study Martian rock and soil (regolith) composition. The Lander and rover will test the viability of transmitting remote sensed data to the MGS and future orbiting spacecraft. The Lander weighs 890kg and contains an imager, magnets for measuring soil magnetic properties, a windsock and an atmospheric and meteorological package. Scientists are looking especially for evidence or past evidence of liquid water. The Pathfinder has a colour discriminating stereo-imager with a set of selectable filters. The system will take full panorama images between -72 and +83° elevation. A CCD camera provides 256×256 pixel resolution. Multispectral images of a significant part of the visible surface will be acquired in 8 spectral bands. The Atmospheric and Meteorological (ASI/MET) package will record temperature using thin wire thermocouples and wind sensors are included in a 1m mast at six different heights above the surface to determine speed and direction.

The Sojourner rover (see Photo 3), named after the American pioneer, Sojourner Truth, is equipped with a forward stereo-imaging system as well as a colour imager on the vehicle's rear. An alpha proton X-ray spectrometer is mounted under the rover, and will determine the elements that make up rocks and soil in the designated Ares Vallis landing area. The sensor head is held against a rock and analyses backscattered alpha particles, X-rays and protons over a 5cm diameter circle from alpha particles radiated by a curium-244 source. The instrument can measure all elements present except hydrogen. The rover has a mass of 10kg, and moves at $1cms^{-1}$ with a top speed of $0{\cdot}4ms^{-1}$. The rover's sensitive electronics are thermally protected using a silica aerogel and 3 small radioisotope heater units containing 2·6g of plutonium-238 to survive the extreme cold of the Martian night (-110°C). The electronics must be stabilised to ±40°C.

Advanced software techniques form an integral part in Sojourner's control and will allow the rover to consider obstacles and then 'decide' what to do for itself. Rover abrasion caused by atmospheric particles, will be monitored by its effect on different paint thicknesses on one of the wheels. The rover's wheels are built on a very stable 6-wheel chassis which can tip up to 60° without falling. Wheels are 13cm in diameter and made of stainless steel foil, and can move up and down independently. Three motion sensors along Sojourner's frame detect excessive tilt and will stop the rover before it can roll over. Sojourner can scale boulders over 25cm high and keep going. The rover weighs 16kg, is 65cm long, 48cm wide and 30cm tall and its performance will be evaluated for future missions demanding better technology, new sensors, more capable rovers and specialist excavation tools. Data will be gathered by the 325kg Pathfinder Lander for 30 Martian days or 'sols' while the rover is deployed for autonomous 7-day periods. Future rovers will travel several kilometres between specific geological targets of mineral and organic interest.

Two trajectory corrections will take place on April 20 and August 22. MGS will perform an attitude correction manoeuvre on reaching Martian orbit and will fire its main engine for about 20-25 minutes to slow down. Because of mass limitations imposed by the Delta 2 booster's lifting ability, the MGS does not carry sufficient propellant to place itself into its final low-altitude mapping orbit when its engine is fired. As a result, the spacecraft will relying on aerobraking, an innovative technique first demonstrated by the Magellan spacecraft around Venus, modifying its initial highly elliptical orbit down to the mapping altitude.

During each orbit, the MGS will pass through the atmosphere's upper fringes when closest to the planet (periapsis). Atmospheric friction will slow the MGS, losing momentum, and bringing it closer to the surface. Momentum loss will also lower the spacecraft's apoapsis (furthest point of orbit). Aerobraking will take place over 4 months and the final mapping orbit will be 350×410km. The MGS will orbit once every 2 hours and the initial mapping mission will begin on March 15, 1998 until January 31 2000. Before re-entry, the Orbiter Camera and TES Spectrometer will be fully calibrated using the image of the Earth to correctly balance the colour scheme and contrast.

Future Missions

Rich Zurek heads the Mars 98 project at the JET Propulsion laboratory (JPL) which forms part of the Lockheed Martin team run by Vice-President Parker Stafford with 150 staff. The Mars 98 Orbiter is scheduled for launch in December 1998, arriving at Mars in September 1999. This will be about 80 days ahead of the Lander which will be launched in January 1999 and arrive on a fast track in December 1999, similar to the Pathfinder launch (a Type 1 fast-track trajectory covering 310 million miles). While the MGS launched on November 7 1996 and Pathfinder Lander/Sojourner rover program cost $155 million and $196 million respectively, costs for the Mars 98 Orbiter and Lander will only be $183·6 million combined. The key to making significant cost cuts in the program is the use of Commonality. The Mars 98 Orbiter and Lander, and the MGS use the same basic design systems wherever possible, e.g., the same RS6000 computer, an identical imaging system and meteorological package.

The Lander will be 1m wide and 49cm

deep. While both the MGS and Pathfinder each weigh about 2,000lb and used a Delta booster with 9 solid rocket motors, the Mars 98 Delta launch will have only 4 solid rocket motors and a combined reduced weight of 2,720lb, saving almost 640lb per spacecraft. The Orbiter's weight is so small that it will be the first to use aerocapture instead of rocket propulsion to enter orbit. After aerocapture, it will use aerobraking, like MGS, to descend to the lower operational orbit. The Lander and two probes are encased in basketball size silicon carbide aeroshells and will separate from the main vehicle before diving into the Martian atmosphere. The aeroshells contain 5·5lb probes intended to impact the surface at 445mph within 120 miles of the Mars 98 Lander. The aeroshells will shatter, allowing the 3·8in. probes to penetrate between 1-6ft. underground. The subsurface probes will contain soil sample chambers designed to provide data on soil water ice content. The Lander's touchdown will be targeted for 80° S, near the South Pole.

The Lander must avoid the CO_2 ice sheet itself as it cannot survive the ice sheet's very cold temperatures and is aimed for a soft landing 100km off the polar cap edge, which sublimes at the start of the South polar summer. Instead of a parachute system for the last 1km terminal descent (as in Pathfinder), the Mars 98 Lander will deploy a similar descent rocket system to the original Viking missions. The Lander will image the surface during the parachute descent with a small camera from Malin Space Sciences of San Diego.

Imaging will begin at 6·4km where the camera should discern surface features 7·6m across, and at 100m, should see objects as small as 13cm. The camera was tested in Antarctica with solar elevation angles of about 130, similar to expected Martian conditions. At 2·2lb, the camera is incredibly only 5% of the MGS camera weight and the wide angle lens will characterise clouds and atmospheric phenomenon.

The MARS 98 Lander payload includes 37lb of integrated scientific equipment, including imaging and weather systems, and a Russian LIDAR to study atmospheric dust content, adding to Mars 96 data. The Mars 98 Lander will carry a 6ft robot arm developed by JPL and a gas analyser. The sampler arm will dig 2ft. deep trenches and a camera will record layer images revealing soil stratification. The Lander carries 16 ovens and permits 8 samples to be analysed and then compared with 8 control samples. The 8 soil samples delivered to the gas analyser will be baked to identify minerals such as the mysterious carbonates uncovered in ALH84001. Oven power is supplied by 2 solar arrays unfurled from the Lander's sides and two arrays mounted on the main body. Since the Mars 98 Lander only uses solar arrays, it will freeze as the Martian winter sets in. Ground controllers at Lockheed Martin and JPL intend to try and reactivate it the following summer but doubt whether they will succeed. The Mars 98 Orbiter will last two Earth years and contains a Pressure Modulated Infrared Radiometer developed originally for the 1993 Mars Observer. The instrument weighs 100lb and is designed to obtain vertical atmospheric profiles of composition, temperature, pressure and dust during seasonal changes; important information for a future manned mission. The next Surveyor Orbiter, to be launched in 2001, is at the design stage, and a final decision will be made after April 1997.

The Mars 98 relay will include a UHF 1m high gain aerial similar to that used on MGS. Future capabilities will concentrate on developing infrastructure: such as communication and navigation satellites, along with technologies for in-situ resource utilisation, e.g., establishing automated 'factories' to manufacture propellants for a much cheaper manned Mars mission using the simple Sabatier chemical process. Ultimately, scientists expect astronauts will go to Mars to look for evidence of life as human intuition, mobility and pattern-recognition abilities still far outstrip even the best neural network designed robots.

Future Sample Return and Manned Return Sample Missions

NASA plans a Sample Return Mission for 2005. It will be the role of Orbiter craft to provide high resolution mapping information to identify possible landing sites for these missions. High resolution colour images, currently only available from spy satellites, will become commercially available from December 1997, when Space Imaging will start to sell digitally acquired data from a 400km Earth orbit having 0·82m resolution.

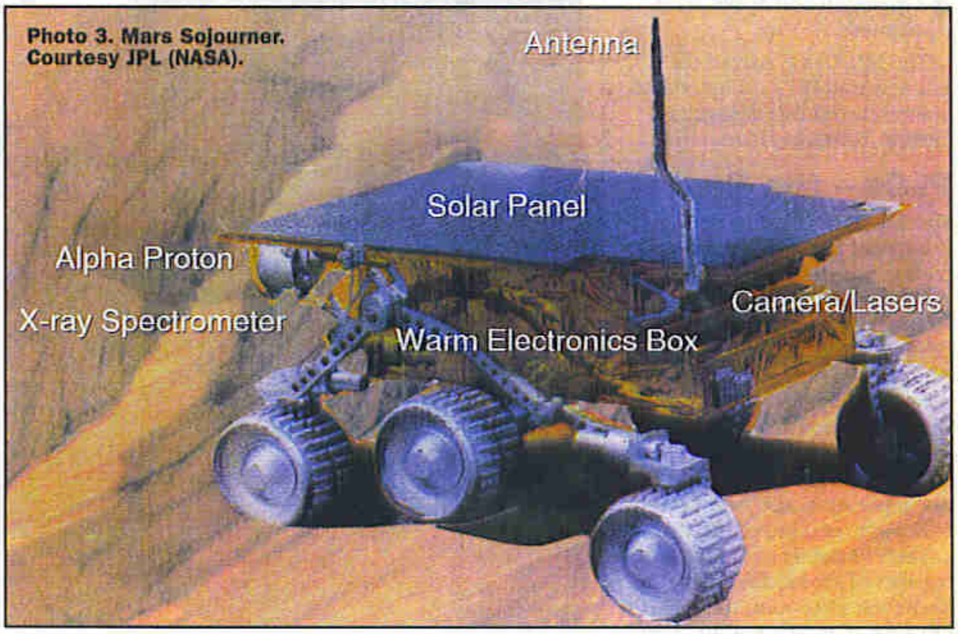
JPL's first scenario for a sample return mission would keep a mothership in orbit whilst jettisoning a Lander and rover to collect samples and then rendezvous with the Orbiter for return to the ISS in 2006. The earliest likely date for a Manned Mission is 2018 with current US financial backing. Several daunting practical problems will exist for any manned mission including zero gravity for 6-7 months, causing cardiovascular and muscular deterioration. The expected cosmic ray dose may be as high as 50 REM, greater than that permitted for radiation workers, but equates to roughly 25 years of high altitude flying and may prove an acceptable risk for such a pioneering voyage. A returning spaceship would probably rely on manufacture of its fuels directly from the atmosphere. Further survival hazards include a lack of intrinsic food or water and fierce dust storms.

What Next?

The Mars Together collaboration initiated between Russian and the United States in the Spring of 1994 has now lead towards plans for a sample return mission in the middle of the first decade of the 21st century. Japan is also building an Orbiter called Planet B to study the Martian upper atmosphere and its interaction with the solar wind and will be launched in August 1998 carrying a US mass spectrometer to investigate the upper atmosphere. Several possible sites for future expeditions have been put forward, Hadriaca Patera, in the Southern hemisphere is believed to contain thermal springs that may harbour primitive life. Parana Vallis contains an extensive site of dried river systems and Gusev crater in the Southern hemisphere is probably the remnant of a 500 mile long lake where life may exist.

The Mars Pathfinder Series is a wonderful example of Man's ingenuity and cooperation to go beyond the bounds of human experience and machine endurance. The tiny fleet of spacecraft with their elaborate sensors, imagers and communicators, sent to unravel scientific mysteries, in some way echoes the early sea voyages that heralded the renaissance and the great ocean voyages of discovery by past giants such as Columbus, Magellan and Drake. Perhaps in a hundred years from now, new names will have joined that list of pioneers on Mars, the New World.

Photo 3. Mars Sojourner. Courtesy JPL (NASA).



The Matsushita FP1 PROGRAMMABLE LOGIC CONTROLLER

by Bob Norfield, Technical Manager, Matsushita Automation Controls

The Programmable Logic Controller, or PLC as it is commonly known, has been part of industrial control for almost 20 years and has evolved from a large, complicated device to a small, compact and extremely powerful microprocessor-based controller. Like the personal computer, the PLC has not only improved significantly in processing power but the unit cost has been reduced.

The reduction in price of PLCs has enabled Matsushita Automation Controls to offer a complete introductory PLC starter kit for just £299 from Maplin (order code SH31). The kit includes everything the first time user requires to introduce themselves to a PLC programming environment and includes the following items:

- FP1-C14 Programmable Logic Controller
- NPST-GR Programming Software
- Programming Leads with built in RS232c/422 Converter
- Input Simulator Switches
- Operation and Application Manuals

The FP1-C14 is part of the FP1 series of PLCs designed and manufactured by Matsushita Electric Works in Japan.

PLCs – the Basics

The Programmable Logic Controller is a microprocessor-based control system initially designed to replace hardware relays, timers and counters. Generally, the size of the controller is determined by their input and output capabilities, referred to as the I/O count, and memory capacity. Generally, the larger the application, the larger the I/O count required of the PLC.

The FP1 family of controllers consists of six models named after their I/O count; these are FP1-C14, -C16, -C24, -C40, -C56, and -C72. Each model can have up to 144 firmware-based timers and counters, together with a number of memory flags used as part of the PLC program. The PLC operates on the method called 'cyclic execution'; this operation can be seen in the Figure 1.

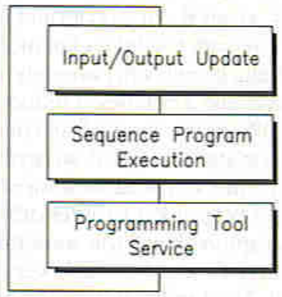


Figure 1. Cyclic Operation.

Input/Output Update

The I/O update is a routine that reads the status of the PLC inputs and writes the information into an area of

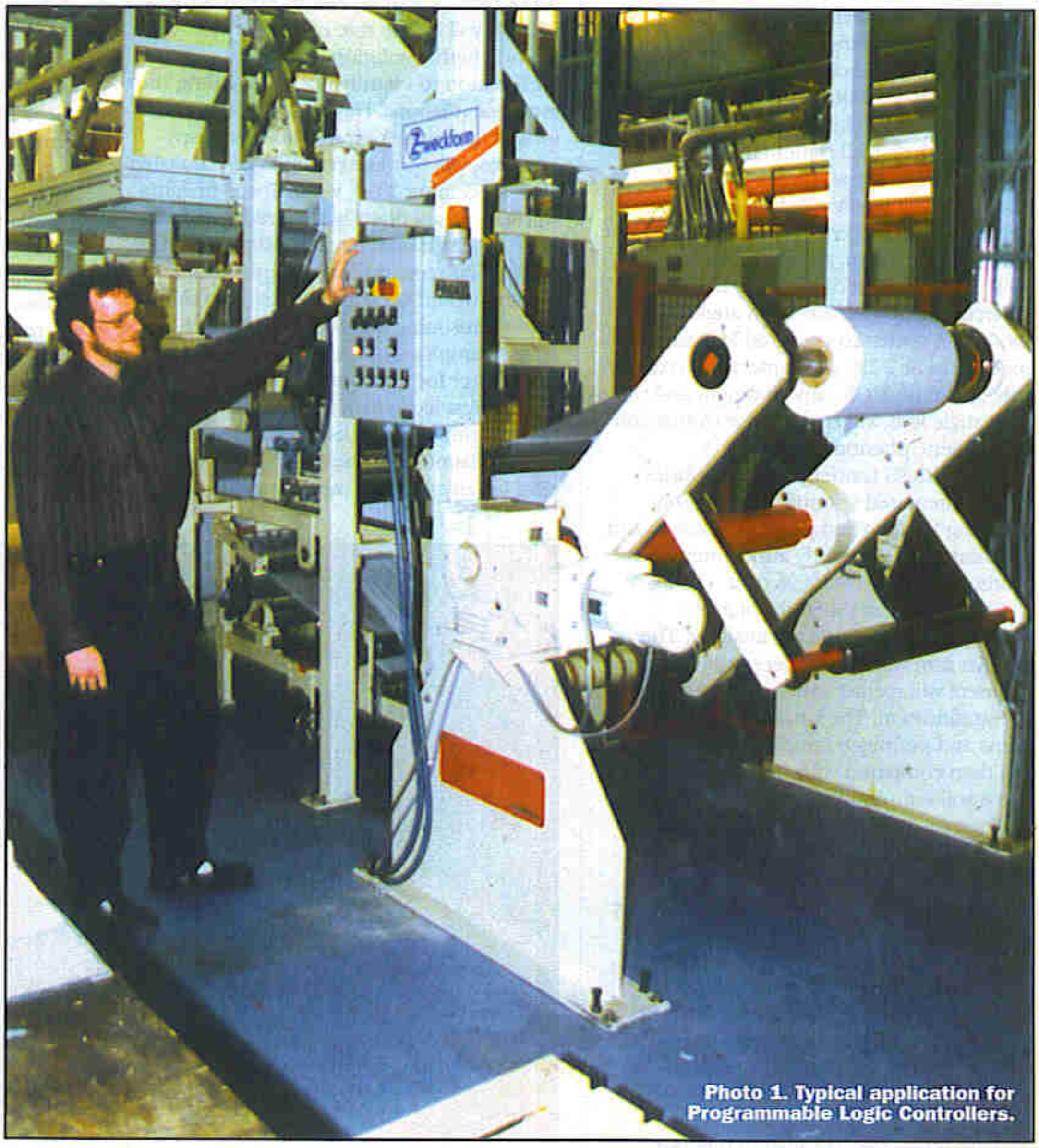


Photo 1. Typical application for Programmable Logic Controllers.

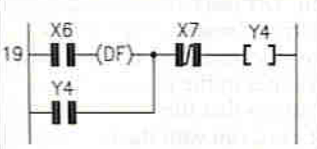


Figure 2. A small Ladder Logic Program.

memory called the input map. The outputs of the PLC are also updated with the information stored in an output map. Other areas also updated are the internal flag map and the timer/counter status map.

Sequence Program Execution

This part of the execution deals with the actual program designed for the application. The outputs and functions of the program are updated with respect to the latest information derived from the I/O update routine. This information will then be written to the outputs via the output memory map.

Programming Tool Service

This is a small part of the execution where communication between the PLC operating system and the outside world takes place, this is usually in the form of either a PC running the programming software or a hand-held programmer.

Programming

There are several methods of programming associated with PLCs that have been developed over the years. However, by far the most popular is a style called Ladder Logic.

Ladder Logic programming is based on the diagrams for describing relay logic circuits, and via the programming software, a graphical representation of the application circuit diagram can be replicated. Using contacts and coils, it is easy to replicate many common circuits used for hardwired logic. The big advantage being that if a wiring modification is required for the application, then only a simple change to the PLC program is required, rather than a change or addition of components and the time consuming rewiring associated with it.

The ladder diagram can be any size from a few rungs to a highly complex program consisting of many rungs, subroutines, and high level functions.

Matsushita are now able to offer the PLC programmer the latest programming technology using their Windows-based programming package based on the European IEC1131 standard. NAiS Control 1131 is a programming system that allows the user the facility to structure their program, not something normally associated with ladder logic.

The programmer can choose or combine one of four programming styles, Ladder Logic, Instruction List, Function Block Diagram, and Sequential Function Chart for their application. With each method, separate programs are generated for separate features of the application, and finally combined to produce an overall application program. The package also allows program features to be saved as a Function in its own right and used in future applications. This saves a considerable amount of time from a debugging point of view.

Addressing

Depending on the manufacturer of the PLC, the inputs and outputs used in the PLC program are addressed using usually one of two methods. This is either hexadecimal or octal. The Matsushita FP series of PLCs relies on the hexadecimal format, and treats groups of I/O in blocks of 16 individual bits.

The PLC instruction set can be split into two distinct areas, Basic Instructions and High Level Functions, and as they suggest, are used depending on the complexity of the task. The number of instructions available to the programmer varies depending upon the type of PLC and the application it is designed for. The FP1 series offers the programmer almost 100 basic instructions and over 130 advanced instructions for more demanding tasks.

The instruction or function used will determine the format of the address. For a simple interrogation of an input, output, or internal flag, the method of addressing will be in bit form. High level functions rely on 16-bit Word addressing.

The basic types of instruction used by the FP series PLC is made up of two basic elements, the relay symbol and memory address.

The following addresses are applicable for the FP1 series PLC:

Relay Type	1st Element	2nd Element
External Input Relay	X	0-12F (Hex)
External Output Relay	Y	0-12F (Hex)
Internal Relay	R	0-62F (Hex)

High Level Functions are used for more complicated program requirements and are required for data handling; there are over 100 available to the FP1 user. Information is treated in either 16-bit Word format, or 32-bit DoubleWord format. The functions allow the PLC to perform various tasks, for example, mathematics, data conversion, comparison instructions and a number of other specialised features specific to the PLC.

Types of Application

The size of the PLC controller can vary considerably depending on the application. A MICRO or mini PLC, like the FP1 series, is generally regarded to have an I/O count of between 10 and 128 points and in the early days of development, provided only sequence control with a very basic instruction set. This has changed considerably in recent years and now the small PLC has processing capabilities very similar to the medium to large PLC systems.

High speed counters, interrupt processing, real time clocks, stepper motor control, analogue processing, and communication networking are all features now built into the small PLC. Therefore, the range of applications the PLC can satisfy are considerable. Due to their low cost, the majority of these applications are for simple relay and timer/counter replacement. Considering the individual cost of timers, counters and relays, and the time required to hardwire them, the PLC offers a very cost-effective alternative. In addition to the cost-effectiveness, the flexibility of the PLC is an extra bonus, allowing simple changes in the application to be carried out in seconds rather than hours for the hardwired method.

The above features allow the PLC to be used in a variety of applications including lighting control, machine control, motor control, etc. The applications are endless and have allowed the PLC to become an integral part of manufacturing equipment.

The FP1-C14 PLC starter kit is now available from Maplin Electronics, order code SH 31, price £299.

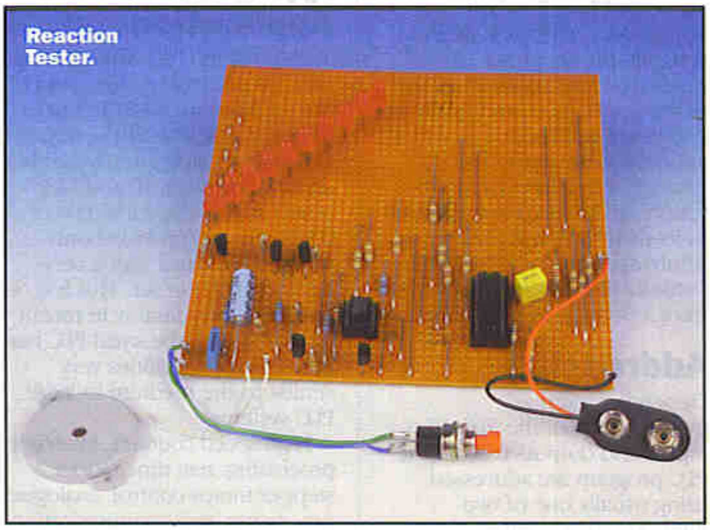
Contact
Matsushita Automation Controls, Sunrise Parkway, Linford Wood, Milton Keynes MK14 6LF.
Tel: (01908) 231555
Fax: (01908) 231599

Educational MINI CIRCUITS PART 1

by Robert Penfold

Reaction Tester

This simple reaction testing game has a 10 LED 'running' light display. When the reset button is operated, the first LED in the display switches on, but after a delay of approximately five seconds, the display starts to 'move'. The idea is to halt the display as quickly as possible once it starts to operate. The display provides a relative indication of the competitor's reaction time, since the sooner the display is halted, the less far the display will have progressed. In order to halt the display, it is merely necessary to use a finger tap firmly on the case.



Circuit Operation

The full circuit diagram for a reaction tester appears in figure 1. The 'running' light display is produced by IC2, which is a CMOS 1-of-10 decoder. The ten outputs of the decoder drive the display LEDs (D1 to D10) via current limiting resistors R12 to R21. This produces what is effectively a very basic decade counter. A positive reset pulse is provided to IC2 at switch on by R22 and C3, and this results in the count being set at zero and D1 being switched on. When the counter circuit is active, subsequent clock cycles from IC1 result in LEDs D2, D3, D4, etc. switching on, one at a time, until eventually, D10 is switched on. At this point, TR5 is also turned on, pulling pin 4 of IC1 to a very low voltage, and switching off the clock oscillator. This prevents the display from going back to the state where D1 is switched on, and then cycling indefinitely.

The clock signal to the counter can also be controlled by the inhibit input at pin 13 of IC2. A low logic level at this input enables normal operation, and a high logic level blocks the clock signal. This input is controlled by a simple latch circuit based on TR3 and TR4, and at switch-on, the latch tends to go to the state where both transistors are switched on. This takes the inhibit input of IC2 high and blocks the counter.

In order to use the reaction tester, first push-button switch S1 is operated, and this results in TR1 and TR2 being switched on. TR1 discharges C3 via current limiting resistor R24, producing a reset pulse for the counter in the process. This ensures that the counter always starts a run with the first display LED (D1) switched on. TR2 places a virtual short-circuit across the base-emitter terminals of TR4, and this takes the latch to the state where both transistors are switched off. On the face of it, this should result in the counter starting to operate immediately. However, C3 and R22 have deliberately been given high values so that a very long reset pulse is supplied to IC2. This holds the count at zero until the reset pulse subsides, which takes about five seconds. The purpose of the delay is to give the contestant time to get ready before he or she has to halt the count. The delay time must be long enough to make it difficult to anticipate the start of the count, but it must not be so long that users get bored and lose interest! A delay of about five seconds seems to be about right in practice.

The count is stopped by tapping on the case so that microphone MIC1 produces a burst of strong pulses that are fed to the base of TR3. Positive half-cycles switch on TR3, which triggers the latch to the state where both transistors are switched on. This takes pin 13 of IC2 high, and halts the count so that whichever LED happened to be switched on at that instant remains switched on. The further the count has progressed, the slower the contestant's reaction time. In order to start another timing run, it is merely necessary to operate S1 again, and the entire cycle of events is then repeated.

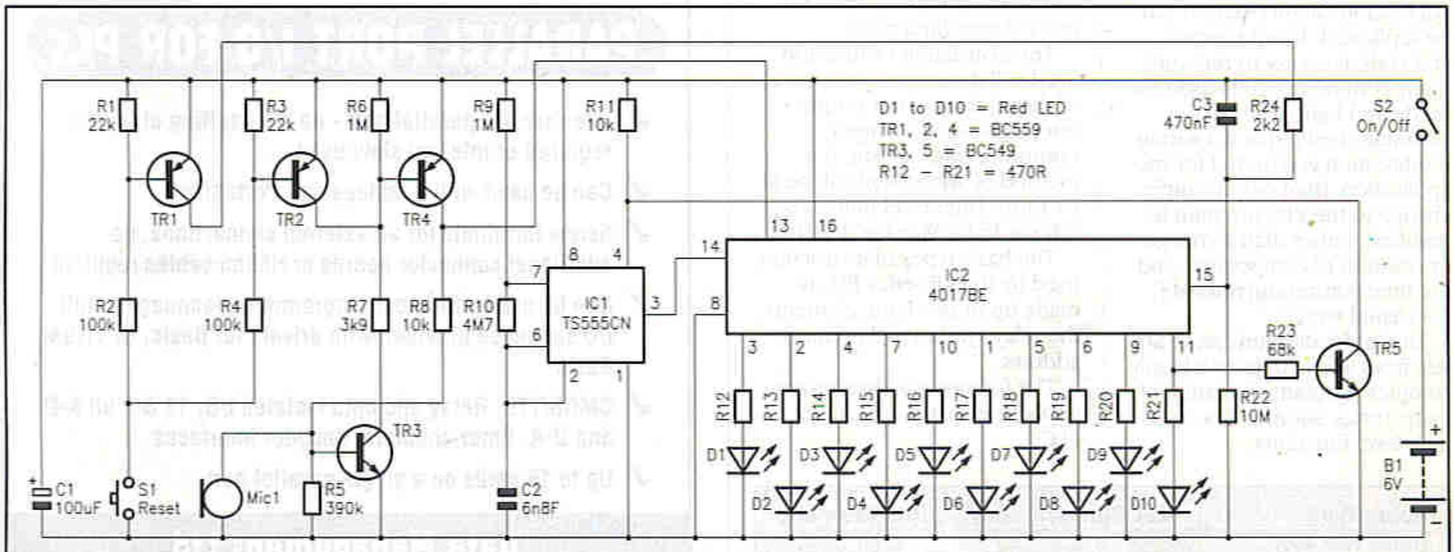
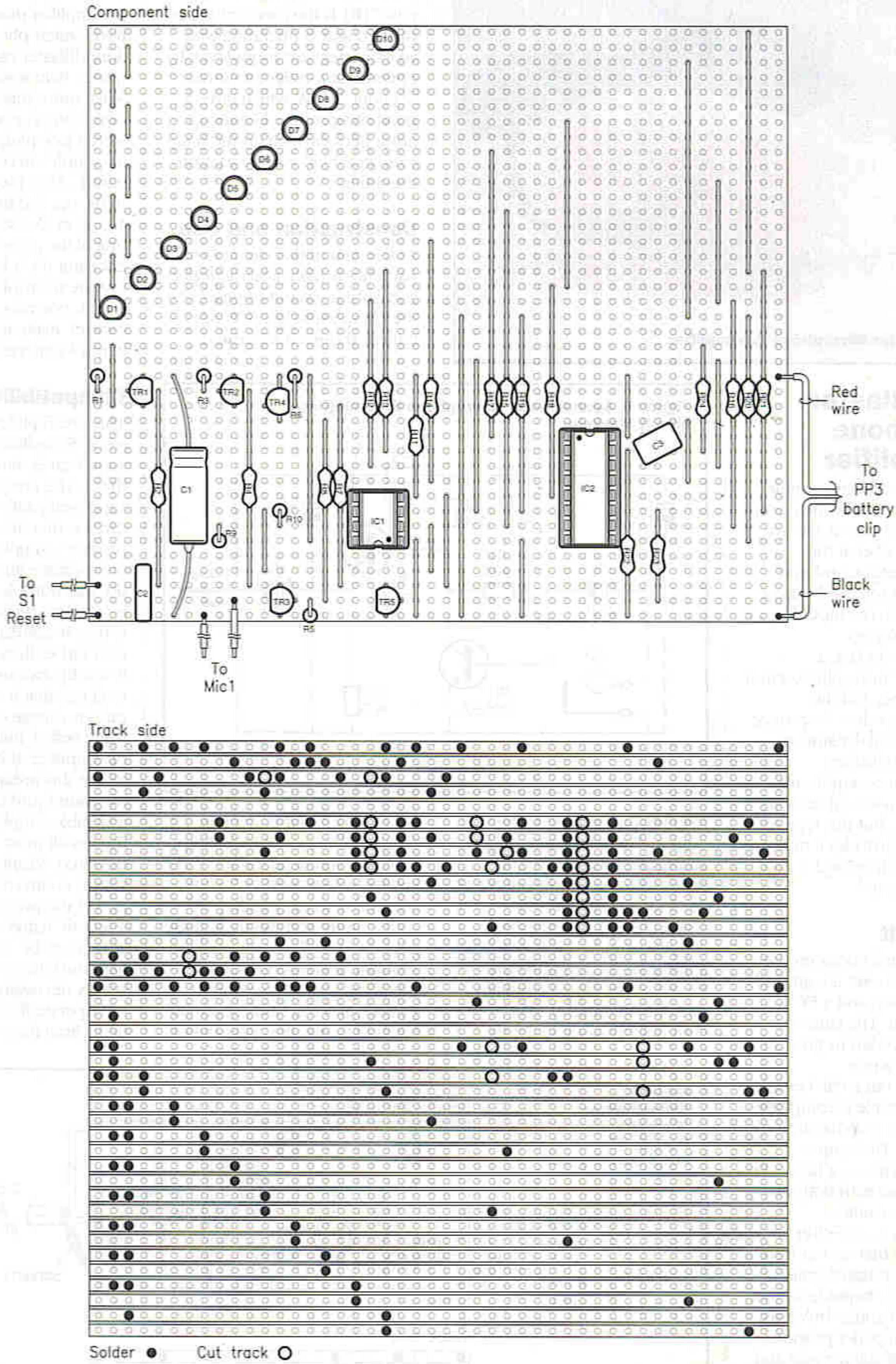


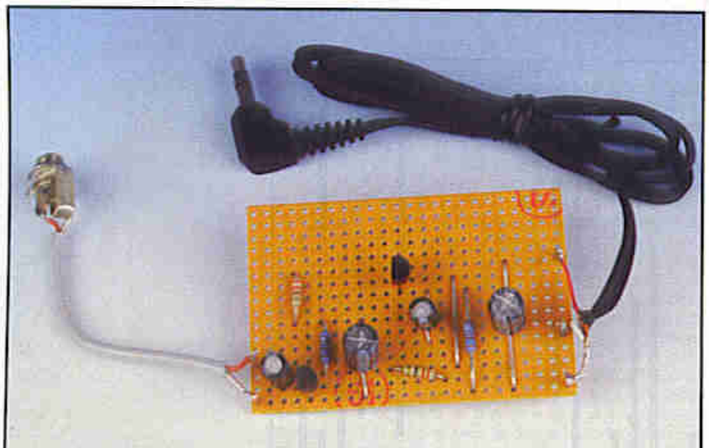
Figure 1. Reaction Tester circuit diagram.

Figure 2. Reaction tester stripboard layout.



Construction

Construction of this project is reasonably straightforward (see figure 2), but bear in mind that the 4017BE used for IC2 is a CMOS device, and that it requires the standard anti-static handling precautions. D1 to D10 can be a 'proper' bargraph display or 10 individual LEDs. As the LED current is only a few milliamps, it is advisable to use a high brightness display or LEDs. The microphone is actually a ceramic resonator, and the circuit was found to operate well using both cased and uncased types. A cased ceramic resonator is probably the easier type to use. These normally have 'flying' leads and provision for screw fixing to the front panel of the case. Do not try to use any other type of microphone, as 'real' microphones are unlikely to provide a high enough output level to drive the latch properly. The circuit is powered from a 6V battery which is comprised of four AA-size sells fitted in a plastic holder. The connections to the battery holder are made via an ordinary PP3 style battery clip.



Soundblaster Microphone Preamplifier.

SoundBlaster Microphone Preamplifier

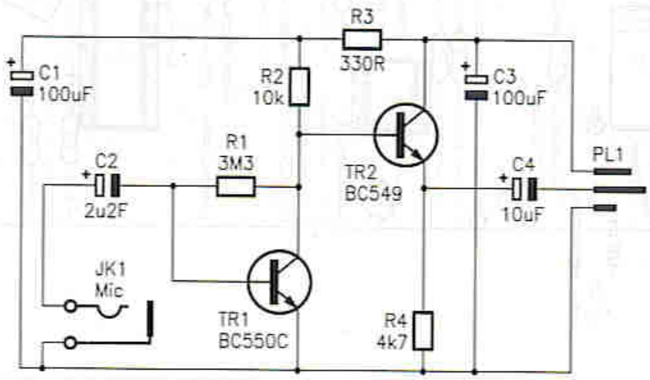
SoundBlaster and compatible sound cards are now the norm for PCs. These have a 3·5mm stereo jack socket at the microphone input, and one could be forgiven for thinking that this is a stereo input for dynamic or electret microphones. In fact, a SoundBlaster microphone input is a mono type, and the sensitivity is too low for proper use with normal dynamic or electret microphones. Apparently, these inputs are intended for use with carbon microphones, but this type of microphone provides a rather low quality output, and is now obsolete anyway.

The Circuit

The three connections on the stereo input socket are ground, the signal input, and a 5V supply output. The latter was originally intended to provide power for a carbon microphone, but it can be used to power a simple preamplifier for an electret or dynamic microphone. The simple preamplifier circuit of figure 3 is suitable for use with both low impedance dynamic microphones and electret microphones that do not have a built-in step-up transformer. These have an output level that is usually well under 1mV rms, but this preamplifier provides about 40dB of voltage gain and should, therefore, provide an output level of around 50mV rms. This seems to be more than adequate to fully drive the microphone input of a SoundBlaster card.

The circuit is a simple two-stage direct-coupled type which has TR1 as a common emitter amplifier and TR2 as an emitter follower buffer stage at the output. There seems to be a current limiting resistor in series with the supply output of the sound card, and this severely limits the available supply current. This is not really a major restriction since the transistors in the preamplifier must be operated at low currents anyway in order to obtain a low signal-to-noise ratio. TR1 is the more critical of the two as it is operating with an extremely low input level. It operates at a collector current of about 350μA, which gives a good compromise between noise performance on the one hand and high voltage gain on the other.

Figure 3. Soundblaster Microphone Preamplifier circuit diagram.



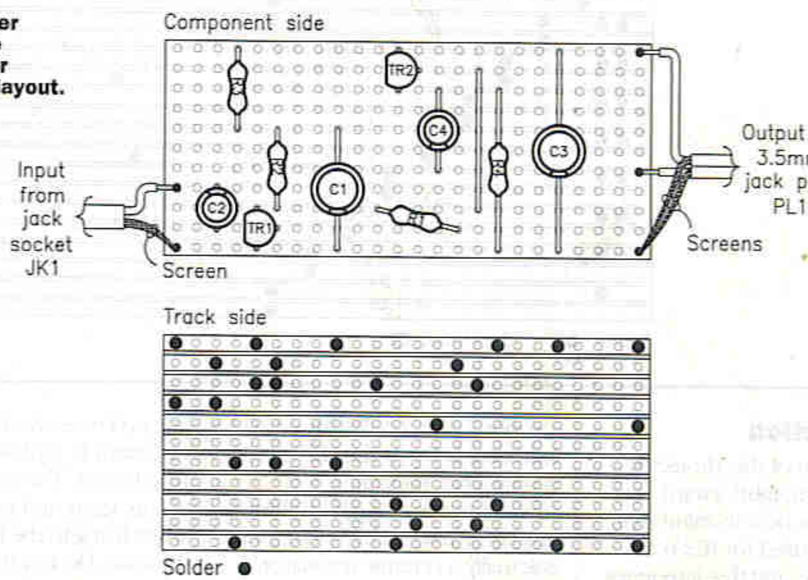
Construction and Use

As the gain of this circuit is not particularly high, and the input and output are out-of-phase, the component layout is not critical, though a suggested stripboard layout is given in figure 4. The circuit is dealing with very low level input signals, which renders it very vulnerable to stray pickup of mains 'hum' and electrical noise generated by the computer and monitor. It is essential that a metal case is used for this project, and the case should be earthed to the 0V supply rail of the circuit. The output of the preamplifier must be connected to the microphone input of the SoundBlaster card via a good quality twin screened cable. Make quite sure that the output of the unit is connected to the stereo jack plug correctly. The 0V supply rail connects to the barrel of the plug, C4 connects to the tip, and the positive supply rail is connected to the ring of the plug. The preamplifier does not include a gain control, but the microphone recording level is normally under software control, making a hardware gain control unnecessary.

Compatibility

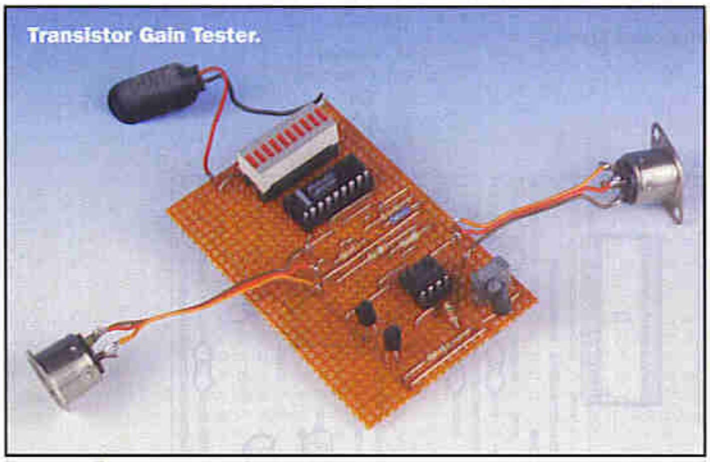
This preamplifier will work with some SoundBlaster compatible sound cards, but not all of them. The problem with some supposedly fully compatible cards is that they do not provide a supply output on the microphone input, or if they do, the available supply voltage is very low. If your PC is fitted with a SoundBlaster compatible card rather than the 'real thing', it would obviously be prudent to check that it can provide an output voltage of around 3V or more before building this preamplifier. It is still possible to use this preamplifier even if the sound card does not provide a suitable supply output, but the circuit must then be battery powered. Simply omit the supply connection to PL1, and power the preamplifier from a 4·5 or 6V battery. An SPST on/off switch can be added in series with the battery, but this is not strictly necessary as the circuit will operate for thousands of hours from three AA-size batteries.

Figure 4. Soundblaster Microphone Preamplifier stripboard layout.



Transistor Gain Tester

This transistor gain tester uses a 10-LED bargraph display to indicate DC gain levels from 50 to 500 at a collector current of a few milliamps. It can be used to test virtually any small npn or pnp transistors, and is also usable with most bipolar power devices. Obviously, a bargraph display provides only limited resolution and accuracy, but the tolerances on transistor gain figures are generally so large that a high degree of accuracy is not really needed. This design is as quick and easy to use as a basic go/no go tester, but it gives a good indication of how much or how little gain each test device provides.



Transistor Gain Tester.

Basics

The basic arrangement used to measure the DC current gain (hFE) of an npn transistor is shown in figure 5a. Feeding a current into the base circuit of a transistor results in a higher current flowing in its collector circuit. The DC current gain is equal to the collector current divided by the base current. In this basic gain test circuit, resistor R1 feeds a reference current into the base of the test device. Meter ME1 registers the resultant collector current, and the meter can be calibrated directly in terms of current gain. As a simple example, suppose that a current of 1μA is fed to the base terminal of the test component, and that the meter has a full scale sensitivity of 1mA (1,000μA). Test devices having gains of (say) 50, 100, and 500 would produce collector currents of 50, 100, and 500μA. The current flow in microamps is therefore equal to the current gain of the test component. Figure 5b shows the test circuit for a pnp transistor. This is essentially the same as the npn test circuit, but the polarity of the supply and meter have been reversed. The circuit operates in exactly the same fashion as the npn test circuit.

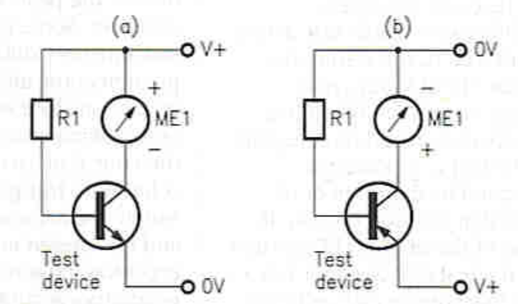
With both circuits, no significant current should flow if the base current is removed. With modern silicon transistors, this leakage current is usually very low indeed, and is typically just a minute fraction of a microamp. With germanium transistors, the leakage current can be quite large, making devices of this type difficult to test. However, this is not a major problem, as germanium transistors are now long obsolete.

Circuit Operation

Figure 6 shows the circuit diagram for the transistor tester. IC1 is a low power 555 timer which is used here as a low frequency oscillator which operates at approximately 1·5Hz. The high value of R2 in relation to that of R1 results in an almost squarewave output signal at pin 3 of IC1. This signal drives the base terminal of the test device via current limiting resistor R3, which is the equivalent of R1 in the basic test circuit. The value of R3 has been chosen to provide a base current of about 20μA. If we consider the circuit with an npn test device, the test component is supplied with a base current when the output of IC1 is high, and is cut off when IC1's output is low. When a pnp transistor is connected to the tester, things operate the other way round (i.e., the test component is fed with a base bias when the output of IC1 is low, and cut off when it is high). The basic idea of this system is to check alternately for leakage and current gain.

The bargraph circuit is based on IC2, which is the ever-popular LM3914N bargraph driver chip. This is the standard version of the chip which has linear scaling, and in this simple arrangement, it has a full-scale input sensitivity of 1·2V. Resistor R6 is connected across the input of IC2 and effectively converts the bargraph circuit into a current meter. The value of R6 has been chosen to give a

Figure 5. Basic test circuits for (a) npn and (b) pnp transistors.



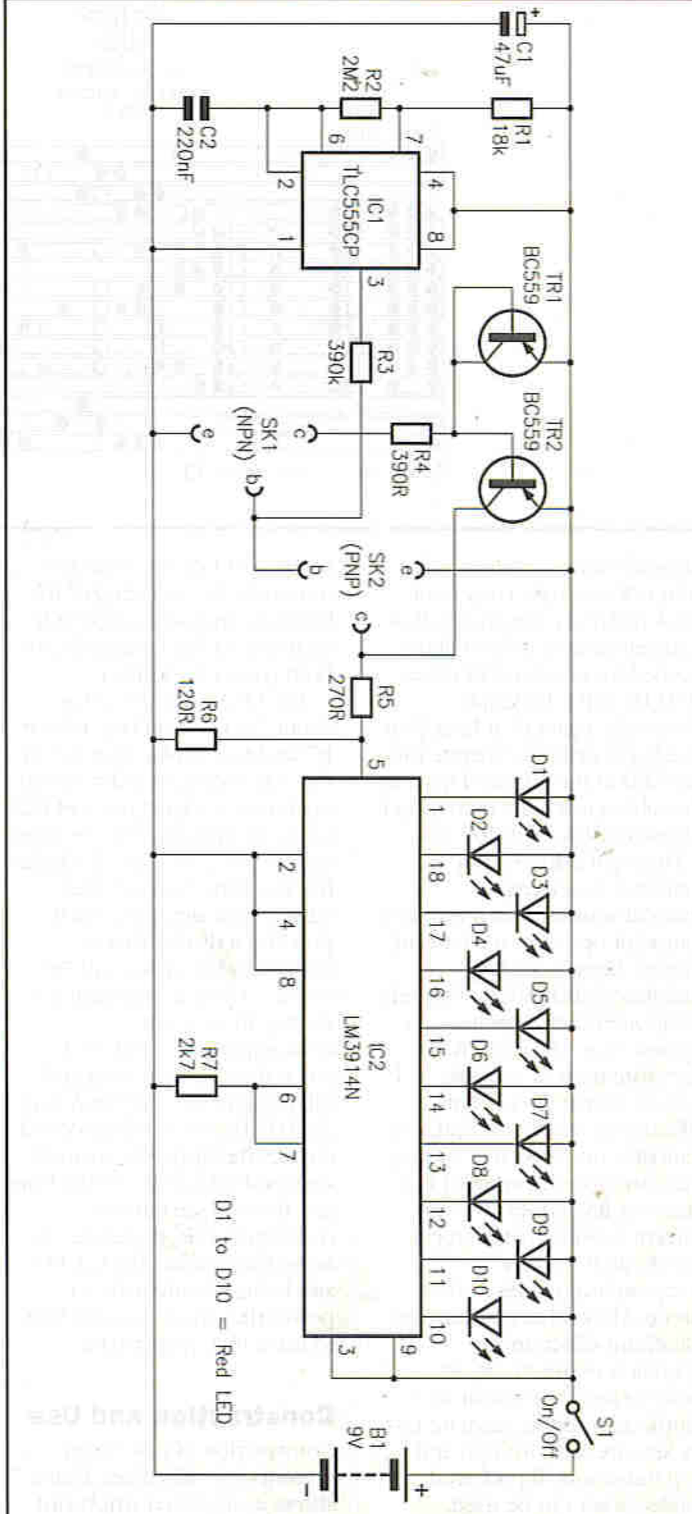
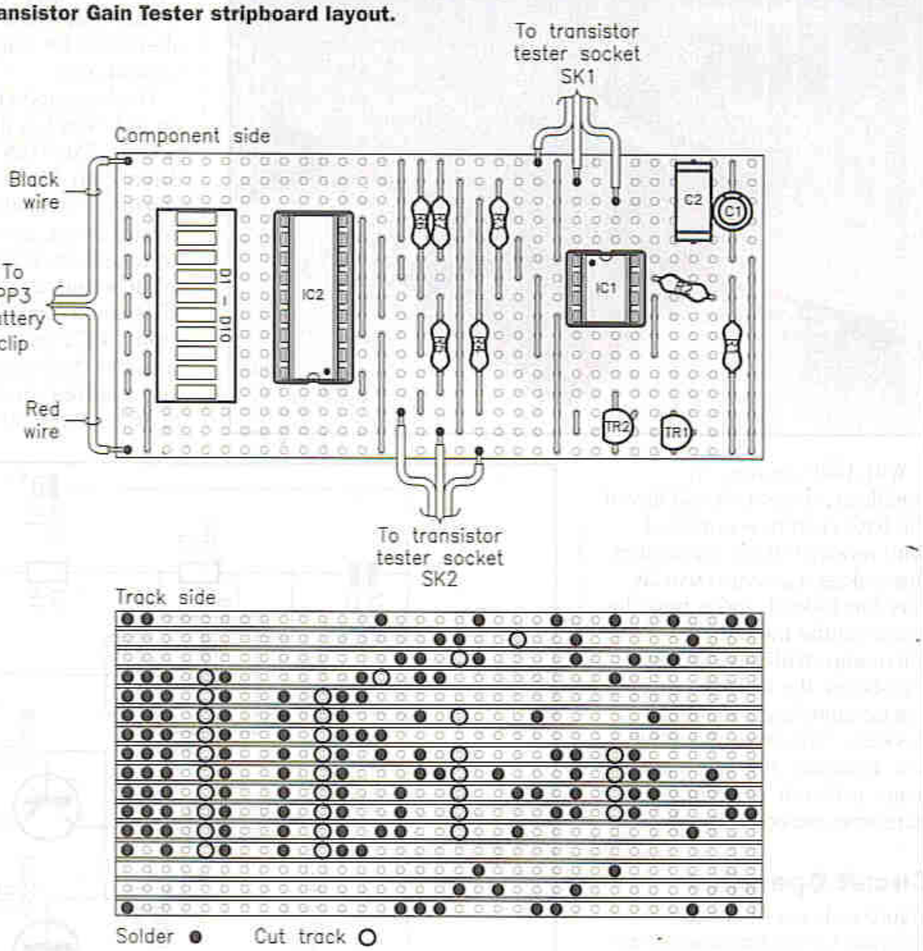


Figure 6. Transistor Gain Tester circuit diagram.

Figure 7. Transistor Gain Tester stripboard layout.



full-scale input sensitivity of 10mA. With a base current of 20μA (0·02mA), this means that a current gain of at least 500 is needed in order to activate all 10 LEDs in the bargraph. Obviously, a gain of at least 50 is needed in order to operate the first LED in the display (D1), and the subsequent LEDs correspond to gains of 100, 150, 200, etc..

Driving IC2 from a pnp transistor is perfectly straightforward, since a pnp test transistor operates as a current source. Matters are less straightforward with an npn test component as it operates as a current sink. TR1 and TR2 are therefore used in a simple current mirror circuit that effectively converts an npn test transistor into a current source that can drive the input of IC2. Resistors R3 and R5 provide current limiting that protects the circuit if the test component provides a short circuit. They otherwise have no significant effect on the operation of the circuit. In order to keep the circuit as simple as possible, separate test sockets are used for npn and pnp transistors. If preferred, a single socket can be used, together with a DPDT switch to provide changeover switching for the emitter and collector terminals. No switching of the base terminal is required as it connects to the same point for both types of transistor.

The LED current is set at about 7mA per LED by resistor R7, and the display operates in the 'bar' mode. For 'dot' mode operation, connect pin 9 of IC2 to pin 11 instead of the positive supply rail. A 'dot' mode display has the advantage of lower current consumption, but it provides a display that is marginally less quick and easy to read. Using a true bargraph display, the current consumption is about 5mA when the display is switched off, rising to around 75mA when all 10 LEDs are switched on. Of course, the display is normally switched off for 50% of the time and the average current consumption is, therefore, no more than about 40mA. A PP3 size battery is adequate to power the circuit, but it is best to use a high power type.

Construction and Use

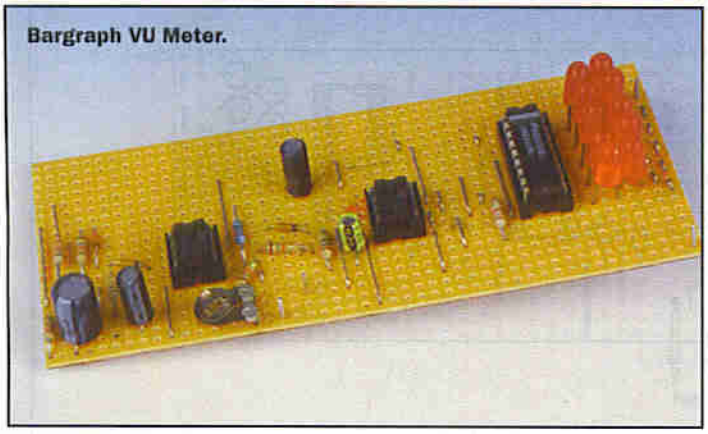
Construction of this circuit presents few difficulties. Figure 7 shows a suggested stripboard layout. On the prototype, a 'proper' bargraph display is used, but the circuit can obviously be used with 10 ordinary LEDs if preferred. Assuming the 'proper' bargraph display is used, it is fitted onto the circuit board via an ordinary 20-pin DIL holder. A window for the display must be cut in the front panel of the case at the appropriate position. SK1 and SK2 are 3-way DIN sockets or miniature DIN sockets, and most small transistors will plug into these without any difficulty. For awkward devices such as power transistors, a set of test leads must be made up. All that is needed is three short insulated leads fitted with a 3-way DIN plug at one end and small crocodile clips at the other. It is advisable to use leads and (or) clips of different colours so that the base, emitter, and collector test leads can be easily identified.

With a serviceable test device connected to the tester, the display should alternately switch on and off. When the display is switched on, the gain of the test component is indicated by the number of LEDs that are switched on. If none of the display LEDs switch on, the test device either has a very low current gain or it has simply gone open circuit. Note that a few types of transistor can legitimately have very low current gains, and these cannot be checked using this tester. Also, some power devices only have very low gains at small collector currents and tend to provide erroneous results when tested with any simple transistor checker. Clearly, a certain amount of common sense has to be exercised when using this unit or any other basic transistor tester. The test device has a high leakage level if the display simply stays switched on. If all the LEDs are switched on continuously while a test device is connected to the unit, it is virtually certain that the test component is providing a short circuit between its collector and emitter terminals.

Bargraph VU Meter

Audio level meters utilising moving coil meter movements are now far less frequently seen, and audio level indicators that use LED displays are the order of the day. This add-on VU meter uses a 10-LED bargraph display and covers a range of -20dB to +3dB. There is a potential problem with any VU meter in that there is a risk of brief but powerful signals failing to register their true peak level. In professional recording meters, this problem is overcome by having a circuit that has a fast attack but a very long decay time. The fast attack time ensures that brief signals are not overlooked, and the slow decay time results in the indication being held long enough to be clearly visible by the user. The usual attack and decay times are 0·5ms and one second, respectively. This VU meter ensures accurate results by using approximations of these times.

Another potential problem is that some waveforms are far from symmetrical, and voice signals in particular tend to have peak levels on one set of half cycles that are about double the peak level of the other set. Some musical instruments exhibit the same phenomenon, and many electric guitars produce some rather odd-looking waveforms during the course of each note. The solution to this problem is to simply use full-wave rectification, and this design incorporates a precision full-wave rectifier that guarantees accurate results with any waveform.



Bargraph VU Meter.

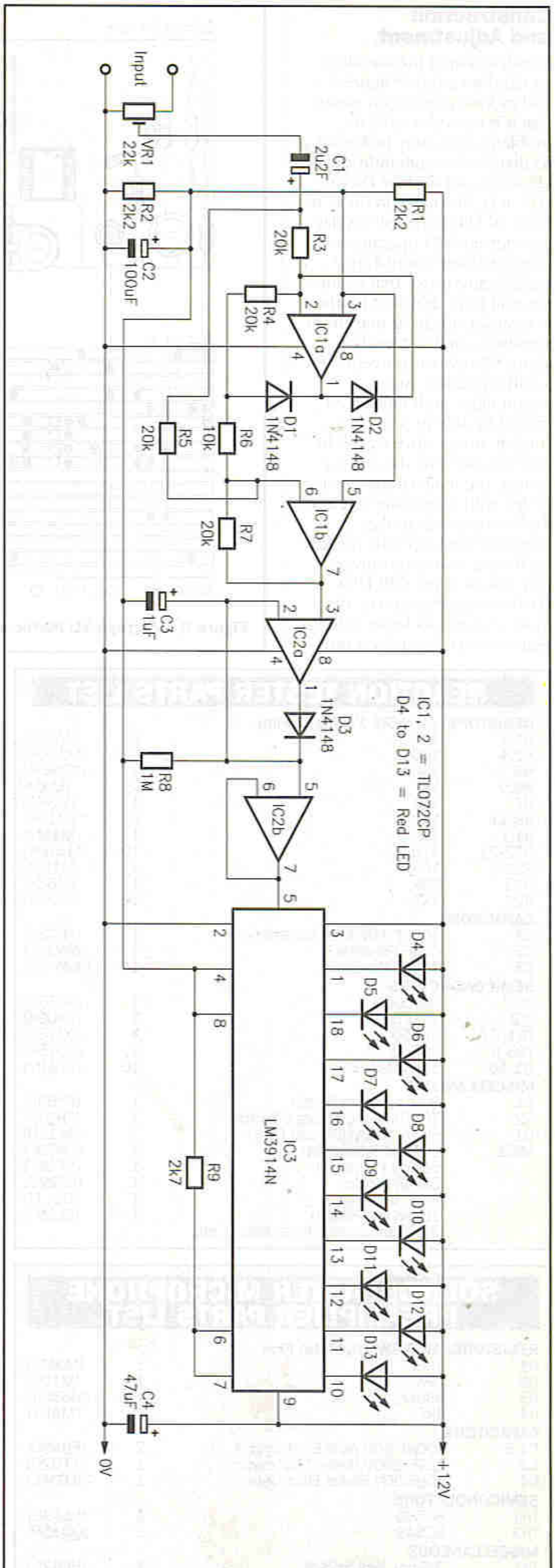


Figure 8. Bargraph VU Meter circuit diagram.

The Circuit

The circuit diagram for the audio level meter appears in figure 8. The circuit really breaks down into three sections, and the first of these is the precision full-wave rectifier which is based on IC1. This is followed by a peak hold detector using IC2, and this drives the bargraph circuit which is based on IC3.

Taking the precision rectifier first, it is not possible to use a basic diode rectifier in a critical circuit of this type due to the non-linearity of semiconductor diodes. At potentials of less than about 0·5V, a silicon diode exhibits an extremely high resistance, but at higher voltages, its resistance drops very rapidly. There are alternative types of diode which exhibit less pronounced non-linearity, but there are none which are good enough in this respect for the present application. The standard solution is to use the diode in the negative feedback circuit of an operational amplifier. In this case, the diode is D1 and the operational amplifier is IC1a. This gives non-linear feedback which counteracts the non-linearity of the diode. The output signal from IC1a is severely distorted, but this distortion complements the non-linearity through D1. The rectifier circuit uses a complex feedback arrangement in order to produce full-wave rectification, but the basic scheme of things is to have IC1a rectify one set of half cycles, and IC1b to rectify and invert the other set so that a full-wave rectified signal is produced at the output of IC1b.

The peak hold circuit uses D3 to provide a low resistance charge path for C3, but the only significant discharge path is through the relatively high resistance of R8. This gives the circuit the required fast attack and slow decay times. As in the precision rectifier circuit, an operational amplifier and non-linear feedback are used to counteract the non-linearity of the diode. IC2b simply acts as a buffer stage to ensure that the bargraph driver does not significantly shunt R8, and reduce the decay time of the circuit.

The bargraph driver is a conventional type based on an LM3916N, which is a version of the popular LM3914N that has been designed specifically for use in audio level indicator circuits. D4 to D13 respectively provide indications at -20dB, -10dB, -7dB, -5dB, -3dB, -1dB, 0dB, +1dB, +2dB, and +3dB. R9 sets the LED current at about 7mA per LED, which gives reasonable brightness from ordinary LEDs. However, better results are obtained using a high brightness type. Of course, a multicolour display can be used if desired (e.g., green LEDs for D4 to D9, a yellow LED for D10, and red LEDs for D11 to D13. The circuit provides a 'bar' style display, but a 'dot' type can be obtained by connecting pin 9 of IC3 to pin 11 instead of the positive supply rail. This gives greatly reduced supply current since there is only one LED switched on at any one time. However, most people find a 'bar' display clearer in use. With a 'bar' display, the current consumption can be as high as 75mA, incidentally. The output voltage from IC2b is referenced to the mid-supply bias voltage produced by R1 & R2, and not to the 0V rail. Fortunately, IC3 can operate with a large offset on the input signal, and it is just a matter of connecting pins 4 and 8 to the appropriate offset potential. In this case, they are simply biased to the mid-supply potential.

Construction and Adjustment

Construction of this circuit is straightforward (see figure 9), and its low voltage gain means that it is not vulnerable to problems with stray pickup or feedback. Although individual LEDs are specified for D4 to D13, it is, of course, in order to use a 10 LED bargraph display if preferred. VR1 operates as a simple volume control style variable attenuator that enables the unit to be adjusted for the correct sensitivity. At maximum sensitivity, an input level of about 500mV rms is needed for a 0dB indication. Any preamplifier, audio mixer, etc., should be able to provide a suitably strong drive signal. In order to give VR1 the correct setting, the main circuit must be fed with a test tone at a level that corresponds to the required 0dB level. VR1 is then set for the lowest sensitivity that results in the 0dB LED (D10) remaining on (i.e., the most counter-clockwise setting that leaves D10 switched on).

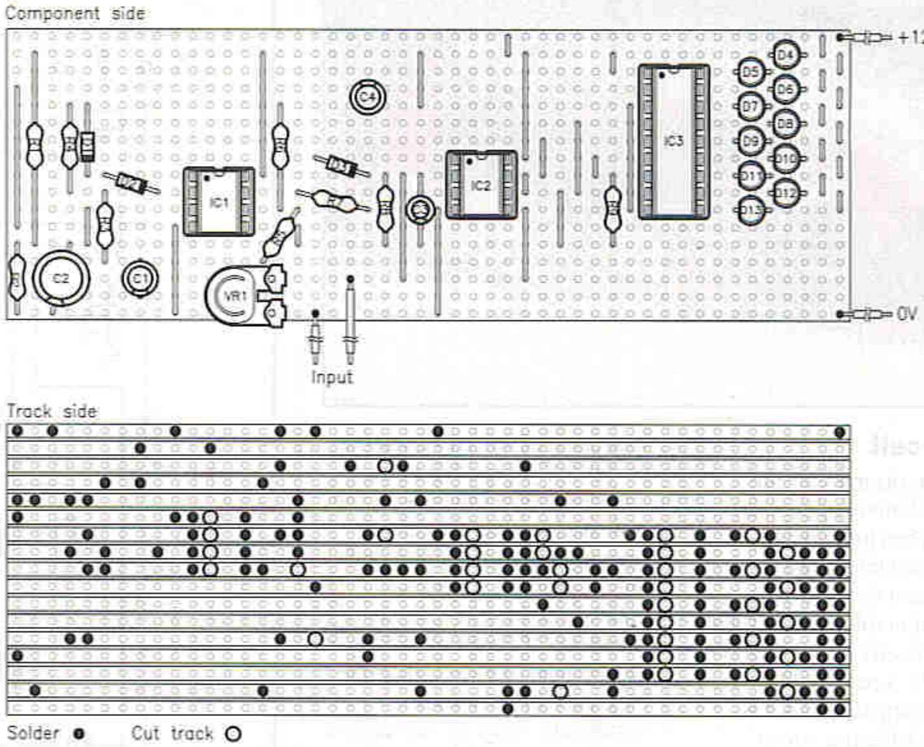


Figure 9. Bargraph VU Meter stripboard layout.

REACTION TESTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,3	22k	2	(M22K)
R2,4	100k	2	(M100K)
R5	390k	1	(M390K)
R6,9	1M	2	(M1M)
R7	3k9	1	(M3K9)
R8,11	10k	2	(M10K)
R10	4M7	1	(M4M7)
R12-21	470Ω	10	(M470R)
R22	10M	1	(M10M)
R23	68k	1	(M68K)
R24	2k2	1	(M2K2)
CAPACITORS			
C1	100µF 10V Axial Electrolytic	1	(FB48C)
C2	6n8F Polyester	1	(WW27E)
C3	470nF Polyester	1	(WW49D)
SEMICONDUCTORS			
IC1	TS555CN	1	(RA76H)
IC2	4017BE	1	(QX09K)
TR1,2,4	BC559	3	(QQ18U)
TR3,5	BC549	2	(QQ15R)
D1-10	5mm Red LED	10	(UK19V)
MISCELLANEOUS			
S1	Push-to-make Switch	1	(FH59P)
S2	SPST Miniature Toggle Switch	1	(FH97F)
B1	6V (4 × AA/HP7-size Cells)	1	(EM12N)
MIC1	Ceramic Resonator	1	(FM59P)
	Battery Connector	1	(HF28F)
	Battery Holder	1	(HF29G)
	8-pin DIL Holder	1	(BL17T)
	16-pin DIL Holder	1	(BL19V)
	0·1in. Stripboard, Wire, Solder, etc.		

SOUNDBLASTER MICROPHONE PREAMPLIER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	3M3	1	(M3M3)
R2	10k	1	(M10K)
R3	330Ω	1	(M330R)
R4	4k7	1	(M4K7)
CAPACITORS			
C1,3	100µF 10V Axial Electrolytic	2	(FB48C)
C2	2µ2F 100V Radial Electrolytic	1	(FF02C)
C4	10µF 50V Radial Electrolytic	1	(FF04E)
SEMICONDUCTORS			
TR1	BC550	1	(UL49D)
TR2	BC549	1	(QQ15R)
MISCELLANEOUS			
JK1	3·5mm Jack Socket	1	(HF82D)
PL1	3·5mm Stereo Jack Plug	1	(HF98G)
	0·1in. Pitch Stripboard, Wire, Solder, etc.		

TRANSISTOR GAIN TESTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	18k	1	(M18K)
R2	2M2	1	(M2M2)
R3	390k	1	(M390K)
R4	390Ω	1	(M390R)
R5	270Ω	1	(M270R)
R6	120Ω	1	(M120R)
R7	2k7	1	(M2K7)
CAPACITORS			
C1	47µF 16V Radial Electrolytic	1	(AT39N)
C2	220nF Polyester	1	(WW45Y)
SEMICONDUCTORS			
IC1	TS555CN	1	(RH76H)
IC2	LM3914N	1	(WQ41U)
TR1,2	BC559	2	(QQ18U)
D1-10	10-LED Bargraph Display	1	(BY65V)
MISCELLANEOUS			
S1	SPST Miniature Toggle Switch	1	(FH97F)
B1	9V (PP3 size)	1	(JY49D)
SK1,2	3-way DIN Socket	2	(HH32K)
	Battery Connector	1	(HF28F)
	8-pin DIL Holder	1	(BL17T)
	18-pin DIL Holder	1	(HQ76H)
	20-pin DIL Holder	1	(HQ77J)
	0·1in. Pitch Stripboard, Wire, Solder, etc.		

BARGRAPH VU METER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Stated)			
R1,2	2k2	2	(M2K2)
R3-5,7	20k	4	(M20K)
R6	10k	1	(M10K)
R8	1M	1	(M1M)
R9	2k7	1	(M2K7)
VR1	22k Miniature Horizontal Preset Potentiometer	1	(UH04E)
CAPACITORS			
C1	2µ2F 63V Radial Electrolytic	1	(AT75S)
C2	470µF 63V Radial Electrolytic	1	(AT43W)
C3	1µF 63V Radial Electrolytic	1	(AT74R)
C4	47µF 16V Radial Electrolytic	1	(AT39N)
SEMICONDUCTORS			
IC1,2	TL072CP	2	(AV60Q)
IC3	LM3916N	1	(YY97F)
D1-3	1N4148	3	(QL80B)
D4-13	5mm Red LED	10	(UK19V)
MISCELLANEOUS			
	8-pin DIL Holder	2	(BL17T)
	18-pin DIL Holder	1	(HQ76H)
	0·1in. Pitch Stripboard, Wire, Solder, etc.		

AIR YOUR VIEWS

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Essex SS6 8LU

Water Under the Bridge

Following the recent discussion on electronic descaling, I think that your correspondent, Philip Thomas, is in error when he states that the phenomenon was first reported by a Dutch group in the late '70s. I personally conducted a series of experiments when I first read of this idea way back in 1956, although I cannot remember the journal (it could have been Nature) after all this time. I was then engaged in the analysis of water supplies in connection with the corrosion of domestic water systems. Since the strength of a magnetic field is primarily dependent on current density, I acquired a transformer with a high current output and wound a coil round a copper water pipe. The water flow (London tap water) was adjusted to a slow rate to achieve the best chance of success and samples taken. These, together with samples of untreated water, were then boiled to break down the temporary hardness, and the deposit allowed to settle. The residues, which showed no difference in their ability or otherwise to stick to the surface, were filtered and allowed to dry naturally. They were then weighed and examined under a microscope. They were also subjected to X-ray crystallography. In no case was any significant difference observed in either the weight or character of the residue. To check whether it would make any difference if the current was DC, the experiments were repeated after rectification. Finally, I strapped a soft iron bar to the pipe and wound the coil around that to see if the effect of a magnet made any difference, again using both AC and DC currents. I admit that I did not use frequencies other than the standard 50Hz, but the experiments were otherwise fairly comprehensive. I have to say that in relation to the tests which I conducted, there was no evidence whatsoever that the theory held water (pun intended) but although I am going back some 40-odd years, the results remain very clear in my mind. Even if the form of the scale did change in some way so that it did not adhere to the surface, there would certainly be no justification for the claim that existing scale is removed or reduced since the water itself cannot be changed by electromagnetic means.

S. T. Payne C.Chem. FRSC, Gt. Missenden, Bucks.

We were recently lent a nationally advertised domestic electronic 'computerised' water conditioner unit for testing and evaluation (thanks to subscriber, S. Johnson of Southampton, Hampshire, for its loan). Its circuitry was based around a PIC16C55-XT/P microcontroller driving a dual LED display and analogue summing/amplifier stages, and emitted a sinewave output of variable frequency and amplitude (starting at around 10V rms @ 1·4kHz, and gradually changing to ≈ 4V rms @ 4kHz over a period of about 11 minutes). The display showed a value, counting from '01' to '64' within this period before resetting to '01', each change of the display coinciding with a slight step change in the output signal's amplitude & frequency. The unit's four outputs drove a coil of 8-10 turns and two 'antennae' of 10-14 turns each, wrapped in any direction around the rising water supply pipe. The most noticeable effect that the unit had on the water (that we could detect) was to increase the lathering of soap. We have studied the literature supplied with or advertising a variety of electronic water conditioners (domestic and industrial) and most operate on the variable frequency output waveform method. It seems this is necessary to ensure effective treatment of the possible range of water conditions (temperature, pH, hardness level, etc.) that will be encountered, i.e., a single frequency signal is unlikely to have much effect, which may explain why your experimental setup didn't give favourable results.

In this issue, Dr. David Harrison, prospero@pncl, wins the Star Letter Award of a Maplin £5 Gift Token for his suggestive e-mail.

Star Letter

Dear Editor,

An adventurous project suggestion: A transportable Network Computer. Take a 286 single-board PC with DOS on ROM (Maplin may consider selling these), add Net Tamer, the all-in-one WWW/Usenet/Telnet/E-mail program in about 470k-bytes, burn it onto a flash ROM, and get it to load on start-up. Add a tiny text processor into any remaining space. Plug in a small/touch sensitive keyboard, and an internal modem. For video, you have a number of choices: for a transportable, include a multi-format VGA-TV adaptor to work in any hotel room. Or add a tiny CRT (cf. the Osborne 1) into a lunchbox design. Or use a flip top to cover the keyboard with a built-in LCD display. Finally, add PRAM for the DNS/POP data and a floppy disk drive for main storage and data exchange. Software upgrades come via the floppy. The PC-on-a-card can accommodate printers and mice/trackballs without a problem, and could simply be plugged into a PC with a null modem cable if the need arose. Run it off a rechargeable battery pack and you have a portable NC, although an AC adaptor with a multi-plug would be fine for hotels. No hard drive (fragile, expensive) and no PCMCIA (expensive). If you needed more storage in the future, you could swop the floppy for one of the new A/Drives giving 100+ M-bytes. Aside from the ROM and PRAM software, everything else is modular and bog standard, so I guess that a prototype could be tested for little cost. Most importantly of all, the final machine would cost less than a WinCE machine. It may be a little bigger, but the three main boards (286/TV adaptor/modem) and the FDD could be piggybacked into a robust box. Net Tamer would require a licence. It is shareware available at: http://people.delphi.com/david colston/, and is worth a mention anyway. Additionally, most electronics magazines have now published designs for low cost PIC programmers, programmed by a PC from the serial or parallel port, some of which can be programmed and then used in-situ. However, for anyone already lumbered with a small pile of switchboxes and an ever smaller space to work, connecting to a PC can be fiddly. So, instead of all those leads and boards, the PIC board could be redesigned to work the way someone recently designed a speaker-cum-volume control: take the PIC board and secure it into a drive bay. Put it on a slider with a handle on the front so that it can be pulled in and out. Use a ZIF socket for the PIC chip. Fix a D-type connector or individual sockets to the front, so that when programmed, you can access the PIC pins and use the microcontroller in-situ. Now, use a spare power cable or a splitter from the main PC PSU to power the unit. Alternatively, if it is enough, there may be an unused supply on the motherboard, say, for an unimplemented IRDA link, but this is more risky. Put a switch and an LED on the front, if only to protect the board from power spikes. Now run the onboard controller, or controller card socket to the PIC board, and then run it back to the I/O socket at the back of the PC, and fix a switch on the front to switch between an external peripheral and the PIC board. Et voilà! An elegant way of implementing a PIC programmer on a PC, or a great way to blow up 1,500 quids worth of kit, if your soldering isn't up to scratch! This may be the only variant on the PIC programmer that hasn't yet appeared on the market.

Some interesting project ideas – if anyone manages to build or has built such items, how about submitting your designs to us for possible publication. . . .

Trainspotter's Guide

Could you please put me on to someone I could correspond with and/or phone who could help me construct a rather special but probably quite simple controller for my American Lionel trains. Unlike 'HO' or 'OO' gauge, they are 'O' gauge (1¼in. track width), 3-rail and they work on around 14-20V AC, so there's no rectifier. I have, within the last 3 years, made a controller with the help of an electronics enthusiast friend who I've lost touch with. This uses a Velleman speed controller that is connected to the primary of a 20-0-20V transformer. However, I am told that this is not a good way of doing it; it apparently breaks up the input AC and can be a dangerous animal! I remember being told that "if the centre tap goes short circuit, the whole mains voltage appears at the output." I wonder if this meant the actual output to the track? If that happened, it would burn my trains out in a flash – very expensive! Also, the transformer should be quite a beast, able to handle up to 12A what with lights in coaches, in stations and accessories, etc. If you could help or recommend someone, I would be very grateful indeed.

P.S. I notice your catalogue does not have the old-fashioned rheostats – what do I do?

Peter Smith, Anglesey, N. Wales.

Have you tried contacting the Model Electronic Railway Group who advertise in our Classified section? Failing this, perhaps a reader 'in the know' may be able to advise Mr Smith on how to go about electrifying his track without risking electrocution! Rheostats, defined as being instruments that control the flow of current by way of altering the resistance, are still available (in rotary form) from our catalogue, as either Wirewound Potentiometers with values spanning 100Ω-100kΩ (Stock Code DA85-94) or (wirewound) Loudspeaker Volume Controls (Stock Code FX40 – 20Ω, and FX97-99 – 50/100/200Ω). It's just that they're no longer called rheostats! You could instead make your own rheostat to the value required by using resistance wire (e.g., BL64U) wound onto a suitable heat-resistant insulating former (e.g., polycarbonate board) and adding a wiper to provide a variable resistance. Incidentally, *rheos* is Greek for stream, in case anyone was wondering.

It's Brilliant!

Dear Editor,

I have been reading your magazine for about 6 months now and I think it's brilliant. It saves me buying individual electronics, science and computer magazines. I thought your educational supplements were good and would like to see the return of them, however, if you do, could you include stripboard layouts; I had trouble working them out for some of the projects. I also think that your Internet page should have more reviews of sites with info and downloads for amateur electronics enthusiasts. I downloaded a logic circuit analyser (written by Arthur Tanzella), which is brilliant. I am compiling a list of good electronics/science web sites and this list can be obtained by e-mailing a request.

Philip Frampton,
LFrampton@msn.com.

Thank you for your comments and offer of the web site list. Where possible, we will try to include stripboard layouts with future educational supplement circuits.

Electric Descaling

Dear Editor,

In 1938, I lived at Maidenhead, a very hard water district. The house had an unthermostatic 'pot' boiler, which needed to be descaled with acid (hydrochloric) every two years if severe 'thumping' and lack of circulation were to be avoided. At about this time, my father fitted a commercial unit to the cold rising main. This consisted of an outer jacket and within, an open-ended tube (7cm × 1cm diameter), supported by an insulated terminal. A low (DC) voltage was applied to the terminal and the rising main from a transformer and rectifier, the current being limited to 15mA via a rheostat. Before installation of the unit, the boiler was descaled and inspected internally through the manholes in the water jacket. After two years, a further inspection revealed a quantity of powdery sludge at the bottom of the water jacket. The boiler continued in use for a further seven years without requiring any attention – until my father sold the house. A research project was described in Practical Electronics (electromagnetic type) on 23/9/95, using a swept frequency of 1·3-3kHz.

Alan Maffett,
Carleton St. Peter, Norwich.

Evidently, the treated water did your memory for detail no harm! It seems curious that a descaler operating with DC current should be effective when most electronic devices operate by giving out an AC signal of varying frequency. Perhaps water in the 'good old days' wasn't so complex to treat?

Sound Location

Dear Editor,

I am enquiring about a directional microphone, as I have tinnitus and cannot pinpoint where exactly noise is coming from. As I live in a block of flats and washing machines are being used at night after 10pm and even later, I would love to have something that could pinpoint the area of noise and also a sensitive meter with enough gain (output of around 5W), also a not-too-large funnel for the microphone. The unit could also be used for bird-watching and such like. Has there been such a project described before?

W. Gibson, Glasgow.

A project that could be used to satisfy your requirements, or at least, be easily modified to do so, would be the Microsonic Audio Booster, detailed in Issue 55 of Electronics, and available as a kit (Stock Code LP52G). It uses a very small built-in electret microphone (an external one could be added for remote listening), features adjustable sensitivity and incorporates VOGAD (Voice Operated Gain Adjustment Device) amplifier circuitry so that headphone volume is more-or-less constant regardless of gain (of up to 52dB), allowing comfortable listening even if the unit is set to high sensitivity and a sudden increase in noise occurs. The unit is capable of detecting very faint sounds indeed across a bandwidth of 300Hz to 3kHz, and if the (external) microphone is housed within a tube, it will have effective directional sensitivity.

Change of Pitch

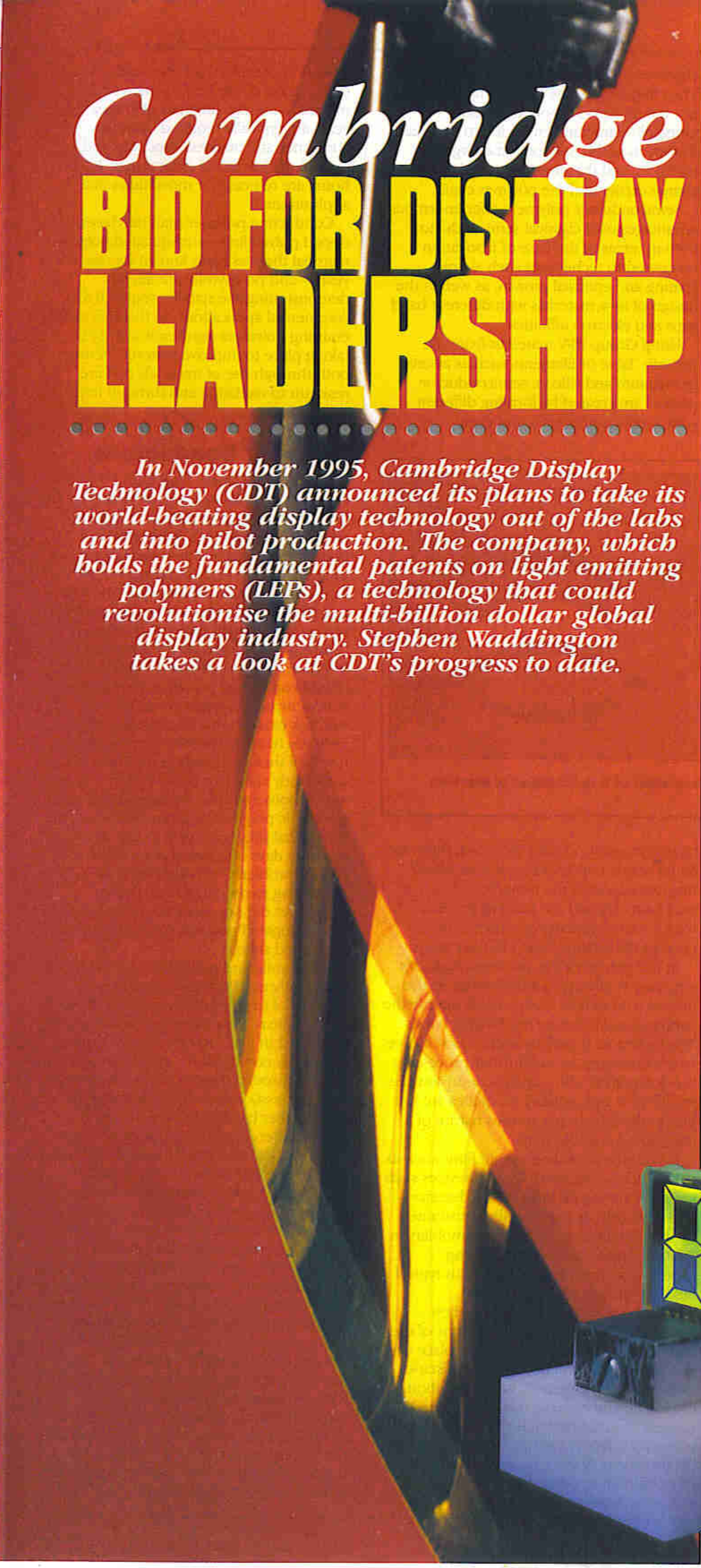
Dear Sir,

The article on page 45 of your May 1997 issue, 'What's in a Name', seriously short-changed Edwin Armstrong. The article gives the impression that Armstrong was litigious. This is not so. The reason why he sued RCA et al was as follows. His patent for FM radio had been loaned to the US Government for the war effort. After the war, parties like David Sarnoff, head of RCA, misappropriated Armstrong's invention and REFUSED to pay royalties on it. They did this in the full knowledge that their legal departments were bigger and that they could afford to pay for litigation. In view of this quite unscrupulous act on the part of big business, it is no wonder that Armstrong jumped out of his window.

PS. You may have noticed that I am writing this from a computer named after Alan D. Blumlein, in recognition of his importance in audio and the fact that I am British. My secretary's computer is named after Edwin H. Armstrong, as she is American.

Dr David Pickett, Director of Recording Arts, Indiana University School of Music, Bloomington, USA.

The author of the article referred to above, Greg Grant of Sudbury, Suffolk, replies: I am sorry if I gave Dr. David Pickett the impression that the great Edwin Armstrong was litigious. That was not my intention at all, quite the reverse, in fact. I have a lasting admiration for the man who not only gave us the Superheterodyne Principle – which, almost 80 years on, is still the fundamental receiver layout – but also Frequency Modulation. More importantly, I had not realised that Armstrong's patent had been loaned to the US Government, nor that Sarnoff and the RCA then proceeded to play the 'my lawyer is bigger and more expensive than your lawyer' game. That the RCA and its Chief Executive Officer should do that need not surprise us: that is, after all, a business tactic that continues to this day, both here in Britain, and in the US. What is shocking is that an even mightier organisation – the US Government – would not protect a patriotic citizen who knew where his duty lay. I shall add this information to my database, and thank Dr. Pickett for bringing it to my attention. This sorry incident recalls a somewhat similar situation where the late Sir Frank Whittle was concerned. He too, put his trust in his government during the same conflict and was short-changed also. Little wonder that he – in turn – left for the Land of the Free.



Cambridge BID FOR DISPLAY LEADERSHIP

In November 1995, Cambridge Display Technology (CDT) announced its plans to take its world-beating display technology out of the labs and into pilot production. The company, which holds the fundamental patents on light emitting polymers (LEPs), a technology that could revolutionise the multi-billion dollar global display industry. Stephen Waddington takes a look at CDT's progress to date.

Photo 1. Professor Richard Friend, the Cavendish Professor of Physics.

Based in Cambridge, Cambridge Display Technology (CDT) was founded at the University of Cambridge with a seed venture capitalist in 1994. The company currently has 23 employees, 18 of whom are dedicated to pure research.

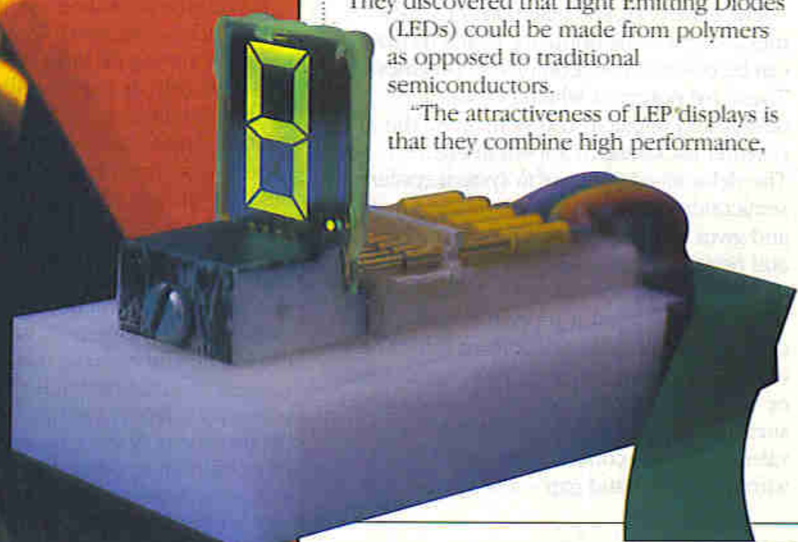
CDT expects light emitting polymer (LEP) technology to be used in areas such as mobile communications, computers, consumer electronics and, ultimately, as an alternative to the cathode ray tube – the display in conventional televisions and computer monitors. Moving into the 21st century, LEPs are likely to become the basis for improving products such as virtual reality headsets.

The potential for LEPs is a substantial proportion of the global electronic displays market estimated by analysts Stanford Resources, estimated at $22·5 billion in 1994, and forecast by the Electronics Industry Association of Japan to go to $45 billion in the year 2000.

Technology

CDT was founded after initial work at the Cavendish Laboratory led by Professor Richard Friend, the Cavendish Professor of Physics (Photo 1), and Dr Andrew Holmes. They discovered that Light Emitting Diodes (LEDs) could be made from polymers as opposed to traditional semiconductors.

"The attractiveness of LEP displays is that they combine high performance,



with low cost and can be fabricated on flexible sheets of plastic using well established and expensive manufacturing processes. Very large area, wafer thin displays of all kinds and shapes can be envisaged," explains Professor Friend, who is the Cavendish Professor of Physics at Cambridge University and also an executive director of CDT.

The Cambridge University team found that the polymer poly p-phenylenevinylene (PPV), emitted yellow-green light when sandwiched between a pair of electrodes. Initially this proved to be of little practical value as it produced an efficiency of less than 0·01%. But by changing the chemical composition of the polymer and the structure of the device, an efficiency of 5% was achieved, bringing it well into the range of conventional LEDs.

characteristic semiconductive behaviour. The charge transport in these materials is not the same as in more traditional inorganic semiconductors due to the chain distortion of the polymer on charge injection, and therefore the coupling of the charge carrier and the polymer chain.

Semiconductor polymers offer enormous advantages over classical semiconductors both in terms of the ease of fabrication compared to techniques such as spin-coating and epitaxial growth, as well as the design of new materials with different band gaps and electron affinities.

Using Group III-V materials from the Periodic Table of Elements such as arsenic, germanium and silicon, semiconductor devices are created by forming different compositions of ternary and even

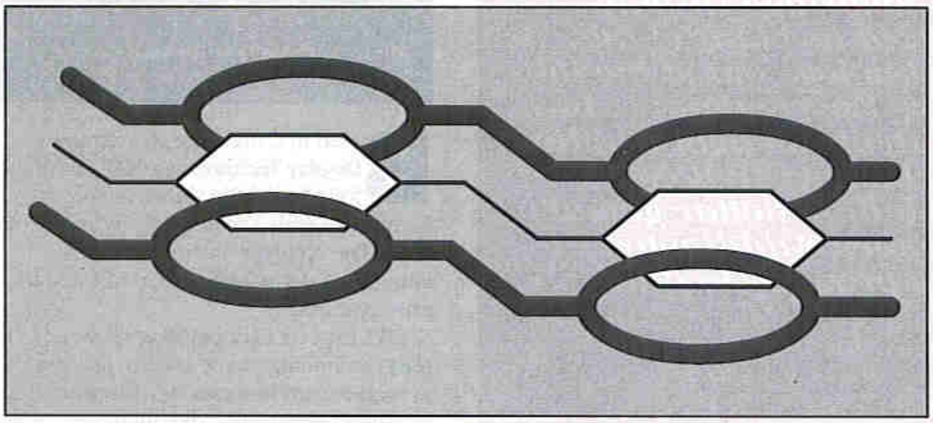


Figure 1. Overlap of Pz orbitals leads to the formation of a delocalised pi electron cloud above and below the polymer chain.

Electronic Polymers

Plastic materials have displaced traditional materials such as metals, ceramics and glass in many applications owing to the combination of their physical and mechanical properties – lightweight combined with physical strength – and ease of ability to mould the shape of plastic materials or extrude into a sheet or rod through a die.

Over the last 30 years, there has been increasing interest in exploiting the characteristics of polymer materials in combination with electrical properties over and above the purely insulating characteristics that one would expect from plastic materials.

The class of plastic materials for which metallic and semiconductor characteristics can be observed are conjugated polymers. These are polymers which possess a delocalised pi-electron system along the polymer backbone as shown in Figure 1. The delocalised pi-electron system confers semiconducting properties to the polymer and gives it the ability to support positive and negative charge carriers with high mobilities along the polymer chain.

The semiconductor properties of conjugated polymers arises from the overlap of pz orbitals that originate from the double or triple bonds. If the overlap is over several sites, the formation of well delocalised pi valence and pi* conduction bands occurs, with a defined band gap – a recipe for this quaternary compounds. However, there are some severe constraints, not least phase diagram access to the required stoichiometry and the need to lattice – match to the underlying substrate to prevent debilitating defect density levels.

In the polymer case, the semiconductor structure is effectively amorphous, so the defects tend to have energy states outside the band gap and there are no dangling bonds. The interfaces therefore are not as sensitive to the environment and further processing is not required. The principal disadvantages are lifetime and mobility. Mobilities are low due to the largely amorphous nature of conjugated polymer films.

Carrier transport across thin films such as that typically required in diode devices such as light emitting diodes (LEDs), detectors and solar cells, is not typically constrained by the mobility values. The hole mobility in PPV is of order $10^{-4}cm^{2}V^{-1}s^{-1}$ allowing transport across a 1,000A layer with typical fields of 50kVcm^{-1} in 0·5μs.

Lifetime is also a big concern when considering commercial applications of the technology. Much work has taken place over the last 50 years to improve the resistance of everyday polymers to photo-oxidation principally through the use of additives to prevent discolouration. It should come as no surprise that similar problems exist with conjugated polymers, particularly since in most electronic applications excited pi* states are necessary intermediates – oxidation of these states can lead to degradation of the performance of the materials. Storage lifetimes of at least five years are typically required by most consumer and business products, and operating lifetimes of greater than 20,000 hours are relevant for most high-value applications.

Conducting polymer materials based on doped polyaniline – a conjugated polymer material that has been known for over a 100 years – and polypyrolle are already demonstrating the stability required for commercial applications. In the area of light emitting polymers significant activity is taking place to improve material lifetimes both through use of materials that are resistant to oxidation and through improved encapsulation.

Polymer Conductors

Conjugated polymers have found their first commercial applications as conductors. The doping of semiconducting conjugated polymers such as polanilyine and polypyrrole leads to the presence of states in the band-gap – hopping states – and at sufficient dopant concentrations the band-gap effectively disappears and the polymer acts as a metal with high conductivities.

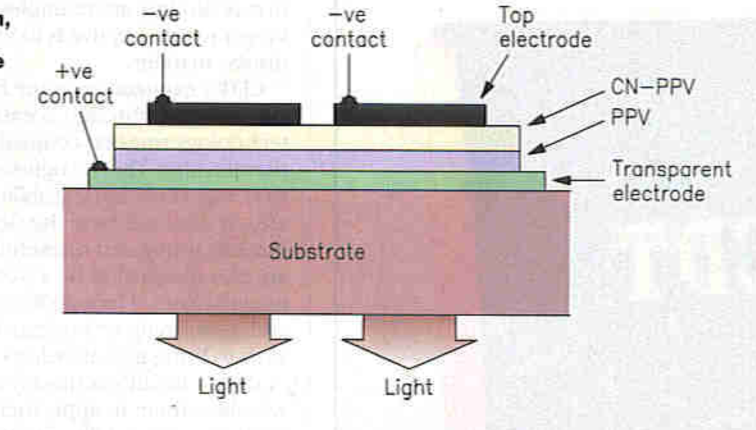
Intrinsic conductivities of materials such as PPV are of the order of 10-12Ωcm^{-1}; doped conjugated polymers have achieved conductivities of greater than 105Ωcm^{-1} which is close to that of copper. A major problem has been producing processable forms of these conducting polymers that are sufficiently stable for commercial applications and it is encouraging for other electronic polymer applications to note the substantial progress made in this area from the early days of polyacetylene which had serious problems with stability. It is interesting to note that most of the challenges did not relate to the stability of the conjugated polymer itself, but more of the doped state.

Polypyrolle and polyaniline are the most commonly used conducting polymers because of their relatively superior stability. Polypyrolle is not directly processable and is deposited in film form by electrochemical means. By comparison, polyaniline is made soluble through the use of soluble counter-ions that associate with the dopant ions on the polymer backbone.

Current commercial applications utilize intermediate conductivity levels of between $10^{-2}\Omega cm^{-1}$ and $10^{2}\Omega cm^{-1}$, and include battery electrodes, conductive coatings for electrostatic speakers, capacitor electrolytes, transparent conductive coatings, through hole plating of double sided printed circuit boards and electrostatic discharge coatings.

The long term stability requirement of the polymer capacitors are about ten years, and the commercialisation of such products using polypyrolle by Matsushita is a testament to the reality of polymer electronic technology. A major future goal for conducting polymers will be replacement of copper for interconnects on printed circuit boards. Improved stability of the highest conductivity materials is the major technical milestone that needs to be achieved for this application.

Figure 2. Typical LEP Cross section, showing simple device structure.



displays is that they can be designed to have good legibility, high contrast and wide viewing angles at low power use levels as shown in Photo 3. The low power characteristic combined with the potential to display high information content makes the screen idea for mobile applications such as digital watches; hand held games machines; calculators; and mobile telephone. Meanwhile the ability to produce flat large area displays means the technology is an ideal replacement in applications such as airport timetable indicators, tube and rail indicators, electronic advertising hoardings or promotional moving displays.

Initially CDT has fabricated a green dot matrix display. By engineering the properties of the LEPs they expect to demonstrate a red version very shortly. In

Displays

The application of conjugated polymers for displays has probably generated the most interest. This has probably been due to the very rapid progress since the first reports five years ago when internal quantum efficiencies of 0·01% were achieved, to the point today when internal quantum efficiencies four orders of magnitude higher have been reported.

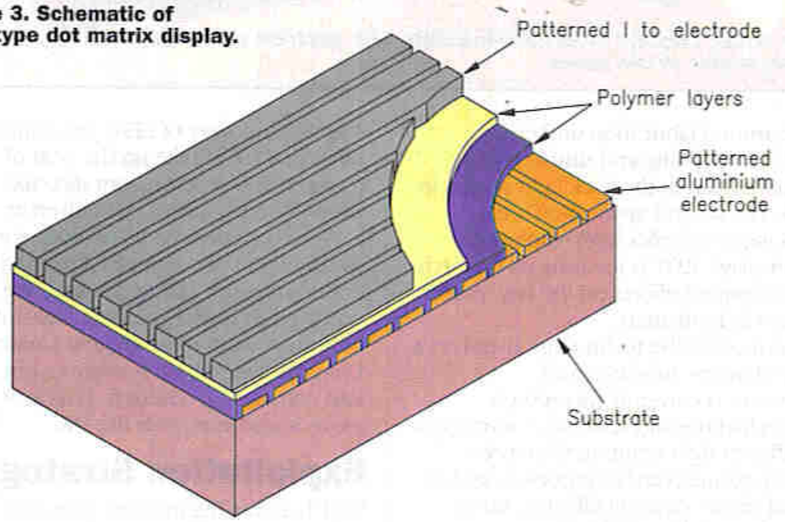
Figure 2 shows a schematic of an efficient light emitting structure. Improvements have been achieved by using device engineering techniques learnt during the improvement in efficiencies of inorganic LEDs such as GaAs, in particular the use of a heterostructure that allows carrier confinement at the polymer/polymer interface is significant. This increases the likelihood of electron/hole capture to form an exciton that can radiatively recombine. Other significant improvements arise from choosing the electron/hole injection barriers to be similar – this can be done through both the choice of the injection electrode material and by modifying the polymer material to be more or less electron withdrawing and therefore to have higher or lower electron affinity.

Construction

LEP displays are constructed by applying a thin film of the LEP onto a glass or plastic substrate coated with a transparent, indium tin oxide electrode. An aluminum-based electrode is sputtered or evaporated on top of the polymer. Application of an electric field between the two electrodes results in emission of light from the polymer.

The LEP display effect has a number of very attractive features. The response time is fast (sub-microsecond), switching occurs at low voltage (<5V), and the intensity of light is proportional to current. If the electrodes are patterned, for example in orthogonal X and Y lines, light will be emitted from the area at the intersection of these lines. The technology therefore combines the low voltage DC benefits of traditional LEDs with large area patternability associated with non-emissive display technologies such as LCDs. This provides a powerful technology base for building high information content displays.

Figure 3. Schematic of prototype dot matrix display.



Dot Matrix Demonstrator

CDT unveiled its first prototype LEP dot matrix display shown in Photo 2, in May 1996, at the Society for Information Display (SID) meeting in San Diego, California. This was the world's first public demonstration of such a prototype.

The prototype display consists of a grid of pixels of density $100cm^2$, and measures 60mm by 20mm. Graphical, text and moving images are generated by driving the displays with conventional matrix display drivers, consolidating the advantage the displays have due to their low cost manufacturing base. The construction of the dot matrix display is shown in Figure 3.

One of the unique properties of LEP

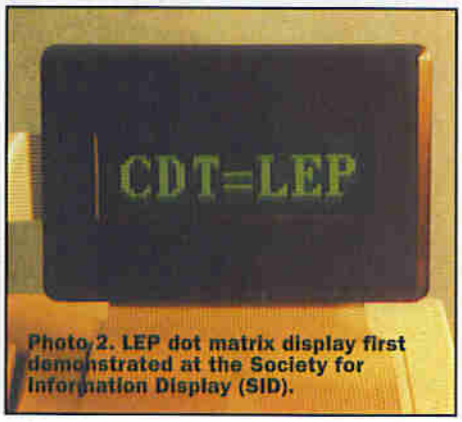


Photo 2. LEP dot matrix display first demonstrated at the Society for Information Display (SID).

the last year, CDT has synthesised polymers which emit light in the red, green and blue regions of the visible spectrum.

Work is underway to develop driving schemes which would allow these to be used to construct full colour graphics displays without the need for a complex active array of electronic switches such as found in today's high performance flat panel displays. This would allow LEPs to be used as a replacement for the cathode ray tube and LCD in computer displays and television.

LEP Benefits

Unlike liquid crystal or plasma displays, which require thin film processing on two glass plates, LEPs can be fabricated on one sheet of glass or plastic. This greatly simplifies processing and reduces cost. Additionally, the ability to manufacture devices on flexible plastic substrates introduces new form factor opportunities and, for example, allows displays which conform to unique shapes to be produced.

The richness of organic chemistry allows the fabrication of new materials with different emission properties, including a wide range of colours. The benefits of this are evident in how quickly light emission from LEPs has covered the visible spectrum when compared with traditional semiconductor LEDs which took 20 years.

LEP technology has the potential to address two distinct market areas. The first

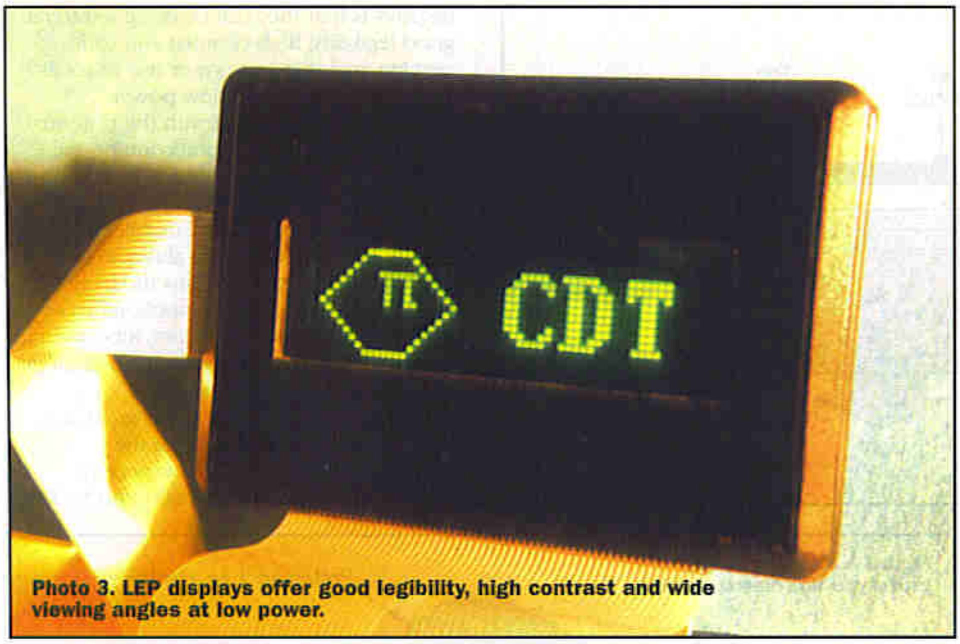


Photo 3. LEP displays offer good legibility, high contrast and wide viewing angles at low power.

is based around fabrication on flexible substrates for lighting and simple display applications such as the back light shown in Photo 4. The second application area involves more complex high resolution colour displays. CDT is focusing its research and development efforts on the key market challenges in both areas.

CDT is moving the technology ahead on a number of fronts. Research and development is currently focused on extending lifetime and reliability; developing more efficient light emitting structures; designing manufacturable processes and, as indicated above, devising effective drive schemes for graphic displays.

Table 1 summaries the manufacturing and technological benefits of LEPs.

Company Investors

Cambridge University is one of CDT's largest shareholders. This is a pioneering step for the university, and for academic institutions in the UK, who have previously been reluctant to invest their own funds in the commercial exploitation of research.

CDT has also secured a number of other investors from a diverse range of backgrounds, including Cambridge Research and Innovation; the Genesis rock group and its manager; the Sculley Brothers Inc; the Generics Group plc; Hermann Hauser a founding director of Acorn Computer; Steve Kahng, president of Power Computing Corporation; and Esther Dyson, president of Edventure Holdings, of New York.

Entrepreneurial Personalities

In March 1996, CDT appointed, Danny Chapchal shown in Photo 5 as its chief executive officer to spearhead its global commercialisation. A veteran industry figure, Chapchal has some 25 years experience in the electronics industry, most recently at Siemens where he was chief executive of Integrierte Systeme Grafische Industrie (ISGI), a company specialising in pre-press solutions.

More recently, Professor Richard Friend, the Cavendish Professor of Physics at the University of Cambridge who made the original discovery of LEPs, has joined the ranks of CDT to take up the post of research and development director, in addition to his role at the university.

Professor Friend is responsible for guiding the direction of commercial research and development of LEP technology. He is expected to spend approximately one fifth of his time with the company. Unlike the United States' where academics often move into commercial research, Professor Friend's move is uncommon in the UK.

Exploitation Strategy

CDT believes the markets accessible to LEPs will increase as the technology is matured however the early target markets – comprising backlights, seven segment and alpha-numeric displays and dot matrix displays – total $2·5 billion per annum at OEM prices. The characteristics of LEP products will also enable new concepts and designs in information display which are not available with current technologies; composite products combining backlights, seven segment, alpha-numeric and dot matrix displays are examples of this. The longer term objective is to enter the graphic display markets.

CDT's exploitation route for the technology is through licensing and technology transfer, coupled with corporate partnerships. This recognises that although CDT has world leading ability in the LEP area, it does not have the developed manufacturing and marketing skills which are also essential to be a world class display manufacturer. Through licensing its patents and performing technology transfer, CDT aims to bring manufacturers up to the state of the art in LEPs as quickly as possible. This will allow them to apply their complementary skills onto the technology to develop specific products for their markets.

CDT is also looking for a small number of corporations to work in partnership with to develop LEPs for high information content graphics displays. It has already started to implement this exploitation strategy and recently announced a signing with Philips Electronics. CDT has also signed additional other licensees which is it is expected to announce shortly.

Under the terms of the agreement Philips has paid CDT an up front license fee together with a royalty on all LEP products. In return, Philips will gain access to CDT's patented technology for the lifetime of its patents. The agreement opens the possibility for Philips Components to scale existing laboratory processes and to develop its own manufacturing techniques and processes for the manufacture of specific small displays.

Philips' initial target for the coming years is to replace the existing backlights for LCDs in applications where space, low voltage and low power consumption are at a premium, such as in mobile telephones. In the next phase displays will be developed for application in consumer products that currently depend on LEDs or LCDs, such as Personal Digital Assistants (PDAs), CD

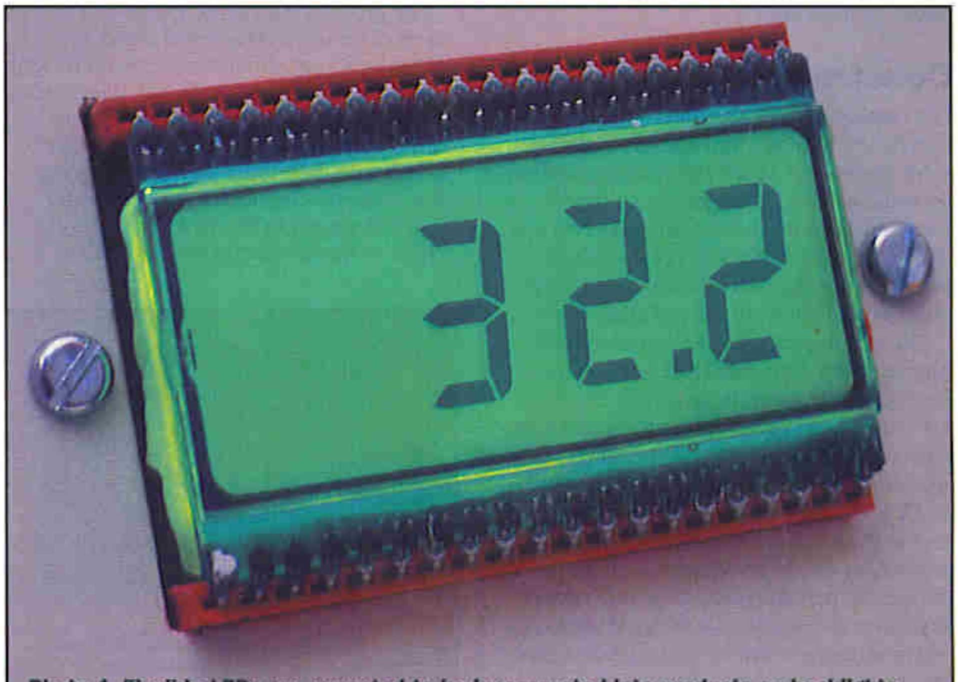


Photo 4. Flexible LEPs are expected to be incorporated into products as backlights.

Feature	Benefit
LEP Processability	Flexible substrates possible Large area coating
Light Emitting	No Backlights required No Colour filters No aperture loss 180 degree viewing angle
Patternable	Define complex light emission patterns simply Very high resolution if required Any pixel shape and size possible
Low voltage	Battery driven devices dc drive
Formable Substrates	Innovative designs for end product displays shaped to product Easy manufacturing integration with product Continuous coating for manufacture
Fast Switching Speed	Video display capability
Lightweight	Portability
Solid State devices	Ruggedness
Thin films	Allows use of polarisers to give high contrast

Table 1. Manufacturing and technological characteristics of LEPs.

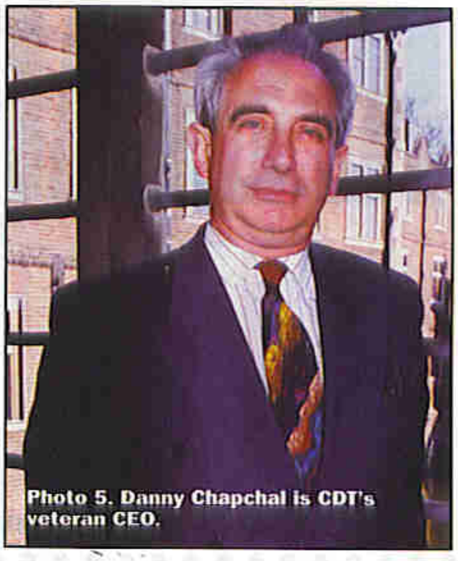


Photo 5. Danny Chapchal is CDT's veteran CEO.

players, electric razors, alarm clocks, radios and, ultimately, television sets.

LEP Futures

LEP technology is now the subject of research by 20 to 30 companies worldwide. CDT is confident that the technology has a great future as a material for display applications and expects early products to be available in the market within 12 to 15 months. Professor Friend gave an upbeat presentation about the future of LEPs in November 1996 at the Stanford Resources 13th Annual Flat Information Display conference in San Diego, California, entitled 'Recent Developments in Light Emitting Polymers'. Friend claimed that there had been a rapid increase in performance since the initial discovery and that the lifetime/efficiency targets for low-cost backlights had already been met.

Further Browsing

Professor Friend presentation from Stanford Resources 13th Annual Flat Information Display conference
`www.cdtltd.co.uk/titleslide.html`

CDT company web site `www.cdtltd.co.uk`

Philip's flexible LEP lighting designs
`www.philips.com/design/vof/vofsite6/light/index.htm`

Optoelectronics Group, Cavendish Laboratory, University of Cambridge
`www-oe.phy.cam.ac.uk/OEWWW/OEHomePage.html`

Melville Laboratory for polymer synthesis in the University of Cambridge Chemical Laboratories `www.ch.cam.ac.uk/CUCL/MLPS`
`www.ch.cam.ac.uk`

LEPs – Technology for conformable graphic displays, a paper by CDT Technical Director Paul May, first presented at the SID Symposium in San Diego
`www.cdtltd.co.uk/Is&tpaper.html`

Society for Information Display (SID)
`www.display.org/sid`

RESEARCH NEWS

by Dr. Chris Lavers

The Space Imaging Race

A new Space Race for commercial exploitation of Earth observation using high-resolution satellite imagery is well under way. Space Imaging of Thornton, Colorado, USA (owned by Lockheed Martin and established in 1994), is set to win the first lap. Satellites have long been used in commercial markets for communications, weather monitoring and Global Positioning, but only recently has the US Defence Department given permission for civilian use of high quality resolution digital images for detailed mapping. In partnership with Eastman Kodak and joined by Mitsubishi in 1995, Space Imaging is developing its first two commercial remote sensing satellites to provide monochrome and multi-spectral digital imagery with an accuracy previously unknown in geographical information systems (GIS).

Computer-generated 0·82m resolution images (see Figure 1) merging panchromatic and multispectral imagery will be sold for applications in civil engineering, land management, construction, agriculture, mining, and environmental monitoring. Currently, satellite-based resolution is 10m at best, which is inferior to aerial mapping. Unfortunately, aerial mapping is more expensive and

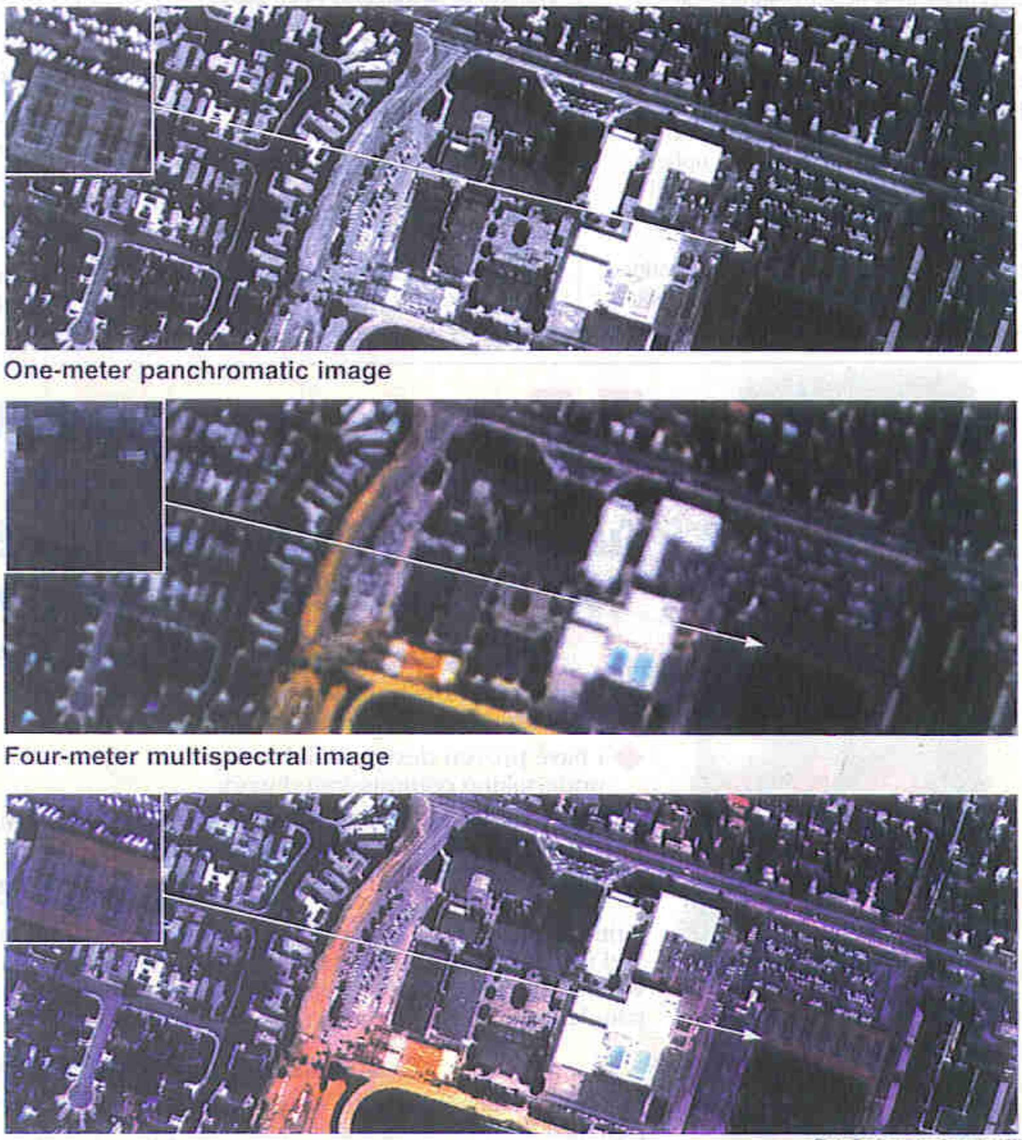
Army Surgeons Who Will Operate in the Dark

Thermalscan Inc. of Baton Rouge, Louisiana, USA, is now working with the US Army Night Vision Laboratory and the US Secretary of Defence's Office to develop an infrared imaging system which can be used on battlefields of the future to treat casualties whilst minimising a Doctor's vulnerability to enemy sniper fire. Thermalscan has developed a system which doctors can use to see patients in the dark, detecting body-generated heat using a head-mounted infrared camera and monitor. The camera will 'see' heat in a similar way to how the human eye is able to see visible light and will permit emergency operations to be conducted passively and in complete darkness, e.g., during a moonless night; this is not possible even with current Generation II and III image intensifiers without additional illumination. From the Surgeons safety point of view, the camera will detect a live patient's breathing on an exposed site as warm air will be expelled from the nose and mouth.

The Thermalscan system will allow surgeons to stitch in the dark and discover veins for inserting intravenous drips or needles. Since the thermal camera detects heat from within the body, it can detect if blood is reaching all the vital organs, which would not be possible with the naked eye. In a similar manner, this system will allow the detection of haemorrhaging and bruising.

Thermalscan is a non-destructive testing company that has previously used infrared cameras to find maintenance problems invisible to the human eye, e.g., faults in building work and roofing, and the location of structural features beneath plastering.

Space Imaging Simulated Satellite Imagery



One-meter panchromatic image

Four-meter multispectral image

Fused one-meter panchromatic / four-meter multispectral image

Photo Credit: Joint project with HJW

Figure 1. The high-resolution and accuracy that Space Imaging will offer. Space Imaging's digital acquisition and processing capabilities, the most advanced in the global commercial market, will process 0·82m panchromatic and 4m multispectral imagery and then merge them to create 0·82m colour products through a rapid automatic process. The images shown were derived from an aerial photograph imaged at 1:18,000 scale and digitally scanned in four spectral bands – panchromatic, red, green and blue. The four images were then fused using digital processing to produce the 0·82m colour enhanced image.

labour intensive. While current satellites provide data over a larger area more quickly and at lower cost, they do not often offer sufficient accuracy and resolution and thus represent only a small portion of the total remote sensing market. Hence, Space Imaging's system with 131m resolution will offer a hundred-fold improvement on existing space systems. Such resolution belonged previously to the realm of the classified spy satellite and Lockheed Martin's lead comes from their involvement in developing the world's first spy satellites, known as the Discoverer series, back in the 1960s. Their President is Jeff Harris, with 21 years experience in responsibility for the acquisition and operation of US space-based reconnaissance and intelligence systems. For many years, he actively promoted the use of government collected space imagery for approved civil applications. Mr Harris was the driving force behind declassifying the Corona satellite program in 1994 and its archive of 800,000 images spanning the period 1960-1972.

Space Imaging already provides synthetic 0·82m resolution through digitally reconstructed aerial photographs under the name Carterra, which has prepared the way for the new satellites. The Space Imaging satellite is based on a standardised 500kg satellite first developed for the Iridium communications system and are 2m high with a 5·6m solar panel wingspan. The digital image sensor payload is supported by high-speed digital processing, a 32-bit processor with 320M-bps datalink and 64G-bytes of memory. Space Imaging 1 will be launched in December 1997 from Vandenberg Air Force Base, California, into a 680km circular polar orbit inclined at 98·1° and is expected to have an operational seven year life. Travelling at 7km/s, it will orbit every 98 minutes providing global coverage in 11km wide image strips. The raw-image data will be collected by the optical sensors, data compressed for transmission, and then processed in the ground station, downloading as many as 600 11311km swaths a day. Philip Walker, Manager of Eastman Kodak's Commercial Remote Sensing division says, "This is the best commercial space telescope ever made or flown by anybody." The demanding flight specifications led to the creation of a honeycomb structure mirror weighing only 15% of its solid weight equivalent and yet strong enough to survive launch into space.

The Competition

Space Imaging has several competitors, including a Russian group marketing former Soviet Union military spy satellite data, but their most serious competitor is EarthWatch, formerly known as WorldView, formed in 1992 to develop high-resolution systems. EarthWatch plans to launch an Early Bird satellite in 1997 to generate 3m resolution images and in 1998 will compete directly with Space Imaging in the 1m resolution class, using two satellites. Early Bird may be delayed due to problems with their Russian launchers and may have to be launched on a Lockheed Martin Launch Vehicle (LMLV). Orbital Imaging Corporation (OrbView) is another company at the forefront of this technology and will deploy a 140kg mini-satellite, scheduled for launch in 1997.

After their December launch, Space Imaging data will be available to end-users in hours or days. Its global network of regional offices will enable it to market and sell Earth information 'products' to users locally. Space Imaging intends to capture the Lion's share of the existing market and then use its digital image collection, processing and world-wide distribution infra-structure to expand into the unexplored market of image-derived products. It will provide extremely cost-effective high quality Earth information solutions for uses in agriculture, transportation, mining and government. In emergencies like the Kobe Japanese earthquake in 1995, imagery could detect impassable roads and collapsed bridges and would be useful for relief efforts, allowing traffic to be re-routed and emergency centres sited.

Space Imaging has recently acquired EOSAT (Earth Observation SATellite Company), the largest US provider of space-based remote sensing imagery of the Earth for commercial government research and academic applications. This acquisition makes the company one of the world's largest suppliers of high resolution imagery. Economic experts conclude that up to 80% of business information has a geographic, or spatial context in nature which is the basis for the GIS industries phenomenal 20% annual growth which although valued at US$3 billion today, is expected to increase to US$5 billion by the year 2000. Clearly, a promising future is in store for satellite imagery. ELECTRONICS

COMMENT

by Keith Brindley

Everyone knows about British Telecom's problem when it comes to paying taxes. The mega-bucks-per-second-earning conglomerate, monopolistic, dinosaur (call it what you will!) telephone operator doesn't seem to like the idea of the new Government's proposed windfall tax. It's even gone so far as to say that it will take the Government to the European court if the situation gets to the stage that the tax bill drops on its doormat. Well, if not windfall-funded companies like BT, who should fund the country's revenue coffers? After all, BT's phone charges would never have come down to the level they currently are had it not been for the other telephone operators which have been allowed to muscle in on BT's act. BT's windfall would have been that much higher had they not been around. So, the windfall tax they would have had to pay would have been even higher. Perhaps BT should be thankful for small mercies.

There is though, another way the Government could make money out of windfall companies. There has been talk for some time about auctioning the airwaves off to telecommunications suppliers, in a cash-for-airwaves scheme to make Governmental money. This isn't a Labour idea, either. Originally brought to life during the last Conservative Government, it's an idea which the current incumbents of Parliament simply can't ignore. There's a precedent too. The US government has been doing just this for the last few years, raising some $25 billion in car boot sales of airwaves. Obviously, the UK auction wouldn't be as big (is this because we don't have the same amount of hot air?), but surely at least one or two billion pounds sterling could come from such a sale. The problem is (well, BT's problem is) that any such sale will fall on BT's doormat once again. It's a tough life, being a mega-bucks-per-second-earning conglomerate, monopolistic, dinosaur, telephone operator. Isn't it?

Whichever way you look at it, it looks like British Telecom's in for a costly ride. However, I can't help feeling that BT is just whingeing for whingeing's sake. Maybe it's got something to do with the recent lucrative contract awarded by the Government's Central Computer and Telecommunications Agency to Mercury (and not to BT), to supply data, voice and image communications services to national and local government offices and departments.

In the Blue Corner . . .

I've commented on this a few times over the last few months – as anyone with half an inkling of what's going on in the personal computer world would obviously do – but it's time to bring the situation up to date with the latest news. I'm talking about the fight that's building up between network computers (NCs) and ordinary personal computers of the Windows/Intel architecture (PCs).

Network computers were the brainchild of Oracle, under its boss, Larry Ellison. In May, Oracle acquired a majority stake in Navio, the makers of Netscape Navigator – a particularly well-known and used Web browser (you might have heard of it) – with the direct intention of using Navigator as the network computer's default Web browser.

There's good reason behind this. If you hadn't already realised it, Navigator's main competitor in the Web browser league table is Microsoft's (yes, Microsoft, of Windows fame itself) Internet Explorer (you might have heard of this, too).

Now, Internet Explorer and Navigator are running pretty much neck-and-neck in terms of numbers of users of personal computers by all accounts, but Internet Explorer is rapidly increasing its market share, simply due to the fact that it's the default Web browser in Windows 95, and as more personal computer users take up Windows 95, more drift across to its browser.

Nobody knows yet how strong the network computer platform is going to be over the coming years, but it's a fair bet that it's going to make deep inroads into the computer desktops of many, many users, in both business and the home. With Navigator as its default Web browser, Navigator can hopefully be assured that it has a good future, which is just great. It would be a pity to see another good application and company bite the dust as it falls in the seemingly never-ending path of Microsoft and its software products – particularly as Navigator is really pushing the market now with its implementations of Java.

In the Air

British Interactive Broadcasting (BIB), the company joint owned by British Sky Broadcasting (BSB), British Telecom, Midland Bank and Matshushita, has announced the manufacturers it's going to use to build digital set-top decoders for the digital television service they'll be broadcasting shortly. Manufacturers Amstrad, Hyundai, Pace Micro Technology, and Panasonic have lined up and been chosen to build the decoders, initially for a contract totalling one million boxes. Hyundai will probably have its decoders built in an agreement with Grundig.

While this number of decoders might not seem excessive – in comparison, there are some six million subscribers to British Sky Broadcasting's current analogue satellite television services – it is, of course, just the beginning. Once digital television services take to the air, it will have a knock-on, snowballing effect that will generate more and more sales. After all, it's taken several years for the analogue satellite television market to come to full fruition.

One thing which might set back the digital satellite television service is the fact that its launch date – originally scheduled for this year, to hit the Christmas market – can't now be met. Instead, the current planned release date is spring, next year. This effectively puts the system a year behind original plans; a fact that will bite deep into the pocket of the companies involved.

Whatever the launch date, on the other hand, it remains to be seen whether the take up of a digital system will be as wide-ranging and as fast as British Interactive Broadcasting hopes it will be. I seem to remember another startup satellite television service operator (British Satellite Broadcasting), with a new high-quality digital system (well, quasi-digital, at least). Despite a significantly enhanced service quality, it bit the dust. Let's hope British Interactive Broadcasting has got its market research right, and that the great British Interactive Public wants to interact with it.

The opinions expressed by the author are not necessarily those of the publisher or the editor.

ELECTRONICS *Classified*

Computers

Circuit Analysis Program for PC. Calculates gain, phase, impedances, provides printer and VGA output. Many examples. £10. SAE for details to P. Montgomery, Downings, Bells Hill, Stoke Poges, Slough SL2 4EG.

Build IBM-compatible PCs for under £200. No special skills or previous knowledge required. This book shows you how. Send SAE to: Richard Garland, 10 Barford House, Bow, London E3 5HP.

Various

Various Components for TVs, mainly CRTs and transformers. Also parts for older IBM computers, e.g., MFM hard drives. Tel: (01924) 406377 after 6pm for details. Buyers must collect.

Blackstar Apollo 100 Universal Counter Timer, Frequency counter. Brand new, £175. Dual-tracking 15V 2A power supply, £60. Tel: (0181) 467 4796.

Wanted

Hitachi TV model no. CPT-2071, tube base no. HM8622. Tel: Mr O'Flynn Sekyi 81 802 0379.

Maplin 25W Stereo MOSFET amp stereo amp PCB, stereo amp switch PCB. Write: Dada, 57 North Grove, Tottenham N15 5QS.

Club Corner

ARS (Aberdeen Amateur Radio Society) meets on Friday evenings in the RC Hall, 70 Cairngorm Crescent, Kincorth. For details contact: Martin, (CM0JCN), 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.

Placing an advertisement in this section of *Electronics and Beyond* is your chance to tell the readers of Britain's best magazine for electronics enthusiasts what you want to buy or sell, or tell them about your club's activities – Absolutely Free of Charge! We will publish as many advertisements as we have space for. We will print the first 30 words free, but thereafter the charge is 10p per word for each added advert per reader.

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Readers who have reasonable grounds to believe they have been misled as to the nature of an advertisement are advised to contact the Publisher and their local Trading Standards Office.

Electronic Organ Constructor's Society. Details of programme magazine and membership from: Don Bray (Hon. Sec.), 34 Etherton Way, Seaford, Sussex BN25 3QB. Tel: (01323) 894909.

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.

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.

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.

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.

BBS Corner

Apple Crackers. FirstClass Client BBS, mainly for AppleMac and PC users. Baud rate 2·4K-bit/s to 28·8K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (01268) 781318/780724.

Mactel Metro/Iconex. FirstClass Client BBS, AppleMac and PC users. E-mail address on Internet for registered users. Baud rate 2·4K-bit/s to 28·8K-bit/s, 8 data bits, no parity, 1 stop bit. Tel: (0181) 543 8017 (Metro) or (0115) 9455417 (Iconex).

Spider! Amiga BBS. The lighter alternative. Mainly Amiga and some PC files. Fidonet, Mercurynet and Mufonet. Online games. Speeds up to 19200. Tel: (01568) 613520.

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The Electronic SERVICING MANUAL REVIEWED

The Electronic Service Manual edited by Mike Tooley is an authoritatively written and clearly presented encyclopedia of electronics maintenance and servicing. Here, Stephen Waddington reviews this guide to broken printed circuit boards (PCBs), burnt-out transistors and worn out variable resistors.

After five or more years separation, I have recently visited an old friend. Not, you must understand, a physical being, but a weighty compendium of electronic faultfinding techniques. The Electronic Service Manual combines the wisdom and pragmatic diagnosis of a veteran electronics engineer with an encyclopaedic list of manufacturers component data.

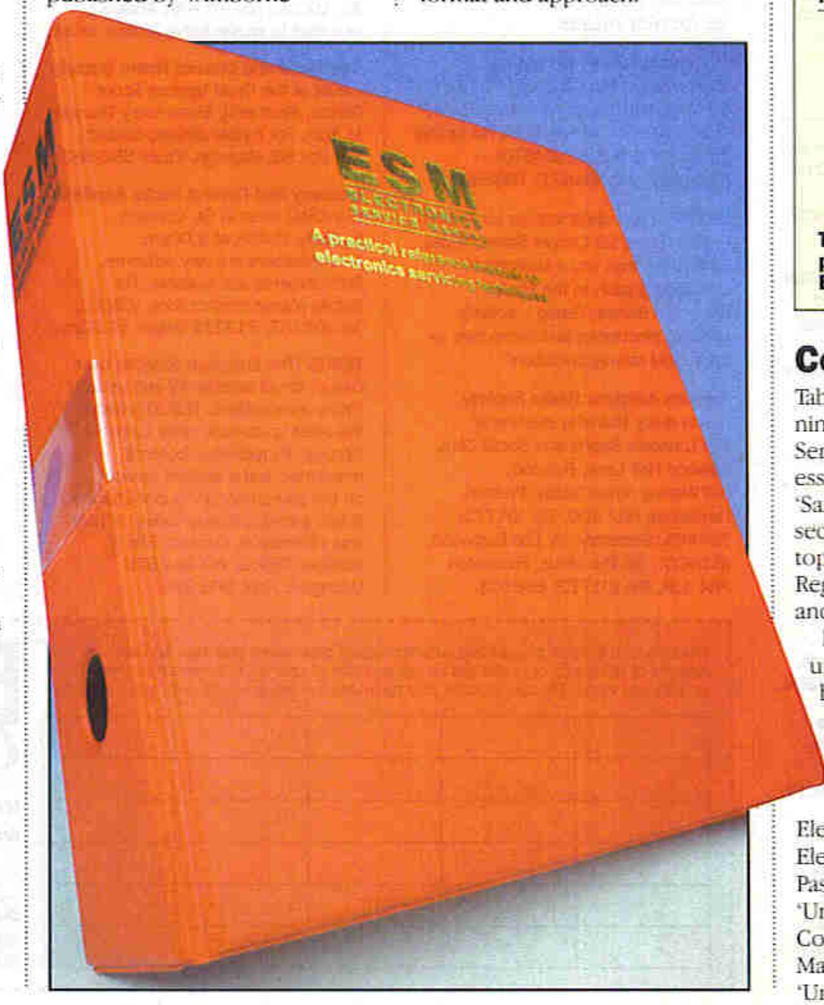
If you're new to electronics, how do you learn the basics? Textbooks vary between the very basic hobbyist manual and complex university level design texts. There is no middle ground. I was fortunate enough to have an electronic engineer for a Grandparent who had an encyclopaedic knowledge of both technology and the electronics industry.

Repair Guide

Revisiting the Electronics Service Manual was a comforting exercise. It was like talking to an old friend. And it prompted me to dig out the ancient Philips valve radio that's stuck up in the loft that needs fixing and the toaster with the bust element that's spent the last six months lying dormant in the bottom of a kitchen cupboard.

According to editor Mike Tooley, "The Electronics Service Manual is not a book that has been designed to be read from cover to cover. Rather, it is a book that has been designed in such a way that readers can rapidly locate the information that they require in order to carry out a particular task".

The Electronics Service Manual, priced £39.90, is published by Wimborne Publishing, the publisher, which also produces The Modern Electronics Manual, is available from Maplin Electronics. It is no surprise, therefore, that the two books have much the same format and approach.



Supplements

Like the Modern Electronics Manual, The Electronics Service Manual is split into two discrete segments. A base work covers nine parts, each of which deals with topics ranging from 'Tools and Test Equipment' to 'Reference Data'. This is supported by additional supplements, which are published quarterly. These tend to either expand on topics covered in the base work or review emerging aspects of electronics such as PC and networking equipment.

Each of the nine parts (A to I) in the base work of The Electronic Service Manual is further divided into sections that deal with sub-topics. A decimal number system is used to uniquely identify each section and sub-topic.

"Many readers will wish to specialise in particular areas of electronics maintenance. Others will wish to obtain a broad understanding of how to service electronic equipment generally. For this reason, the manual includes sections which deal with general principles as well as those that deal with specific maintenance tasks", said Tooley.

Part	Contents
A	Safety
B	Underpinning knowledge
C	Practical skills
D	Tools and test equipment
E	Servicing techniques
F	Technical notes
G	Reference data
H	Useful addresses
I	Index

Table 1. Outline of the nine parts which make-up the Electronics Servicing Manual.

Contents

Table 1 summaries each of the nine parts in the Electronics Service Manual. Part A is essential reading as it deals with 'Safety'. This is part includes sections which deal with vital topics such as 'Safety Regulations', 'Electrical Safety' and 'First Aid'.

Part B will equip you with the underpinning knowledge to be able to deal with a wide range of components and circuits. The part has sections which deal with 'Understanding Electricity', 'Understanding Electronics', 'Understanding Passive Components', 'Understanding Active Components', 'Understanding Manufacturers Data', 'Understanding Circuit

Diagrams', 'Fault Diagnosis', 'Interpreting Circuit Measurements', 'Understanding Radio', 'Understanding Microcomputers' and 'Understanding Valves'. This part is primarily designed with the newcomer in mind, although it should also prove an invaluable reference for the seasoned enthusiast.

Part C is devoted to 'Practical Skills' and it includes information on 'Soldering' as well as 'Component Removal and Replacement', 'Avoiding Static Hazards' and 'Component Identification'.

Part D deals with 'Tools and Test Equipment'. It also includes advice on setting up a workshop and provides a practical guide to the selection and use of a variety of the most common items of electronic test gear. The emphasis here is on how to get the best out of the equipment at your disposal, whether it is a simple multi-range meter or a complex sweep generator. In conjunction with the supplements, all the common items of test equipment are described together with practical hints and tips of how to use them.

Through the supplements, Part E deals with 'Servicing Techniques'. This part features fault symptoms, faultfinding charts, voltages and waveforms for all of the most common items of electronic equipment.

Part F is a collection of 'Technical Notes' devoted to a wide range of the most popular items of electronic equipment. For example, it starts off with extensive technical details of the IBM PC, PC-XT, PC-AT and compatible computers. This part is regularly expanded in the Supplements.

Part G provides a practical collection of 'Reference Data'. This part will help identify a huge variety of electronic components. It includes maximum ratings, pin connections and substitution information. Part H lists a variety of useful addresses of consumer product and component manufacturers in case you need to track down an elusive circuit diagram or component.

Finally, Part I is the most important part of any reference manual. It provides a comprehensive index to the entire contents of the manual. This part enables readers to locate information in the manual about selected subject, which are indexed by word and key phrase. Information is sorted in alphanumeric order, with abbreviations appearing at the head of each alphabetic group. Additional small indexes are issued with each supplement covering the subject within them. Periodically, the main index will be updated to update supplement subjects.

Confidence

The aim of the Electronics Service Manual is to provide its readers with the level of knowledge and confidence to tackle even the most complex faults. However, it is important to start with relatively simple fault-finding projects, building on experience until you are able to handle the most demanding of electronic faults. Start with something straightforward such as a hairdryer and build up to radios, amplifiers and perhaps even televisions or PCs.

Once you have gained a level of expertise in one area of electronics repair, it can be easily applied to many other areas. According to Tooley, "An understanding of electronic circuits will undoubtedly result from experience and reference to the Electronic Service Manual. Furthermore, many of the skills and techniques are readily applicable to several areas of electronics. Expertise in the repair of audio amplifiers, can, for example, be immediately applied in the field of tape recording".

Availability

The Electronic Servicing Manual costs £39.99, available from Maplin Electronics, order code AN45Y. Additional supplements are available from the publisher, Wimborne Publishing, priced at £23.50 + £2.50 p&p per manual. Readers that sign up for the base work have the option to receive the supplements quarterly on approval. This provides an opportunity for the reader to review the text and return it if it is not relevant or simply not required.

Modern Electronics Manual

We reviewed the Modern Electronics Manual, the companion to the Electronic Servicing Manual, in Issue 110 of Electronics and Beyond. Priced at £39.95, it is also available from Maplin Electronics, order code AN46A.

WHAT'S IN A NAME

PART 6

Laying Down the Law

by Greg Grant

"If the law supposes that the law is a ass – an idiot", as Mr. Bumble famously remarked. More recently, the late Professor C. Northcote Parkinson demonstrated, in two deservedly successful books*, that laws can still be made to look asses: often, in fact, idiotic.

Many of the laws in our field were looked on as exactly that when they were first put forward. In fact, for a profession only a century young, communications engineering has some pretty elderly laws governing it.

Our profession, of course, begins with conduction, and the Law of Electrical Conduction was first put forward in 1729 by the English physicist, Stephen Gray. He discovered that electricity flowed more readily through some materials than through others. This resulted in materials being classified as either conductors or non-conductors. The latter were later termed Insulators, an expression introduced by the Franco-British physicist, Theophile Desaguliers, around 1730. It comes from the Latin Insula, meaning an Island, since non-conductors confined electricity as the sea does an island.

Nothing much happened in electricity for the next half century or so until, around 1770, the British physicist, John Michell invented the Torsion Balance, and stated the Inverse Square Law for magnetism, although he couldn't offer any proof. Fifteen years later, using a Torsion Balance of his own design – shown in Figure 1 – the French physicist, Charles-Augustin de Coulomb, announced that the Inverse Square Law applied to the force between two electrically-charged bodies AND to that between two magnetised bodies also.

Coulomb's Law, as it has come to be called, states that 'the mechanical force between two charged bodies is directly proportional to the charges and inversely so to the square of the distances between them.'

This was the earliest attempt to quantify both electricity and magnetism and was the result of – wait for it – Coulomb's attempt to improve compass operation!

The early decades of the 19th century were the foundation period of the electrical industry, a period dominated by what could be termed the Lawgivers.

By 1822, Jean-Baptiste-Joseph, Baron Fourier – at once physicist, mathematician, author and Napoleonic Governor of Egypt – had worked out the mathematics behind the flow of heat. Since heat flow between two points depended on the temperature of the points in question, as well as the conducting nature of the material linking them, it seemed to some physicists that a similar technique could be applied to an electric current.

After all, from experiments and observations so far, it appeared that electric

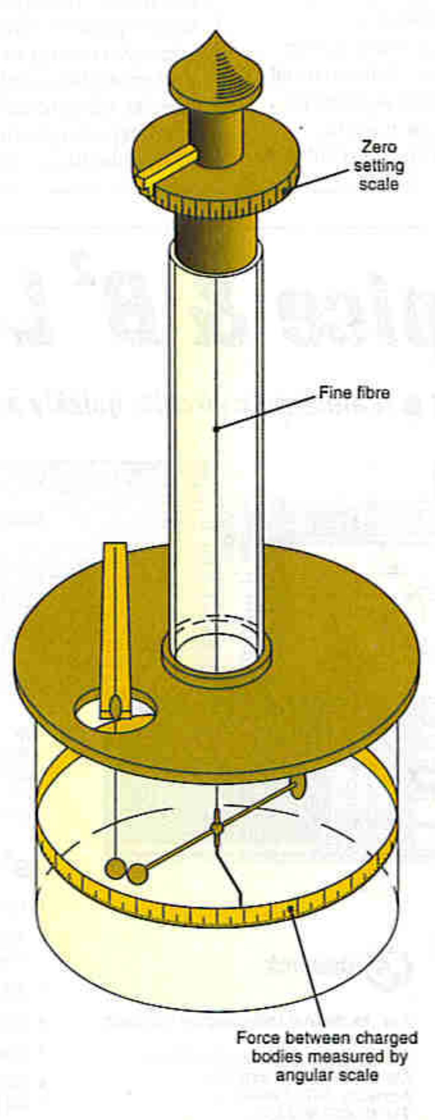


Figure 1. The Torsion Balance developed by Coulomb.

* Parkinson's Law and The Law and the Profits.

flow between two points depended firstly on their respective potentials, secondly on the conductivity of the connecting material.

In 1827, a German physicist, Georg Simon Ohm, published 'Die Galvanische Kette, Mathematisch Bearbeitet' or 'The Galvanic Circuit Investigated Mathematically'. This 'web of naked fancies', this 'incurable delusion' which had 'no support in even the most superficial observation of facts' to quote but three comments on the work, would fundamentally change science's perception of electrical circuits and how they worked.

Using wires of different lengths and thicknesses, Ohm discovered that the quantity of current passed through them was inversely proportional to the wire's length and directly proportional to its cross-sectional area. This enabled him to state the wire's resistance and, in his tome, declare that 'current through a conductor is directly proportional to the potential difference and inversely proportional to the resistance', that fundamental law with which we have all been long familiar.

Its acceptance took time, however, and a great deal of it. And why did Ohm have to endure so much vituperative verbal in the course of this reluctant recognition?

Probably because the experimental difficulties of the time led his peers, and contemporaries alike, to suspect that his methods were less than definitive.

Two of the major difficulties of the day, for example, were firstly current surges on switch-on and switch-off and secondly, the rapidly decreasing output after switch-on of the Voltaic pile, at that time the only battery available. Ohm, however, overcame these problems by using a Thermocouple, fashioned from copper-bismuth, as his power source. Discovered in 1822 by the Estonian-German physician-physicist, Thomas Seebeck, this arrangement was a considerable improvement on Volta's battery.

By continuously applying boiling water on the one hand and melting ice on the other, Ohm maintained a constant temperature difference across his power source, thus avoiding the difficulties experienced by other researchers.

Some thirteen years after the publication of his work, Ohm was at last elected a member of the Berlin Academy and, in 1841, was awarded the Royal Society's Copely Medal for his achievement. It was also the year when Joule's Law first saw the light of day, more of which shortly.

In 1832, the man who has long been considered the Patron Saint of the electrical industry, Michael Faraday, made yet another stunning contribution to his profession when he announced his Laws of Electrolysis.

Not only did he evolve these laws but, in co-operation with his friend and fellow-scholar, William Whewell, he evolved much of the terminology also.

The liquid, or solution, that conducted electricity Faraday termed an Electrolyte and the metal rods inserted into it he and Whewell termed Electrodes, from the Greek words for the expression 'the road to electricity.' The positive electrode was termed the Anode, or High Road and the negative terminal the Cathode, or Low Road.

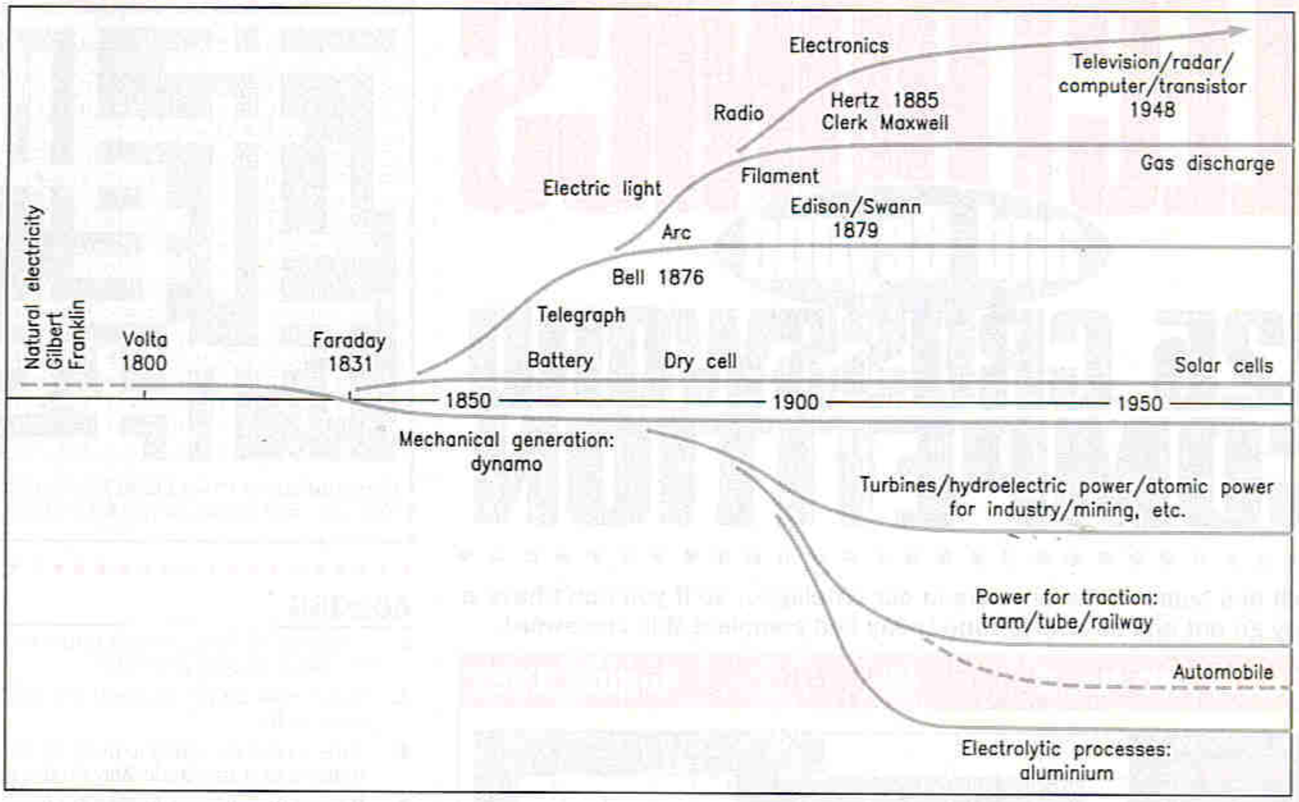


Figure 2. The advance of the electrical power industry and its acolytes after 1832.

Faraday's two laws of electrolysis state firstly that 'the mass of material released at an electrode during electrolysis is proportional to the amount of electricity driven through the electrolyte' and secondly, 'the mass released by a given quantity of electricity is proportional to the atomic weight of the element liberated and inversely proportional to the combining power of the element'. And this followed on the heels of another of his laws, that of Electromagnetic Induction, which he'd published the year before.

This last, of course, would lead to the development of the first electric generator which, subsequently, would lead almost directly to the world of today, as Figure 2 makes clear.

In 1834, the Estonian physicist, Heinrich Emil Lenz, discovered the law which bears his name. He found that a current produced by electromagnetic means opposes the change that produced it in the first place.

Lenz too had earlier made another contribution to the advance of electrical knowledge by discovering that the resistance of a conductor increases as the temperature rises and, conversely, falls as it's lowered.

Today however, it's his ubiquitous law he's remembered for and little else!

By 1841, another British physicist, James Prescott Joule, discovered that the quantity of heat produced per unit of time was proportional to the Resistance times the Current squared. The electrical industry now had a formula for calculating circuit power dissipation.

Seven years later, the German physicist-mathematician, Gustav Robert Kirchhoff, took Ohm's Law a little further, applying it to more complicated circuit arrangements than its creator had done. As a result, he'd give all future generations of communications engineering students their earliest mathematical headache!

The first law states that 'the algebraic sum of the current at any junction of conductors is zero.' In other words, at any point in a circuit, there is as much current flowing away from the point as there is flowing towards it.

The second law, on the other hand, declares that 'the algebraic sum of the EMFs and voltage drops around any closed circuit is zero.' In short, in ANY closed circuit, the applied EMF is equal to the voltage drops around the circuit. This is shown in Figure 3, a circuit all-too-familiar to most of us!

Kirchhoff's Laws were to prove every bit as important and pervasive as Ohm's law, from which they were developed. In the understanding of series, parallel and bridge circuits as well as network analysis, Kirchhoff's creations became, eventually, fundamental tools.

But not immediately. It would be 1876 – half a century after he'd published his results and twenty-two years after his death – before Ohm was resoundingly vindicated by the British Association for the Advancement of Science. The Association stated that his achievement was right up there with the laws of gravitation and static electricity, all three, in the Association's judgement, being fundamental laws of nature.

Whilst this was all very well, the one thing that WAS urgently needed, laws couldn't provide: standardised units of electrical measurement. It was this as much as anything else that delayed the acceptance of the laws already put forward. This problem, however, would only be solved through extensive international co-operation over the next 80 years or so.

Today, the advent of the computer has brought us two further laws. In the first twenty years of integrated circuits, for example, the number of components carried per circuit doubled every year.

This fact was first noticed by Fairchild Semiconductor's Gordon Moore, as long ago as 1964. Consequently, it has come to be known as Moore's Law.

Conversely, one of the problems with parallel computers is memory. When, for example, information is required for a particular operation, the processor calls it forward. However, with thousands of processors all presenting information to be acted on, the machine slows down considerably.

In 1967, the American computer scientist, Gene Amdahl, put forward the view that the boost given by the addition of processors becomes counter-productive because they eventually lead to bottlenecks. This has subsequently become known as Amdahl's Law.

What of the future? That depends on any number of research and development programmes being pursued in a wide variety of locations throughout the world. Of one thing, however, we can be sure: whatever communications engineering creates, it'll be done within some form of law. For all our vaunted conceits about freedom, we're born with a belief in constraint!

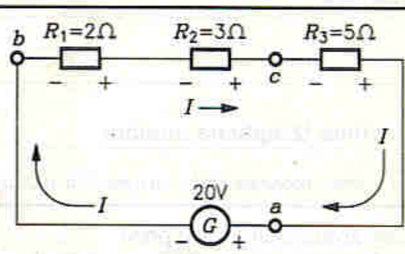


Figure 3. Circuit representation of Kirchoff's second law.

ELECTRONICS and Beyond

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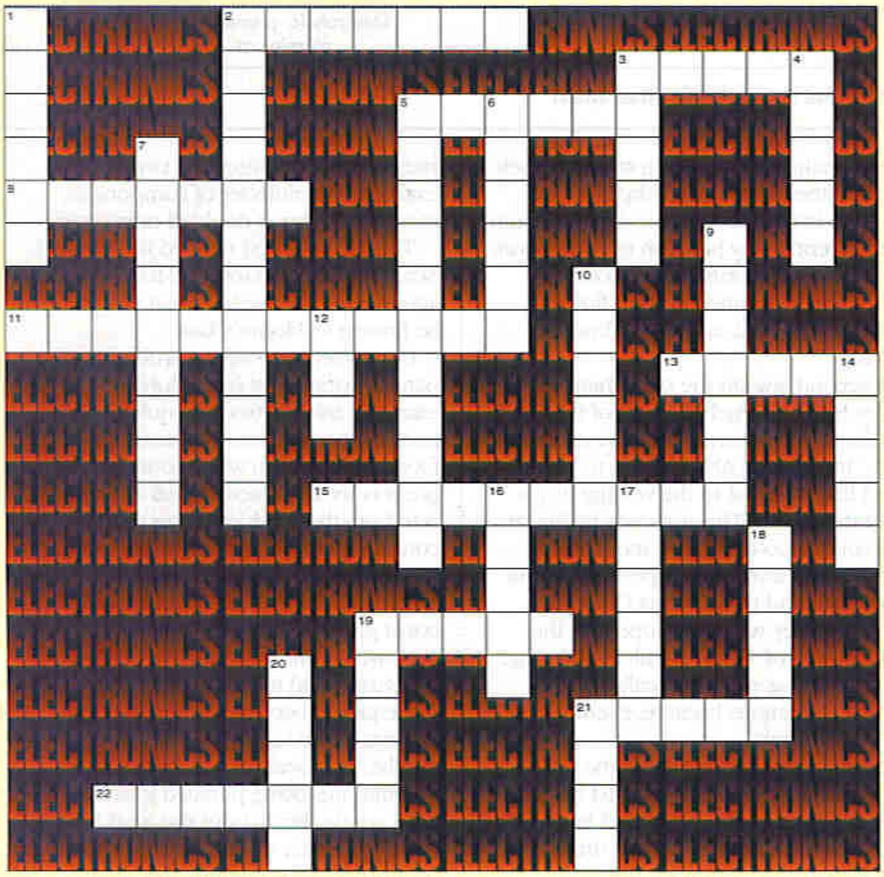
You will find some of the answers in our catalogue, so if you don't have a copy go out and search for one today and complete this crossword.

CROSSWORD No. 5 August 1997



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CROSSWORD No. 3 *Solution* June 1997

Congratulations to Mr David Marston of Newark – £25 comes to you for your efforts.

ACROSS

2. Sequence of programming instructions. Do the same thing as per usual

3. Order code for the 1000mfd /10v Radial electrolytic

5. Time it takes for sound to build up from zero to maximum amplitude. May do this if angry

8. What is the order code ZH38R ? Its as clear as black and white

11. The name given to the light emitted by phosphors when they are struck by electrons

13. This mains socket order code has a built in fuse holder and RF filter

15. Order code is YD66W, what type of security camera is it ?

19. Order code for laptop modem card

21. Time taken for sound to fall to a small value. Protect your teeth from this

22. Period of time that a note is maintained

DOWN

1. Common term for the amplitude of sound. Parents usually say "turn it down"

2. Name given to the treatment of disease by radiation

3. 5 Amp auto reset circuit breaker order code

4. JT23A is a 3 button serial device. The cat loves to chase

5. Name given to current that changes direction at regular intervals

6. Distintive quality of sound. Turn the last two letters round and you have a name for wood

7. Electromagnetic radiation, wavelength range 0.003m to 0.3m. Find one in the kitchen

9. The force that pushes electrons through a circuit

10. PA speakers on page 456. Part of a car

12. Abbreviation used to describe the "Brains" of a computer

14. Sealed in-line fuse holder part number

16. Order code for the lead fitted with a 9 way male D type plug and a 15 way female high density D plug

17. Resistor colour band representing the number three

18. This thermal fuse goes open circuit at 229 degrees, whats the order code ?

19. Clock this camera order code

20. Name given to a group of three phosphor dots on the screen of a cathod ray tube.

21. Term used to describe the time a machine is not capable of performing its job

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Kit includes all components, PCB, box, box label, sockets, wire, etc., and full instructions. Requires Alkaline PP3 battery (not included in kit).

AUDIO LEAD CHECKER KIT LU26D £19.99
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- EMC / CE compliant

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Issue 113 / May 1997 Electronics & Beyond XD13P £2.25

SIREN SOUND GENERATOR KITS

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- Speaker or buzzer output drive
- Touch, switch contact or digital input to trigger siren
- Pulsed LED output
- Compact PCB
- EMC / CE Compliant

IDEAL FOR:

- Audible warning devices
- Sirens and alarms
- Children's toys

PROJECT RATING 1 Simple

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WAILING POLICE SIREN KIT LU89W £7.99
Construction details: Siren Sound Generator Leaflet XZ42V 50p
Issue 112 / April 1997 Electronics & Beyond XD12N £2.25

These kits are:

- Supplied with high-quality fibre-glass PCBs – pre-tinned, with printed legend and solder resist
- Supplied with comprehensive instructions and a constructors' guide
- Covered by the Maplin Get-You-Working Service and 12-month warranty

Kits do not include tools or test equipment. Kits may require additional components or products, depending on application, please refer to construction details or contact the Maplin Technical Support Helpline (Tel: 01702 556001) if in doubt.

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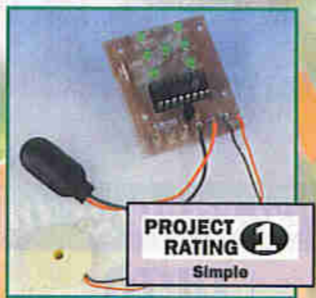

PROJECT RATING 1 Simple

FEATURES:

- Easy to build – ideal beginners' project
- Auto power-off for long battery life
- Low quiescent current (typically 1μA)
- 3V supply voltage (2 x 1.5V cells ideal)
- Touch, switch contact or digital input to 'roll' dice
- 'Rolling dice' sound effect
- Dice can be interlinked for games requiring more than one dice
- EMC / CE Compliant

Kit includes all components, PCB, LEDs, piezo sounder and full instructions. Enclosure, fixing hardware, switch/touch pads, battery, etc., are dependant on user's intended application and therefore not included in the kit.

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PROJECT RATING 1 Simple

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IDEAL FOR:

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PROJECT RATING 1 Simple

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Tektronix

DIGITAL REAL TIME WAVEFORM ACQUISITION

Advertisement Feature

The history of electronic measurement has been a succession of steps toward viewing ever faster, more complex waveforms and signal details.

An oscilloscope's display has been the final judge of electronic circuit performance. For decades, a key tool in acquiring the most challenging of waveform events has been digital sampling, and more recently the digital storage oscilloscope (DSO).

DSOs now dominate most scope applications because they offer crucial advantages over analogue oscilloscopes. Digital scopes document, analyse, and compare waveforms far more efficiently. They present stable, clear images of complex waveforms. Even so, several limitations of conventional DSOs have hampered their acceptance in some applications.

Capturing Digital Real Time (DRT) waveforms eliminates distortion and aliasing sometimes found in conventional Digital Storage Oscilloscopes, while achieving full bandwidth for both repetitive and single-shot events.

The superior capabilities of Tektronix TDS and THS Series of oscilloscopes are based on Digital Real Time (DRT) acquisition. This technical brief shows the key benefits of DRT and how they increase measurement confidence and efficiency.

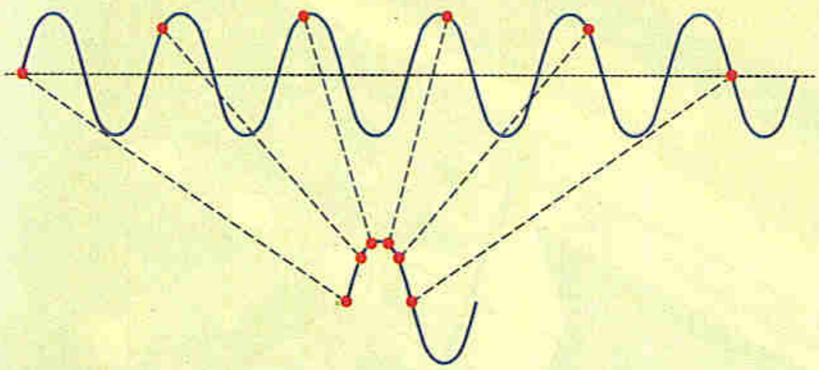


Figure 1. Equivalent Time Sampling: Data points are aquired from many cycles to build one screen image

Equivalent-Time sampling (ET) was for years the only available sampling architecture. ET uses relatively slow sample rates – a fraction of the input frequency – to gather samples across many cycles of the input signal. Inherently, the update rate is slow because it takes so many cycles to build a record to display onscreen. If the input signal is perfectly repetitive, the ET scope will produce an accurate waveform image. If the waveform changes during the sampling cycle, the scope will create false data points and aliasing rendering the image meaningless. This characteristic prohibits Equivalent-Time sampling from capturing one-time momentary events.

Most DSOs use a combination of real-time and ET sampling techniques. At lower frequencies real-time acquisition provides enough sample points to define the waveform. As a scope approaches its analogue bandwidth, it will automatically switch to ET. In other words, a conventional DSO trades off critical transient capture capabilities to achieve its specified bandwidth.

DRT waveform acquisition uses high-speed sampling and digitizing rates. This allows the waveform to be digitized into a complete set of points (a waveform record) from a single, triggered acquisition. Figure 2 illustrates this DRT process where each sample is taken sequentially as the waveform occurs in real time.

In digital real-time DSOs, a high-speed sampler takes samples in sequential order and fills the waveform record from beginning to end in a single, triggered acquisition.

The value of DRT is that it provides a faithful reproduction of the instantaneous time and amplitude values of each waveform. By contrast, analogue oscilloscopes and conventional DSOs show composite displays of captured waveforms. These composite methods have problems and limitations that are not encountered with DRT methods.

For capturing single-shot waveforms, this means that you don't have to worry about limits imposed by a reduced single-shot bandwidth. Simply capture the single-shot waveform with the same methods that would be used with a traditional analogue oscilloscope. Not only will the single-shot waveform be captured to full bandwidth and resolution, but it will be stored for easy viewing and measurement.

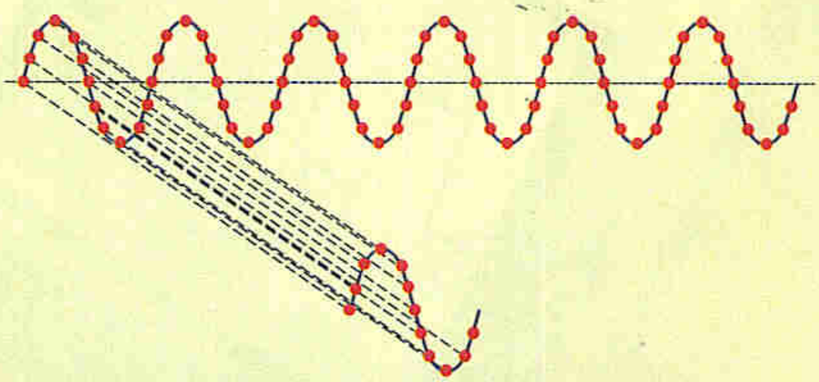


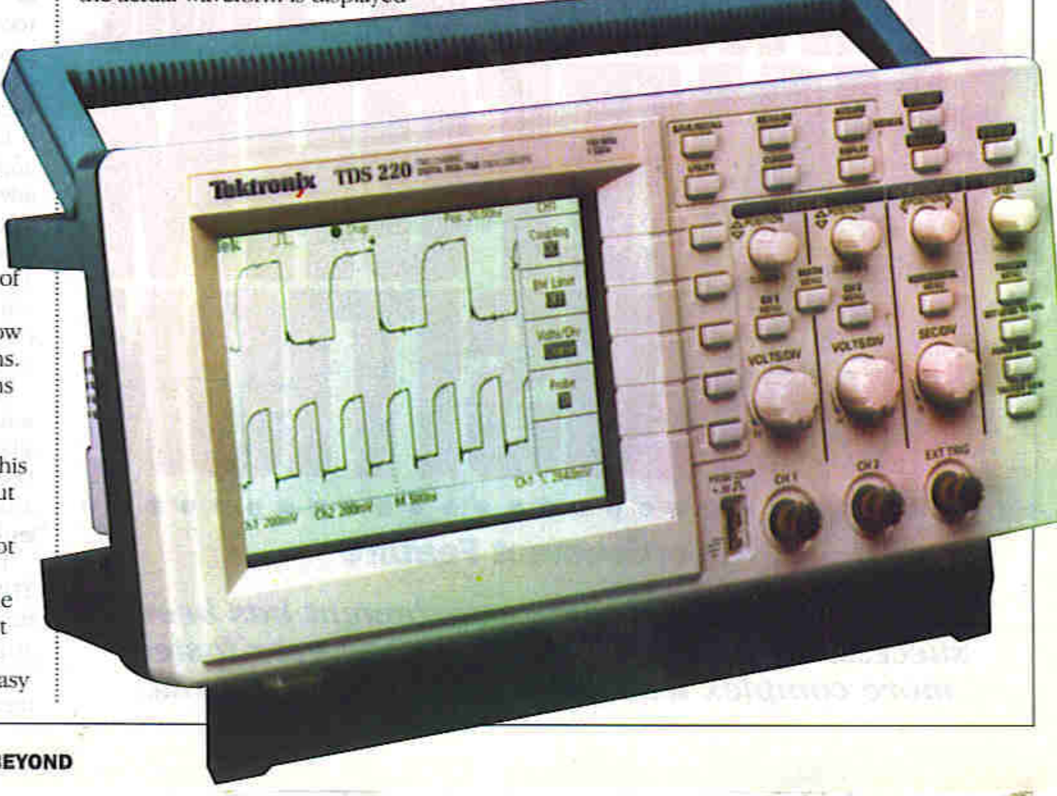
Figure 2. Digital Real-Time Sampling: Each waveform cycle produces more than enough data to build a full record (screen display).

Similarly, fast, low-repetition rate signals are captured from a single, triggered repetition. You can capture the narrow, fast pulse at any time/division setting without having to wait through the multiple acquisitions needed to build a full display with equivalent-time methods.

When it comes to seeing the realities of a waveform, nothing beats DRT acquisition. Because the waveform is sampled and acquired in real time, as it actually occurs, the actual waveform is displayed in all its detail. This includes depiction of waveform noise and other random or nonsynchronous aberrations. With Tektronix digital real-time, if you can trigger on the waveform, you can see it!

Summary

DRT acquisition technology has provided a platform for high-performance digital scopes at all price points. It overcomes the traditional limitations of digital storage scopes, and therefore is ideally suited for applications in the manufacturing, education, and service fields-applications traditionally claimed by analogue scopes. The TDS 210 and TDS 220 are low-cost DRT-based oscilloscopes optimized for these applications. Real-world users will find the scopes' performance better than analogue scopes. Moreover, the TDS 210 and TDS 220 provide a host of automated digital functions that will enhance productivity wherever they are used. These new products will hasten the final transition to digital scopes. The TDS 210 and 220 are now available through Maplin Electronics (order codes KV56 and KV57).



Users guide to SPECIAL AUDIO PROCESSING IC'S

PART 2

Ray Marston looks at practical ways of using Hi-Fi analogue switching ICs in the second episode of this 3-part series.

Last month's opening episode of this series looked at the basic theory and practical working details of three dedicated audio signal processing ICs, namely, the MC3340P electronic attenuator IC, the NE570/571 dual 'compander' ICs, and the LM1894 dynamic noise reduction IC. This month's episode continues the 'special audio processing' theme by looking at a variety of analogue switching ICs that are suitable for use in several multi-way Hi-Fi channel selection applications.

'Analogue Switch' IC Basics

Unscreened cable has a natural tendency to pick up radiated audio and RF signals. Consequently, when conventional control switches are mounted on an audio unit's front panel and are interconnected to various signal-carrying parts of the unit's circuitry, they and their wiring must be very carefully screened to avoid unwanted signal pickup. Voltage-controlled 'analogue switch' ICs offer a very efficient solution to this particular problem, and are simply placed directly in the signal-carrying paths of the unit's main circuitry (thus eliminating the need for long signal-carrying cables) and are activated – when required – by DC voltages derived from the unit's front panel switches or via a normal remote-control system.

All practical voltage-controlled analogue switch ICs conform to one or other of the basic forms represented by the '4-switch' units shown in Figures 1 and 2. In the Figure 1 unit, the input and output of each switch is separately accessible, and each switch can be independently controlled. The signal path of each switch is known as a 'channel', and the Figure 1 unit is thus known as a basic 4-channel analogue switch IC. In the Figure 2 unit, the outputs of the four switches are internally shorted together, and the switches are (in this example) controlled via a 2-bit binary voltage that allows only one switch to be closed at any time. This unit thus acts as a 4-way analogue selector switch or multiplexer. Real-life analogue switch ICs have up to sixteen channels or 'ways'.

The actual 'switch' part of the IC may be either a unilateral or a bilateral element. Unilateral switches can pass signals in only one direction, from input to output, and take the basic form shown in Figure 3, in which 'A' is a linear amplifier that gives unity gain when acting as a closed switch and (ideally) zero gain when acting as an open switch. Usually, the amplifier takes the form of a simple op-amp that has its input and/or feedback connections controlled via one or more JFET switches, or a simple OTA that has its gain controlled via the OTA's tail current.

Figure 1. Diagram representing a basic 4-channel analogue switch IC.

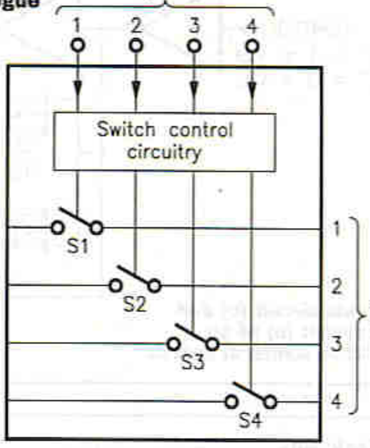
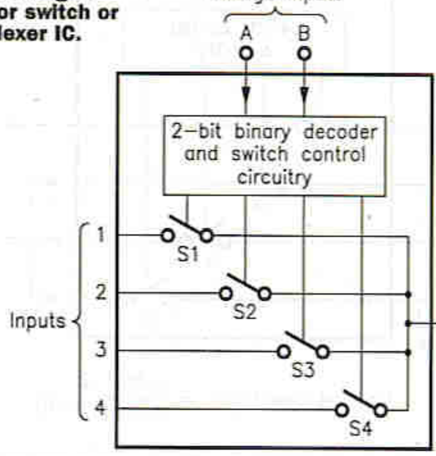


Figure 2. Diagram representing a basic 4-way analogue selector switch or multiplexer IC.



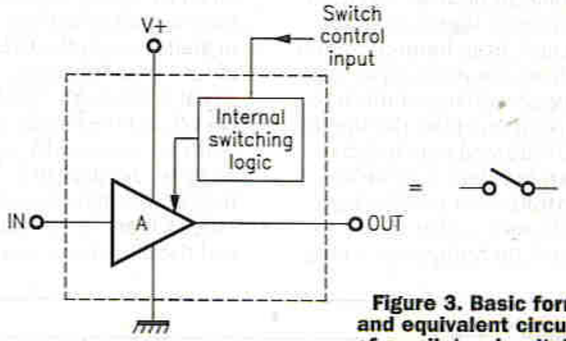


Figure 3. Basic form and equivalent circuit of a unilateral switch.

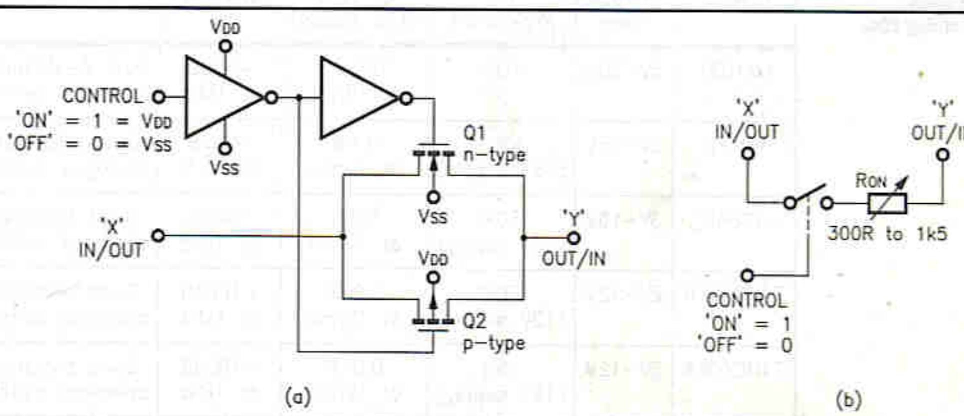


Figure 4. Basic circuit (a) and equivalent circuit (b) of a simple CMOS bilateral switch.

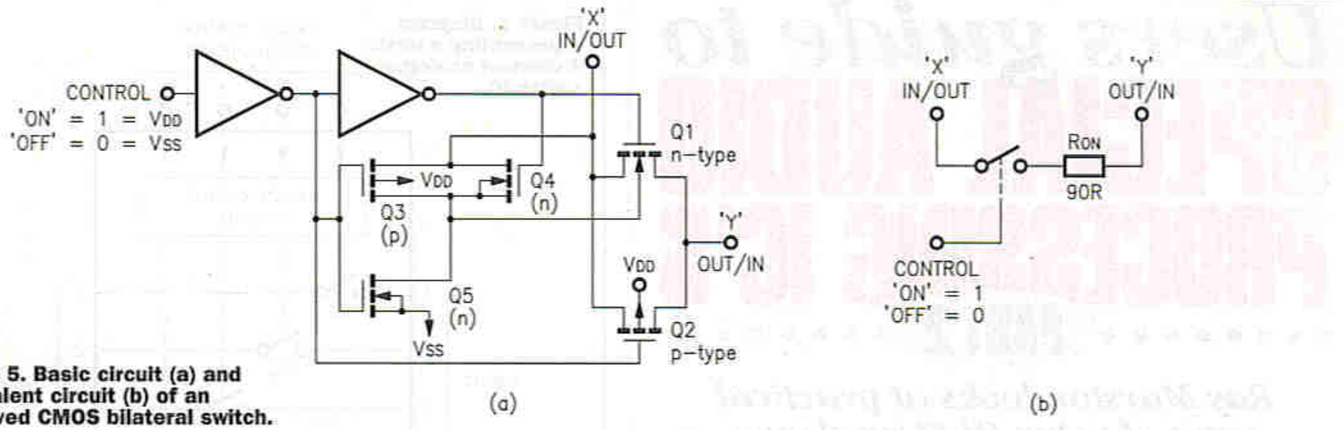


Figure 5. Basic circuit (a) and equivalent circuit (b) of an improved CMOS bilateral switch.

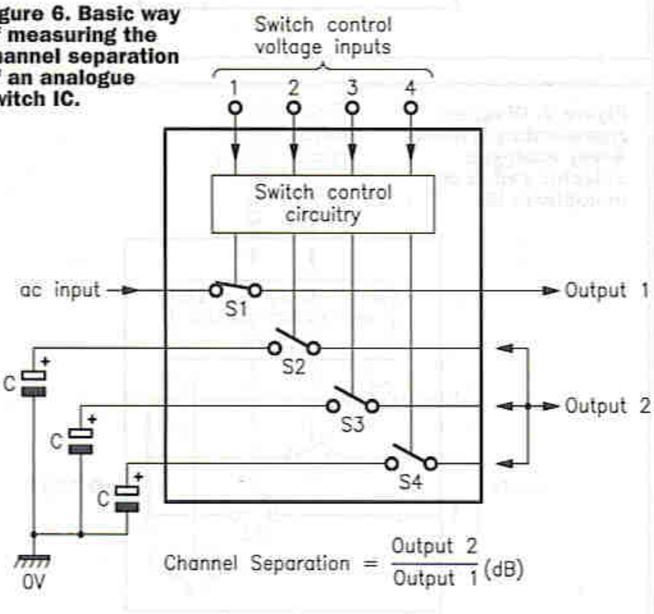


Figure 6. Basic way of measuring the channel separation of an analogue switch IC.

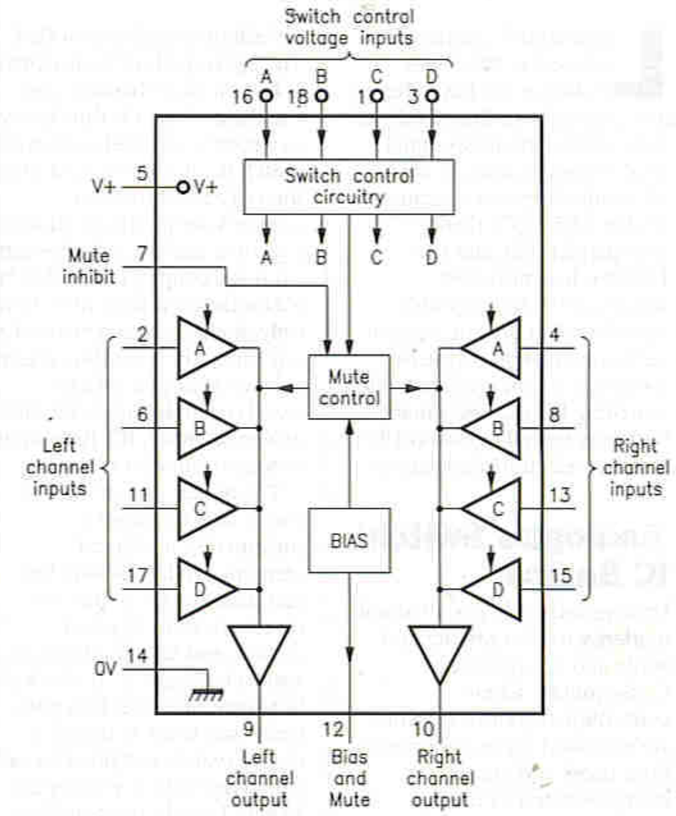


Figure 8. Block diagram of the LM1037 dual 4-channel analogue switch.

Bilateral analogue switches can (like an ordinary electrical switch) pass signals in either direction, from input-to-output and from output-to-input. All analogue switches of this type are based on either the simple CMOS bilateral switch circuit shown in Figure 4, or on an improved version of the basic switch, such as that shown in Figure 5. In both cases, n-type MOSFET Q1 and p-type MOSFET Q2 are wired in inverse parallel and are driven in antiphase via the CONTROL input signal. When the control signal is low, both MOSFETs are cut off and the circuit acts – between the X and Y points – as an open-circuit switch. When the control signal is high, both MOSFETs are driven fully on and the circuit acts as a closed switch that can pass current in either direction between the X and Y points but has an ON resistance that, in practice, may range from a few ohms to several hundred ohms.

Ignoring the basic architecture of an analogue switch IC (i.e., its type of construction and number of channels), its two most important basic parameters are its signal distortion and channel separation figures. The signal distortion (THD) figures are usually specified at a particular frequency (typically 1kHz) and amplitude level (typically in the range 100mV to 1V rms. Channel separation defines the amount of signal breakthrough (in dB) that occurs between

Figure 7. Basic details of five popular analogue switching ICs.

Device number	Supply voltage range	Switch 'ON' impedance	THD at 1kHz (12V supply)	Channel separation	IC description
LM1037	5V–28V	10R	0.04% at 1Vrms	−95dB at 1kHz	Dual 4-channel analogue switch
4016B	3V–15V	400R (15V supply)	0.4% at 1Vrms	−90dB at 1kHz	Quad bilateral analogue switch
4066B	3V–15V	80R (15V supply)	0.1% at 1Vrms	−90dB at 1kHz	Quad bilateral analogue switch
74HC4016	2V–12V	20R (12V supply)	0.01% at 1Vrms	−100dB at 1kHz	Quad bilateral analogue switch
74HC4066	2V–12V	15R (12V supply)	0.01% at 1Vrms	−100dB at 1kHz	Quad bilateral analogue switch

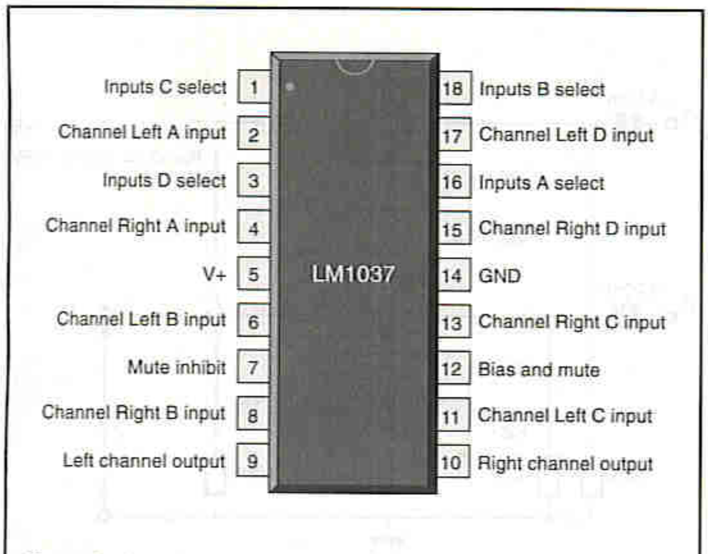


Figure 9. Outline and pin notations of the LM1037 IC.

used and unused channels of the IC, and is measured using the basic technique shown in Figure 6. Here, the AC test signal is applied to the 'S1' input, and all other inputs are decoupled to ground; the magnitudes of the 'unused channel' output signals are then measured and the largest of these is compared to that of the used channel output to determine the IC's channel separation figure. Thus, if the Channel 1 and 2 output signals have RMS magnitudes of 1V and 0·1mV respectively, the channel separation figure works out at -80dB.

Practical Analogue Switch ICs

For many years, the most popular analogue switch IC for use in Hi-Fi applications has been National Semiconductor's LM1037 dual 4-channel IC, and the most popular types for use in mid-fi and low-fi applications are the low-cost 4016B and 4066B 4-channel members of the '4000-series' CMOS family. In recent times, however, changes in Hi-Fi fashions and advances in semiconductor technology have caused a shift in this situation. In the Hi-Fi field, for example, it is now fashionable to make all major user-variable Hi-Fi functions fully remote controllable via one sophisticated IC that houses full analogue switching and tone/volume control circuitry. This trend has greatly reduced the market for dedicated 'Hi-Fi' analogue switch ICs such as the LM1037 type.

Concurrent with the above development, advances in CMOS technology have resulted in the development of very-high-performance, low-cost variants of the 4016B and 4066B 4-channel switches, the 74HC4016 and 74HC4066, which each give lower distortion than the LM1037. As a result of these changes, the LM1037 has now ceased production, but will continue to be available from individual distributors for several years. Thus, if you wish to use a dedicated analogue switching IC in an audio project, you can still use an LM1037 or a low-cost CMOS IC such as the 4016B, 4066B, 74HC4016 or 74HC4066 for the purpose. Figure 7 lists basic details of these five devices.

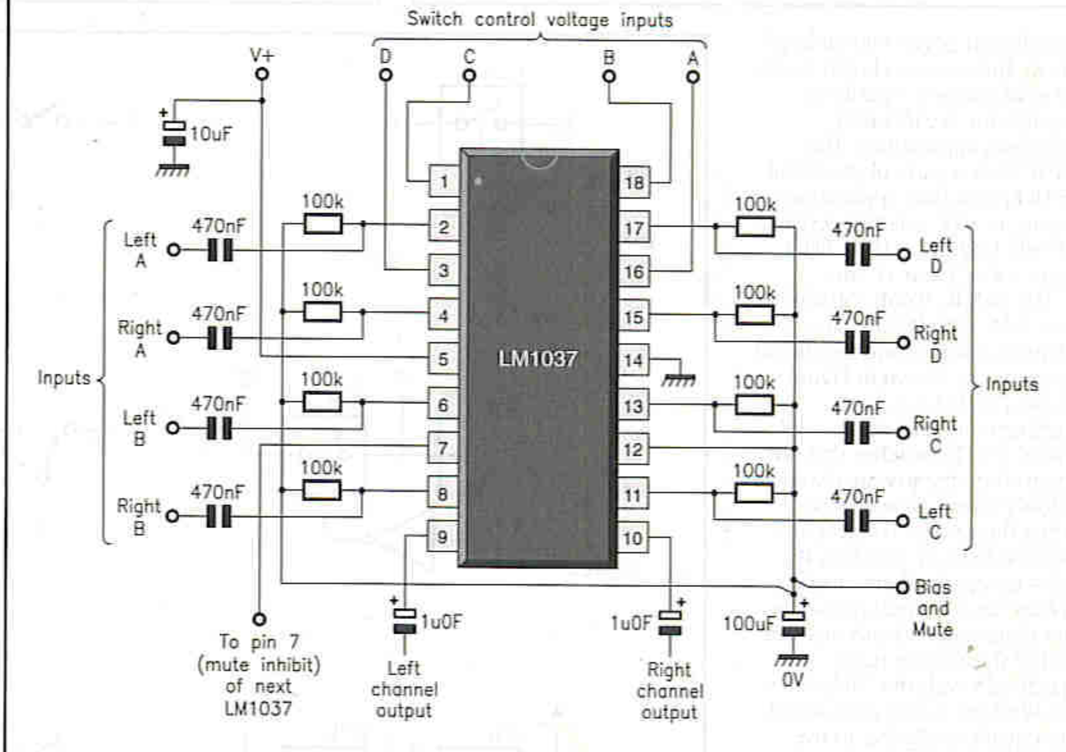


Figure 10. LM1037 dual 4-channel analogue switch application circuit.

The LM1037 IC

The LM1037 is a dual 4-channel unilateral analogue switch that allows any one of four stereo input signals to be selected via the appropriate one of four control terminals (pins 1, 3, 16 or 18), and which incorporates a 'mute' facility. Figure 8 shows the internal block diagram of the IC, Figure 9 shows the IC's outline and pin notations, and Figure 10 shows the IC's basic usage circuit. Stereo output signals are available on pins 9 and 10, and input channel selection is achieved by taking the appropriate switch control terminal high (only one terminal must be high at any given moment). Each signal input is applied to the IC via a 470nF capacitor, and each signal input pin is biased into its linear region by connecting it to the pin-12 'bias' terminal via a 100kΩ resistor.

LM1037 ICs can be wired in parallel to increase the available channel switching capacity, e.g., two ICs can select up to eight stereo channels. In this application, the pin-7 mute inhibit terminals of both ICs should be direct coupled to each other, and the stereo output terminals of the ICs should be shorted together (pin-9 to pin-9, and pin-10 to pin-10) and made externally available via a single pair of 1μF capacitors.

The 4016/4066 IC Family

The 4016/4066 family of CMOS ICs are designed primarily for use in high-speed digital applications (the 74HC4066, for example, has a switch signal bandwidth of 12MHz and a

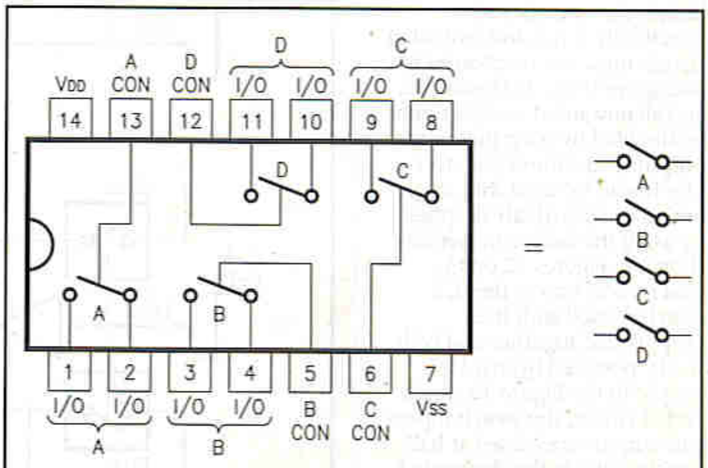


Figure 11. Outline and functional diagram common to the 4016B, 4066B, 74HC4016 and 74HC4066 quad bilateral switch ICs, which each act as four independent SPST switches.

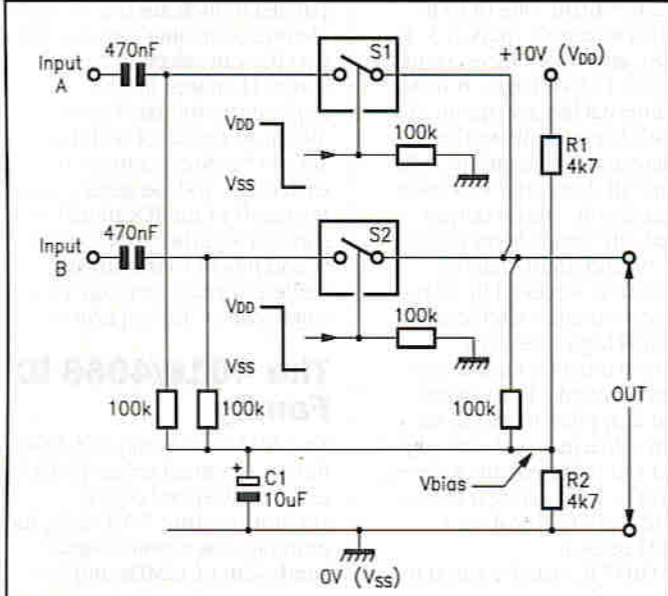


Figure 12. Basic way of using the 74HC4066 IC with a single-ended +10V power supply.

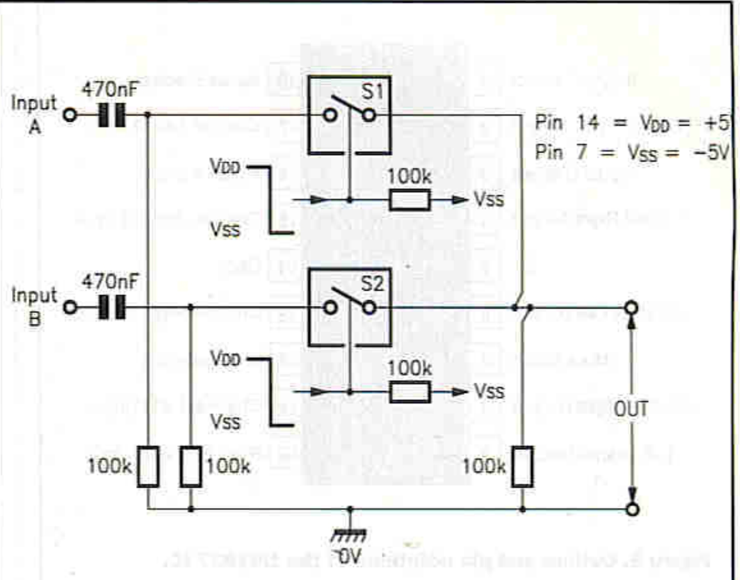


Figure 13. Basic way of using the 74HC4066 with a split power supply.

switch turn ON or OFF time of 10ns), but are – as shown in the table of Figure 7 – perfectly suitable for use in audio switching applications. The 74HC4066 is particularly useful in Hi-Fi switching applications, having an 'ON' switch impedance of only 15Ω and a 1kHz THD figure of 0·01% at 1V rms.

The 4016B, 4066B, 74HC4016 and 74HC4066 ICs all have identical outlines and functional diagrams, as shown in Figure 11, and each act as four independent single-pole single-throw (SPST) switches that are open when their control voltage is low (at logic-0) and closed when the control voltages are high (at logic-1). The four ICs are – except for their supply voltage limits – used in exactly the same way, and although the rest of this section deals specifically with the 74HC4066 IC, all of the points mentioned are equally applicable to the 4016B, 4066B and 74HC4066.

The 74HC4066 is very easy to use, provided that basic CMOS usage rules are obeyed. Specifically, input and switching signals must not be allowed to rise above V_{DD} or fall below V_{SS}, and all unwanted switches must be disabled by tying their input, output, and control pins to V_{SS}. The IC can be used with single-ended or split (dual) supplies by using the basic connections shown in Figures 12 or 13, which show two of the IC's switches used with their outputs tied together and with the IC powered from a 10V supply. In the Figure 12 single-ended circuit, the switch inputs and outputs are biased at half-supply volts via the decoupled R1-R2-C1 bias network and via 100kΩ isolating resistors, and the switch control voltage swings between 0V (V_{SS}) and

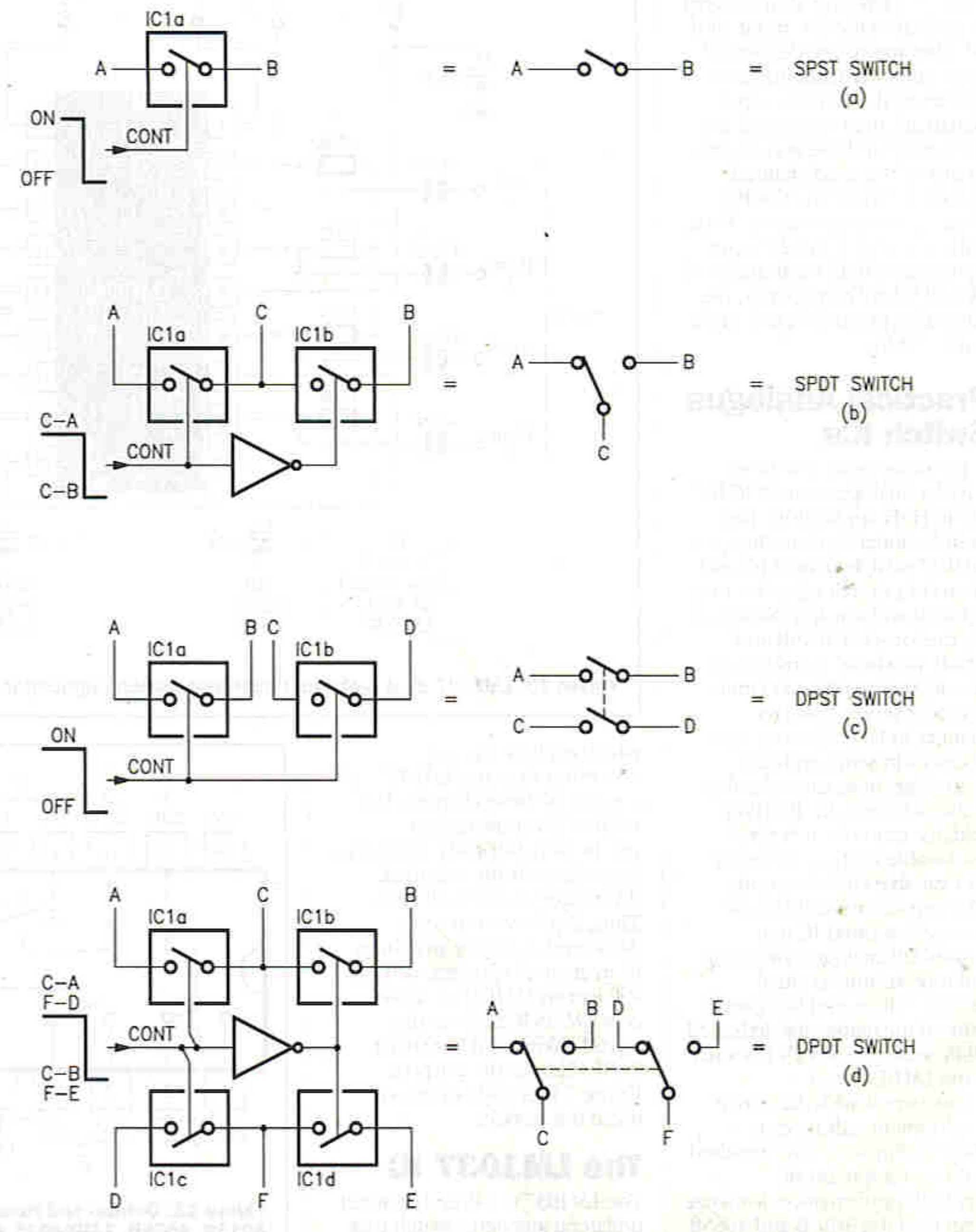


Figure 14. Implementation of four basic switching functions via the 74HC4066 IC (IC1).

+10V (V_{DD}). In the Figure 13 split-supply circuit, the switch inputs are tied to zero volts via 100kΩ resistors, and the switch control voltage swings between -5V (V_{SS}) and +5V (V_{DD}).

The 74HC4066 IC's internal switches can be used in a wide variety of configurations, and Figure 14 shows how it can be used to implement the four basic switching functions of SPST, SPDP, DPST and DPDT. Figure 14(a) shows the SPST connection, which has already been described. The SPDT function (Figure 14(b)) is obtained by wiring a simple inverter stage between the IC1a and IC1b control terminals. The DPST switch (Figure 14(c)) is simply two SPST switches sharing a common control terminal, and the DPDT switch (Figure 14(d)) is two SPDT switches sharing an inverter stage in the control line.

In audio applications, the most useful application of the 74HC4066 is as a voltage-controlled multi-input signal selector or switch. Figure 15 shows the basic way of using the 74HC4066 as a single-pole 4-way selector switch in which the desired input signal is selected by driving the appropriate control input high. The 74HC4066 can provide a maximum of four 'ways' per IC, and an 8-way switch can thus be made by using two ICs and connecting all of their switch outputs together, or a 4-way stereo selector can be made by using two ICs, configured as in Figure 15, but with the control inputs of the two ICs wired in parallel, as shown in Figure 16.

The 74HC4052 IC

Another low-cost and easy-to-use CMOS IC that can be used to make a 4-way voltage-controlled low-distortion stereo selector switch is the popular 74HC4052 dual 4-channel analogue multiplexer IC. Figure 17 shows this IC's functional diagram and truth table, etc. The IC is used in the same basic way as the 74HC4066, except that its channel selection is executed by applying two simultaneous voltages in the form as a 2-bit binary code, as shown in the truth table. One very useful feature of this IC is that the selection process can be inhibited by applying a logic-1 (high) voltage to pin-6, which can thus be used as an audio 'mute' control.

Next month's concluding episode of this series will look at a number of remote-controlled 'tone and volume' ICs, and at the MF10C switched-capacitor universal filter IC.

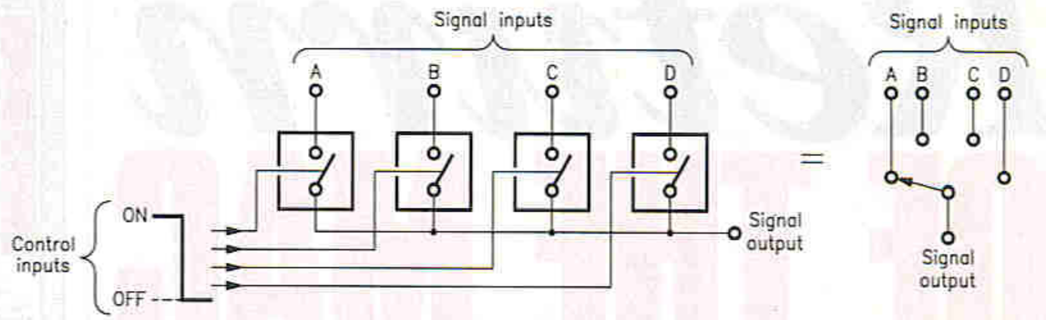
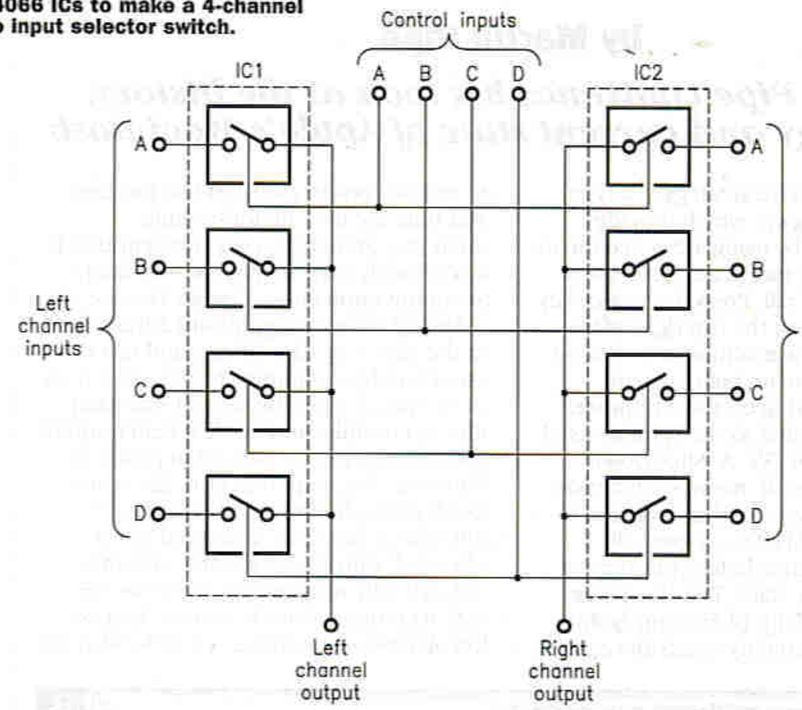
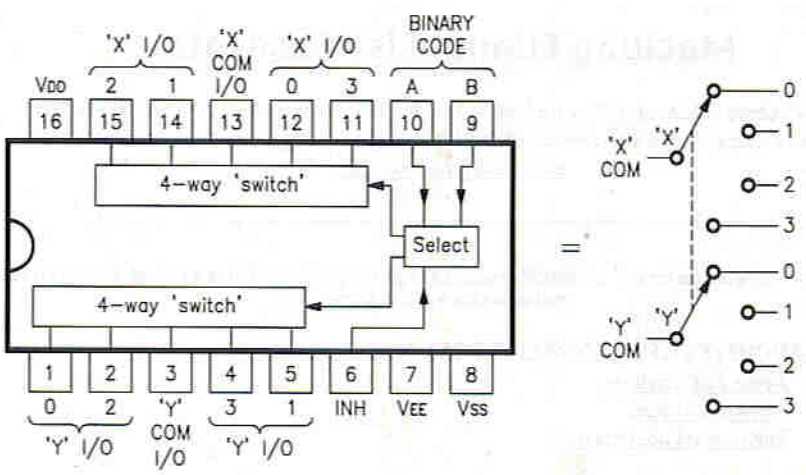


Figure 15. Basic way of using the 74HC4066 as a single-pole 4-way selector switch.

Figure 16. Basic way of using two 74HC4066 ICs to make a 4-channel stereo input selector switch.





INPUT STATES			'ON' CHANNEL	
INH	B	A	'X'	'Y'
0	0	0	0	0
0	0	1	1	1
0	1	0	2	2
0	1	1	3	3
1	X	X	NONE	

X = Don't care

Figure 17. Functional diagram and truth table of the 74HC4052 dual 4-channel analogue multiplexer IC, which acts like a ganged 2-pole 4-way analogue switch.

Return OF THE MAC

PART 2

by Martin Pipe

Martin Pipe continues his look at the history, technology and current state of Apple's Macintosh

Apple's Internet site.

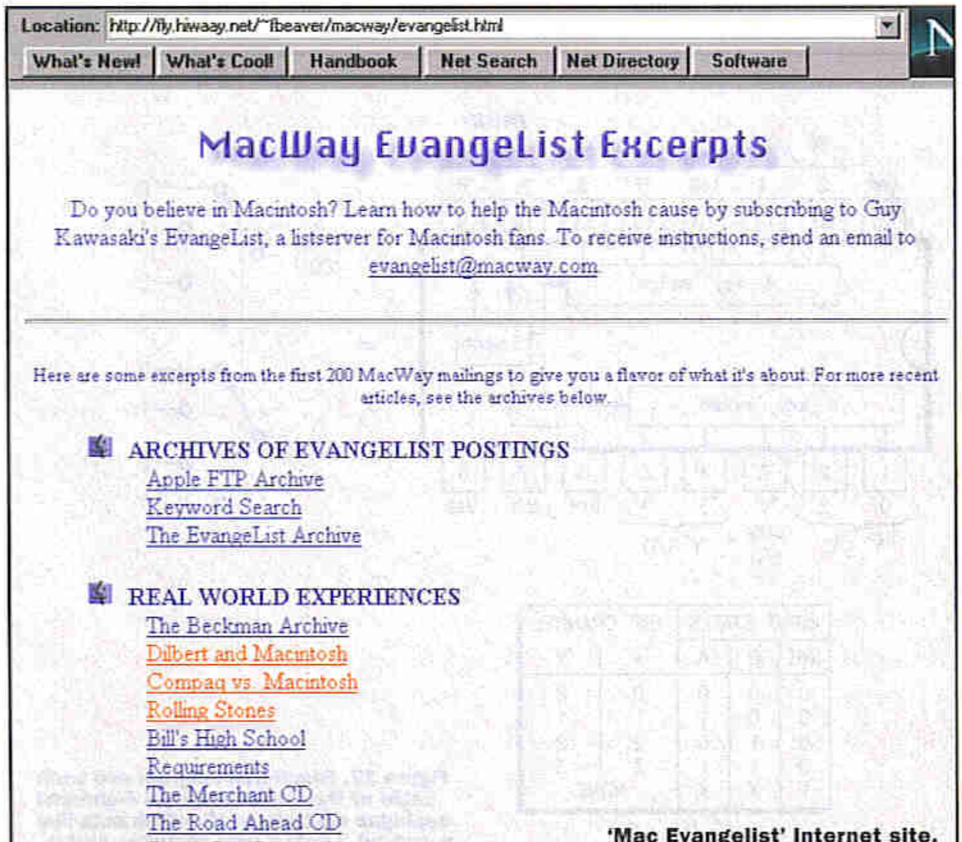
Macs also have an elegant way of powering up, which is made possible by using a tiny section in the power supply that generates a low-current 'standby' rail. Press the power key (the isolated key on the top right of the keyboard), and the machine is woken up, switching on the main high-current supplies and booting up the computer. It's not too dissimilar to the systems used by remote control TVs. A 'Shut Down' option in the 'special' menu – a function of the 'Finder' program that is central to the operation of MacOS – closes all programs and menus before placing the Mac in its standby state. The Mac power supplies provide a lot of filtering against spikes, but it is certainly a sensible option to remove power (settings like the date and time are held in non-volatile memory). Standby power consumption is low enough to be negligible – certainly along the same lines of those TV sets.

One of the most significant advantages of the Mac is its ease of use, and it is this aspect of the computer that has won it so many friends over the years. Organising files is a doddle, and Apple's search utility has only just been matched in power by Windows 95's 'find' function. For years, the Macintosh has had a 'wastebasket' into which you drop unwanted items. Microsoft only finally caught onto this user-friendly feature with Windows '95, with its more politically correct 'recycle bin'. Occasionally, though, you do wish for the 'security' of the command line (as a seasoned PC user, I often revert to a DOS window for carrying out certain operations).

Perhaps this Macintosh tendency to keep you far away from the nuts and bolts is one of the things that antagonises PC users so much. Feelings still run strong in the Mac-v-PC debate – there are web sites that allow both sides to vent their steam, the most comprehensive of which are run by self-styled Mac 'evangelists' whose job in life is to get all their friends to buy Macs rather than PCs. I have also seen Windows game applets in which you shoot Macs, space invaders-style, and clandestine Mac screen savers that do nasty things to the Windows logo. And of course, there's Apple's recent 'Windows 95 = Macintosh '89' badges!

Amazingly, it's still possible to run the more recent Mac applications on some rather ancient Mac hardware. Most Mac application software arrives in two versions – one for older 680x0 machines, and another for PowerPC-based computers. Some of the latest top-of-the line Macs, such as the Power Macintosh 9500/180MP, incorporate multiple PowerPC chips. Multiprocessing extensions are available for some software, such as the Adobe Photoshop photo-manipulation program and some 3D packages, for speeding up rendering of 3D images and filters. I know somebody with a 1988-vintage Mac Plus, expanded to 4M-byte and with an external SCSI hard disk. He's running his machine as an Internet host, thanks to a simple graphical Web browser and TCP/IP. Imagine doing that with a 286 PC or XT! My old Mac II, expanded with a Daystar 68030 processor card, a sizeable hard disk and 8M-byte of memory, is quite capable of running Photoshop (albeit with small images).

When the Mac first arrived, it was bought by the kind of people who would not normally buy a computer, or who appreciated their advantages but were intimidated by their user-unfriendliness. Its graphical user interface appealed to those of a creative bent, and desktop publishing and drawing packages first arrived on the Mac. The Mac was the first



'Mac Evangelist' Internet site.

affordable computer to support genuine WYSIWYG (What You See Is What You Get), which was essential for layouts. It also introduced us to multiple (TrueType) fonts, again essential for DTP and design applications. The PostScript page description language is now a print industry standard, but it was originally conceived as a file format by which pages could be transmitted from a Mac to a laser printer.

The Mac was adopted wholesale by the publishing industry – for example, many catalogues (such as the Maplin/MPS catalogue), magazines (including the one you're reading now), newspapers and product packaging are prepared on a Mac using the industry-standard Quark Xpress and Adobe Photoshop packages. These packages were originally Mac-only; they only found their way onto Windows four or so years ago. Computer artists swear by the Mac, using scanners to acquire images and software such as Illustrator, Photoshop and xRes to distort it to their creative ends. Some Macs, known as AV models, are also supplied with QuickTime video capture and output; the Adobe Premiere non-linear editing package debuted on the Mac. 3D work is also well served by the Mac. The 'Intel Inside' TV advert was, as Mac aficionados are fond of saying, apparently produced on a bank of six Quadra 840AVs.

As it stands, MacOS is not supplied with very much application software, although once upon a time, this situation was rather different. Compare this with all the goodies that are supplied with Windows 95 (everything from a decent 3D game to a pop video!). Mac OS does include, amongst other things, the MacTCP TCP/IP stack for Internet connectivity (both Netscape and Internet Explorer have been ported to the Mac, and there are plenty of other Mac-based Internet clients, server tools and web design packages). The SimpleText text editor provides very basic tools, but is totally unusual in that it includes a text-to-speech converter. You can actually get your Mac to read out your letter or article to you; surprisingly, the US-dialect speech quality is good enough to be understandable. The limited software need not be a deterrent, though; most Mac vendors bundle a range of applications with the machine, the nature of which depends on the destination of the machine (for example, home, office, Webmaster, graphic designer and so on).

The Mac doesn't benefit from the same level of software and hardware support that PC converts take for granted. There is, nevertheless, a wide range of products out there, from graphics cards to twelve-speed CD-ROMs. Software exists for just about every application that's mainstream, and many that are not. There is also a wide range of shareware and public-domain programs that can be downloaded from the Internet (try `http://www.shareware.com`) or bulletin boards. Among the best-known shareware programs are Black Knight (a basic but excellent comms program), Graphic Converter (displays and converts between various graphic formats, amongst other things), Stuffit (a file compression system that is to the Mac what PKZip is to the PC) and BBEdit (a well-featured word processor).

On the commercial software front, Microsoft's Office (familiar to PC users) is one of the best selling office suites for the Mac, although many prefer to stay loyal to its main competitor, ClarisWorks, which originates from the Apple-owned Claris. Microsoft also ports some of its multimedia/educational titles across to the Mac, the most famous being the excellent Encarta multimedia encyclopedia. In terms of artistic software, the Mac is perhaps the best served computer of all, with Photoshop, Illustrator and After Effects (respectively, photo-editing, drawing and special effects, all from Adobe), Macromedia's Director (a powerful multimedia-authoring tool), Fractal Painter (a 'natural' painting tool) and Strata's Studio Pro (for 3D modelling, animation and special effects).

Windows software can, however, be run on a high-end Power Mac, by virtue of Insignia's SoftWindows. This gives 486-level performance. If you need more powerful PC performance, Apple sells a range of PC-compatibility expansion cards based around Intel processors such as the 100MHz Pentium. You can switch between Mac and Windows using the keyboard. It's not quite the same level of performance as a genuine PC, since Windows applications and files are stored as DOS-compatible files. But it does allow Mac users to benefit from the huge pool of software that exists for the PC; the best of both worlds, if you like.

Until fairly recently, Apple was the only manufacturer of Macintosh hardware, and it must be said that it was rather expensive. In 1994 – ten years from the launch of the original Mac, Apple decided to licence Mac technology (the MacOS, motherboard designs, BIOS software and custom ICs) to third parties, presumably to counter the threat from the more popular Wintel platform. Apple has suffered badly over the last few years, returning a loss. Some say that Apple may turn into a technology licensing company, like its ARM processor offshoot. Some fear the worst. At the CeBIT trade show, the big news was that Apple was 'pulling out of desktop hardware'. The truth turned out to be somewhat different; Apple was dropping the 'Performa' name from its lower-end products, in favour of its Power Macintosh branding. Others reckon that Apple will produce its own Wintel clone, something that an Apple spokeswoman wouldn't confirm or deny.

Today, a number of companies – 13, in fact – are (or will be) producing all variety of Macintosh-compatible 'clone' computers, from PPC603e-based home machines to multiple-604e models destined for 3D design studios (note that the 604e chip is 50% faster than a 603e of the same clock speed). All will run the same software that Apple's PowerMacs can. Interestingly enough, the latest 7.6 release of MacOS drops references to the word 'Macintosh' in favour of 'computer', presumably to acknowledge the clone manufacturers.

Anti-Mac web site.

Mac enthusiasts' web site.

The list of Mac clone producers includes Umax (the producer of the first sub-£1,000 Power PC-based machine, pitched at home users who would normally consider a Pentium PC), Motorola, Power Computing and Mac add-on supremos Daystar. Daystar currently produces the most powerful and expensive Mac-based computer, which combines a total of four 180MHz 604e processors. The latest Macs, such as the 9500 and 9600 models benefit from pluggable processor cards, which makes upgrading easier. It is possible to upgrade a single-processor Mac into a dual-processor model, for example.

It is interesting to learn that DayStar's multiprocessing architecture, nPower, has been licensed back to Apple, and is currently in use within the dual-processor 9500/180MP and 9600/200MP models. At the lower end, clone Macs use various techniques to get costs down. Motorola's machines use standard PC mice, keyboards, ATAPI CD-ROMs and IDE hard disks. The core technology responsible for this, a motherboard design known as Tanzania, was co-developed by Apple and Motorola. Motorola envisages a standard-size motherboard that would fit in a PC case. The bottom-end machines from Umax and Apple also make use of IDE disks. Despite this shift to IDE, all Mac-compatible machines still have that 25-pin connector for the attachment of SCSI peripherals.

Although new versions of MacOS are under development, the next generation of Apple's operating system is codenamed Rhapsody. It will use many elements of the NeXTSTEP operating system, developed by the NeXT Technologies organisation that was bought up by Apple late last year. Ironically, NeXT was founded by Apple's co-founder, Steve Jobs. There were rumours last year that Apple was to buy Be, a start-up founded by another ex-Apple employee. It seems that Apple was looking for different approaches to operating system design, even if it meant buying out the company responsible.

Rhapsody will release in beta form to software developers later on in the year, and will be commercially available some time in 1998. Although Apple says that it is investigating the possibility of making Rhapsody running on older 680x0 Macs, there is the distinct possibility that it will be the first Macintosh operating system that will require a PowerPC-based machine. We may also see Rhapsody ported to another platforms, including, perhaps, Intel. Rhapsody is, like multiple-platform operating systems such as Unix, based around a microkernel – the basic 'guts-level' interface between the operating system and the platform's hardware.

According to Apple, Rhapsody's user interface will combine elements from both MacOS and NeXTSTEP, but will be closer in look and feel to the Finder that current Mac proponents use and love. It will certainly include support for all of the existing Mac benefits, such as genuine plug and play. In addition to handling new applications that take advantage of its new features, Rhapsody will also run most existing MacOS programs. Above the microkernel is OpenStep – the part of the operating system borrowed from NeXT.

OpenStep is the component that will support pre-emptive multitasking, protected memory and the other elements expected of a decent desktop operating system. Rhapsody will also provide support for Apple's existing multimedia technologies, such as QuickTime (video and audio), and QuickDraw (3D capabilities). A Java virtual machine will also be included for Intranet and Internet applications; it is interesting to note that the latest release of OS/2 also includes this facility. Despite the rumours being bandied around, it does seem as if the Mac and Apple do have a future that extends into the next millennium.

Review – Apple Power Macintosh 9500/132

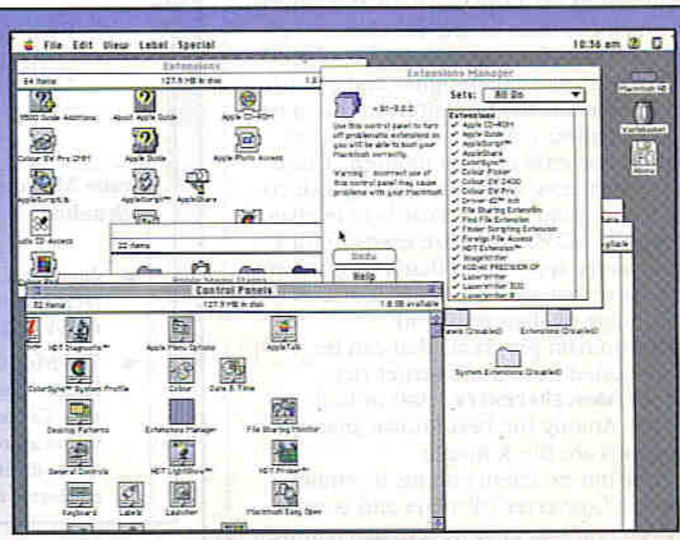
Until the recent introduction of the 9600 series, the 9500 was Apple's top machine. The 9500 series, available in 132, 180, 200MHz and dual-180MHz PPC604e variants, are still available from some retailers at discounts that make them very attractive when compared with some of the clones. I have seen one retailer sell a 9500/132 for around £1,500 (+VAT), which represents good value. The 9500 series is aimed very much at multimedia designers and publishers, and it has proved itself to be a reliable workhorse in server applications (many are using it as a Web server).

The multiplicity of processors is made possible through the use of pluggable processor cards; it is possible to upgrade the 132MHz model to the dual-processor 180MHz model, should you decide that the extra power is necessary. It is interesting to learn that some of the latest PC motherboards use pluggable processor cards, rather than the ZIF sockets of old; this will be done to make upgrades easier, and give the motherboard some kind of protection against obsolescence.

The mini-tower case is of an attractive design, and has a spare drive bay. It will, however, only accommodate a single 3·5in. drive and then again only if the appropriate adaptor is purchased. The 9500/132 includes 16M-byte of fast EDO RAM that is expandable to 768M-byte (there are 12 sockets). The higher configurations offer 32M-byte of RAM. Memory takes the form of dual in-line memory modules (DIMMs), which are of a different design to the PC-type 72-pin SIMMs that look so similar.

Sadly, the case design is such that getting to the memory sockets is

Photoshop on Mac.



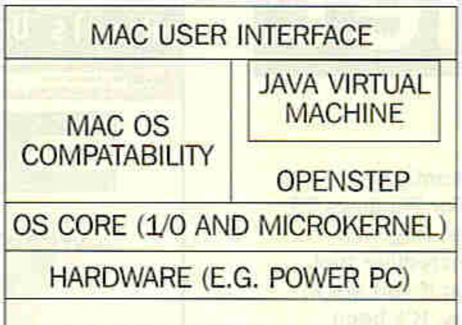
Apple Mac desktop.

extremely awkward and requires you to completely remove the motherboard. This is stupid – you have to completely disassemble the machine; a far cry from previous-generation machines like the 7500. Apple recommends that upgrading the memory is left to the dealer. Upgrading the processor card is much easier.

Another important provision is the 512k-byte (expandable) of Level 2 cache that's fitted. Some of the lower-end Macs don't ship with cache, although an upgrade socket is available. Cache can make things considerably faster; unfortunately, cache memory for such machines is very expensive (compare this with the PC situation). The 9500/132's drive complement is a SuperDrive (high-density) floppy, a 4-speed CD-ROM (8-speed in higher configurations) and a 2G-byte hard disk. Both CD-ROM and hard disk are attached via a Fast SCSI-2 interface.

A Mac-standard 25-pin SCSI interface is also available. Other socketry includes Ethernet (in the form of 10-Base-T and AAUI terminals), 16-bit audio in/out, high-speed serial ports (for printer and modem) and an ADB port for keyboard, mouse and other peripherals. There are a total of six PCI slots, one of which is occupied by a reasonable (but hardly leading-edge) ATI graphics card equipped with 2M-byte of VRAM (upgradable to 4M-byte). At the moment, an 8M-byte Matrox Millenium is being used in the review machine to excellent effect.

Although a mouse is supplied, a keyboard and monitor are not. We used



Rhapsody Architecture.

the Apple Extended keyboard, which has a decent enough feel. The monitor is Apple's Trinitron-based (the company has had a long relationship with Sony) 1710, a high-quality 17in. model. We found that the monitor works well at higher resolutions; at lower resolutions, linearity is quite poor (as we found when using it with a PC in DOS mode, and at 640 × 480 Windows resolution). The 1710 communicates with the Mac using the ADB port, as discussed earlier.

Performance of the 9500/132 is of a very high standard. We found that Photoshop rendering operations run considerably faster on the 9500/132 than they do on a Pentium 133 with twice the memory. Other applications, such as word-processing, don't fare quite as well. Nevertheless, this is still a powerful machine that will serve the creative community well for some time, thanks to its upgrade potential.

- 132MHz PowerPC 604e processor (with in-built floating point processor and 64k-byte cache), upgradable.
- Runs both 680x0 and PowerPC-accelerated applications.
- 512k-byte Level 2 cache.
- 2 high-speed RS422 serial ports compatible with LocalTalk, printers and modems.
- 4 × SCSI CD-ROM.
- 2G-byte SCSI hard disk.
- External SCSI port (5M-bps; Internal SCSI bus 10M-bps).
- 16M-byte RAM (expandable to 768M-byte); 12 DIMM sockets (10 free).
- 5 free PCI 2.0-compliant expansion slots.
- 1 free 3·5in. drive bay.
- 16-bit audio input/output with support for text-to-speech and speech-to-text.
- In-built Ethernet (10BaseT/AAUI) with Open Transport (TCP/IP, AppleTalk) support.
- ADB bus for keyboards, mice, etc. Mouse supplied.
- Support for internal GeoPort modem (v.34 and 14.4k-bps fax, plus speakerphone/answerphone capability).
- Real-time clock/calendar.
- 2M-byte QuickDraw accelerated graphics card (expandable to 4M-byte); capable of 24-bit colour at 1,152 × 870 resolution.
- MacOS version 7.5.2.
- Power requirement (computer only): 225W, 100 to 240V, 50/60Hz.
- Size (WHD): 196 × 430 × 400mm.
- Weight: 12·7kg.

Table 1. 9500/132 specification.

Contact

Apple Computer (UK) Limited, 6 Roundwood Avenue, Stockley Park, Uxbridge UB11 1BB. Tel: (0800) 127753.

Internet Sources

http://www.euro.apple.com.

HTML Editing Updates

A couple of nice HTML editors have recently been updated and are worth mentioning. For Windows 95 users, Adobe has just announced that PageMill version 2 is about to ship. PageMill is an incredible tool, and you should give it serious consideration if you are in the business of having to create Web pages. It's been available for a while at this version in Mac format, and (with Macintosh computers being used to produce around two-thirds of all Web sites in the world) has a large following already in Web site generation circles.

The Windows 95 version brings all the aspects Mac users have enjoyed already for so long: full WYSIWYG control of pages, drag-and-drop import of text and images, scalability, you name it, PageMill handles it. You only have to use it for a few minutes to see its beauty. Just drag in borders to create frames – live on-screen – drag in images, and Bob truly is your uncle. It's the best thing since sliced bread. Adobe's Web site at `http://www.adobe.com` has the gen.

Not forgetting Mac users (who've had it their way for so long with PageMill), there's a brand new version of PageSpinner out (version 2) which has several new features. PageSpinner is a shareware HTML editor, which doesn't profess to be WYSIWYG in any way – you have to preview your pages in a Web browser as you construct them – but it does have a certain power which most other HTML editors fall way short of.

New PageSpinner features in the new release include full AppleScript support which allows you to automate tasks. It's now an open architectured program, which allows the use of plug-in extensions to adapt the program to suit your way of working. And, a really powerful new feature, you can designate special files (called Include files) which appear in several places in your pages. You can adapt or edit an Include file and the HTML pages the Include file is called in are changed automatically. Checkout the PageSpinner Web site for details and a download: `http://www.algonet.se/~optima/pagespinner.html`.

CompuServe Moves Into the Fast Lane

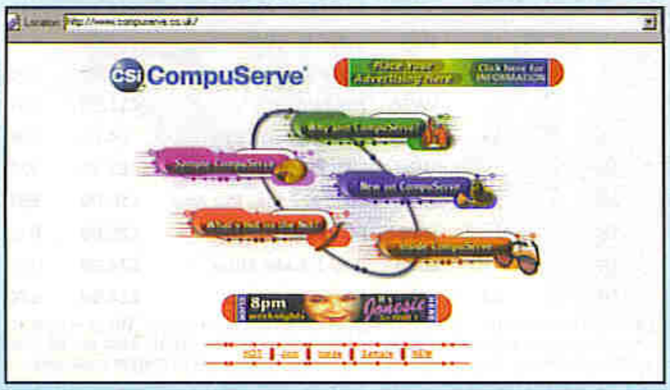
CompuServe has completed the upgrade of its global network to support 33·6k-bps dial-up access on an international scale. Members can now access CompuServe content and the Internet at modem connection speeds greater than 28·8k-bps, in most cases for the cost of a local call.

The company is also conducting high-speed 56k-bps modem tests. CompuServe has tested the US Robotics proprietary technology, and has already begun offering a service based on this technology in the US.

The company is also evaluating the K56Flex protocol, developed by Rockwell International Corporation and Lucent Technologies.

For further details, check: **www.compuserve.co.uk.**

Contact: CompuServe, Tel: (0118) 9525555.



Rivals Unite in NC War

Netscape and Oracle have joined forces to meet the threat posed by Microsoft. The two companies are to merge their affiliate network computing divisions. The new company will retain Oracle's NCI brand and is set to develop software applications for open standards-based network computers and other Internet appliances that will be used in homes, businesses and schools.

Navio brings the branding power, innovative approach and technology leadership of Netscape to consumer electronics manufacturers. NCI, owing to the expertise of its parent company, Oracle, in sophisticated software management products, has begun licensing a family of software products that help companies establish large, simple and inexpensive networks of network computers for use in both business and consumer settings.

For further details check: **www.nc.com.** Contact: NCI, Tel: +1 415 631 4600.

Centre for Cyberculture

A US-university student has developed a Web site at **otal.umd.edu/~rccs** for the academic study of cybercultural issues. The Resource Centre for Cyberculture Studies has a variety of areas for teachers and students to explore.

Solomon Stamps on Internet Viruses

Dr Solomon is set to stamp out Microsoft Word macro viruses for good, with the latest version of its Anti-virus Toolkit. This new form of macro virus is highly infectious and is spreading far quickly than any other type of virus. It is transmitted whenever an infected word-processor document is shared or exchanged.

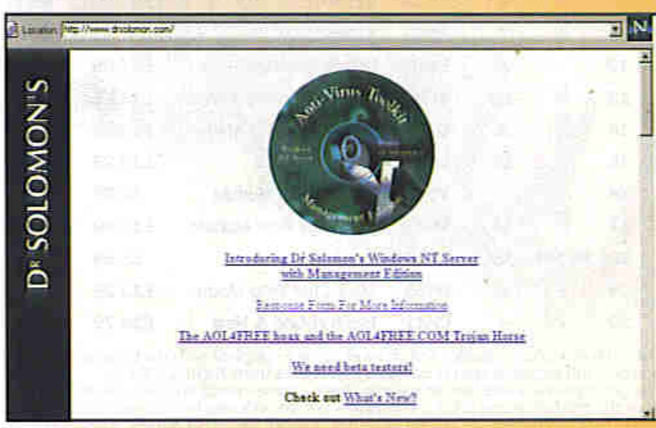
The virus embeds itself within Word documents rather than executable applications. Consequently, conventional anti-virus tools have been unable to stop its spread. To date, viruses have always been embedded in application files rather than user data such as a word-processor, spreadsheet or database data file.

Computer viruses, particularly viruses transmitted through attachments to e-mail and in downloadable files, are increasingly prevalent on the Internet and can hurt consumers' computers. In one of many recent studies about virus threats, Ernst & Young/ Information Security Survey reported that 62% of all losses of business computer information are caused by computer viruses.

Dr Solomon's Advanced Macro Heuristic Analysis – part of the Dr Solomon's Anti-Virus toolkit – can detect over 80% of new, unknown macro viruses, by examining the macros contained within Microsoft Word documents for virus-like code.

For further details, check: **www.drsolomon.com.**

Contact: Dr Solomon, Tel: (01296) 318700.



CompuServe Goes Local

CompuServe has written to all its UK members this month to advise them to switch to a new national local call access number, (0845) 080 1000. Local access numbers are being phased out at the end of June.

CompuServe introduced the 0845-access number last August as part of its ongoing network upgrade and expansion. Through the use of a Virtual Point of Presence (VPOP) solution, this now enables users to dial one local rate number irrespective of where they are in the UK.

Martin Turner, general manager at CompuServe UK, told *Electronics and Beyond*, "As well as offering access at local call rates, this number has greatly increased capacity, making it even easier for you to get online and now supports access for all modem speeds up to and including 33·6k-bps."

If your telephone service is provided by British Telecom, you could add the number to your Friends and Family selection for even greater savings.

For further details, check: **www.compuserve.co.uk.**

Contact: CompuServe, Tel: (0118) 9525555.

Tamagotchi Hatches on AOL

Tamagotchi has landed! Bandai and AOL have joined forces to create an online care centre area that will help you nurture your new little creature as well as get in touch with other new 'parents'.

Tamagotchi – which means 'loveable egg' in Japanese – is a keyring-sized plastic egg with an LCD screen that shows the birth, growth and, sadly, inevitable death, of the little key ring companion.

The Tamagotchi is almost as demanding as a real pet – it needs feeding, amusing, exercising, nursing and cleaning – and AOL is here to help you do this. And all this loving attention brings its own reward when little Tama develops his or her own unique personality, but if neglected, it will fly off to a virtual heaven and you can hatch out a brand new one.

Tamagotchi is hugely popular in Japan, with over 5 million sold, 7 factories devoted to their production and a whole sub-culture has grown up surrounding the little fellow, including crèches and bereavement counsellors.

UK stocks went on sale at the beginning of May and sold out in a matter of hours. And the AOL/Tamagotchi area has already received hundreds of e-mails asking for a list of suppliers and more information.

For further details, check: **www.aol.co.uk.**

Contact: AOL, Tel: (0800) 279 1234.

European Search Engine Partners to Extend User Reach

EuroSeek's 40-language search capability is now available direct through the Microsoft home page. EuroSeek's service is a permanent fixture under the 'international' listing on the search section of **home.microsoft.com,** one of the most popular sites on the Web with an average daily hit rate of 75 million.

EuroSeek's service, which launched in March, provides a pan-European search-engine, offering search capabilities in 40 languages. The EuroSeek engine is increasingly pitching itself against existing US-based solutions such as Yahoo at **www.yahoo.co.uk,** InfoSeek at **www.infoseek.com** and AltaVista at **www.altavista.com.**

As well as providing the unique searching capabilities to the European market, EuroSeek is focused on the vast potential for advertising on the Internet. According to Forrester Research, Web advertising revenue is set to reach at least $4 billion by 2000. A substantial proportion of this revenue will be raised through high-traffic sites such as search engines.

For further details, check: **www.euroseek.com.**

Going Up . . .

Internet users who want more speed up their sleeves and more power to their elbows naturally look to ISDN as a way to upgrade from sluggish modem connections. ISDN (Integrated Services Digital Network) allows data throughput up to 128k-bps, which is significantly faster than anything modems can handle now (or in the future, too).

Currently, however, BT's costs to install and connect a computer to its ISDN service are something of a letdown. The minimum charge of £199 plus VAT is enough to make you think a modem's not so bad after all. Think again, though. Electronic Frontier **(http://www.electron.com)** has a deal at the moment which connects users to ISDN for free after purchasing one of the company's ISDN adaptor cards. And, as the cards are priced from as little as £99 plus VAT (less than the price of a modem running at around one third of the speed, after all), there's never been a better time to get an ISDN connection.

Going Down . . .

If you thought that the Internet was uncrashable, think again. On April 24th, there was a major Internet problem, which resulted in the whole thing being caught with its trousers down around its ankles. The story makes interesting reading.

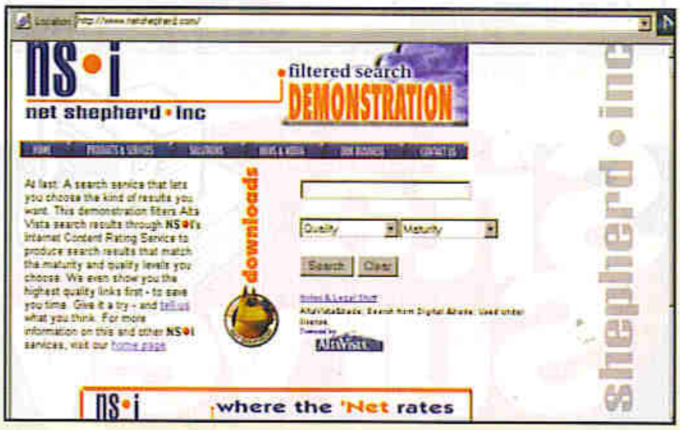
There are some 45,000 routes on the Internet, which usually are sufficient to hold all the Internet's traffic, even on busy days at peak times. True, these bung up and traffic goes rather slow at the worst of the peak times, but the whole thing hangs together nevertheless. Anyway, it appears that a single network in Florida, USA, started to advertise routes which did not belong to it to other networks. At the peak of the problem, they were actually advertising in excess of 30,000 of these routes.

In effect, this one organisation was claiming to own two-thirds of the entire Internet. It's not yet clear whether this was due to human error or equipment failure. What we do know, though, was that the Internet at large started routing data packets incorrectly and connections failed over much of the world.

Fortunately, the situation was quickly detected and some 15 minutes after the start of the incident, Internet service providers around the world were refusing to accept routing information broadcast from the errant source. But, by that time, much damage was done and it took considerable time for the Internet to re-establish the valid routes and return to normality. Spectacular fun.

Additional information can be found at: **http://www.news.com/News/Item/0,4,10083,00.html,** or **http://www.wired.com/news/technology/story/3442.html.**

Net Shepherd and AltaVista Offer Filtered Web Search



Net Shepherd and AltaVista are set to give millions of Internet customers a fast and powerful Web search and content filtering service.

This agreement is based on Net Shepherd's Internet rating and review database – the largest of its kind in the world for English language content – and the state-of-the-art AltaVista Search service.

Net Shepherd has rated 97% of the English language sites on the Internet as indexed by AltaVista Search. Users can modify their searches with one of six age-appropriate categories and a unique five-star quality review.

Net Shepherd is also building and managing customised ratings and reviews databases, powered by AltaVista Search, where businesses and organisations can rate, review and filter content according to their organisation's perspective on Internet content.

For further details, check: **www.netshepherd.com** and **altavista.software.digital.com.**

ISPs in No-Win Situations

Internet service providers (ISPs) are increasingly struggling to make a profit using a flat-rate charging model. And now, ISPs are faced with the cost of upgrading their network infrastructures to cope with 56k-bps.

It's likely to cost ISPs a considerable amount of money to upgrade their technology and access equipment to the new standard. But it gets worse – because industry standards have not yet been set and probably won't be for another 18 months. This means ISPs that upgrade run the risk of having to spend even more down the road.

The confusion stems from the arrival of two separate and incompatible 56k-bps modem technologies – X2 from US Robotics and K56flex from Lucent Technologies and Rockwell International.

@Internet

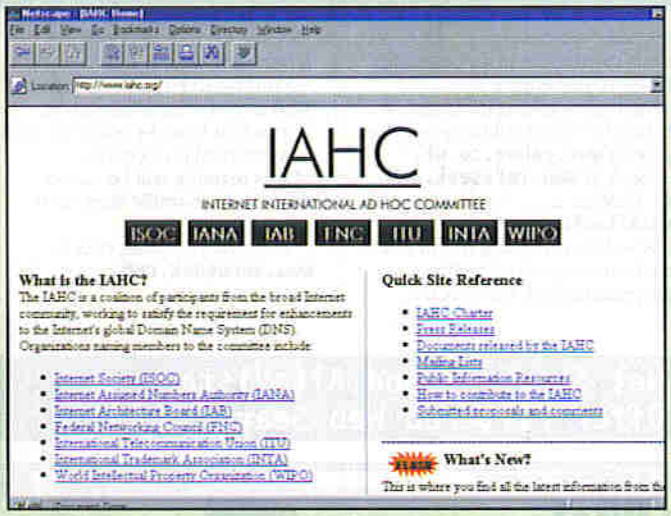
Internet Registration is Not Unanimous

Fifty-seven companies and organisations, including Digital Equipment and MCI, have signed the proposal put forth by the International Ad Hoc Committee (IAHC) to create seven new top-level Internet domain names and appoint 28 new name registrars.

An additional 23 have indicated their willingness to sign, but a number of other companies, including AT&T, IBM and PSINet, are either still considering the proposal or have voiced their opposition to the plan.

In February 1997, the IAHC announced the creation of seven new generic Top Level Domains (gTLDs) and the establishment of additional registrars to conclude the chartered monopoly currently administered by Network Solutions.

For further details, check: **www.iahc.org.** Contact: IAHC, Tel: +1 703 648 9888.



Internet in the Sky

Boeing is to invest $100 million along with Microsoft chairman, Bill Gates, in Teledesic, a US start-up that is extending the reach of the Internet skyward. Using a constellation of several hundred low Earth orbit satellites, Boeing and Teledesic will create the world's first satellite network to provide affordable, global 'fibre-like' access to telecommunications services such as broadband Internet access, video-conferencing and interactive multimedia.

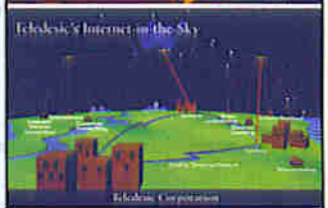
The announcement comes on the heels of the Federal Communications Commission's approval of Teledesic's license to build and operate the advanced, two-way telecommunications network. Teledesic had stated previously that the FCC license was a necessary first step before entering into commitments with industrial, service and investment partners.

The Teledesic Network will provide switched, broadband network connections through service partners in host countries – from the largest urban centres to the most remote villages. The network emulates the most famous distributed network, the Internet, while adding the benefits of high-quality service and location-insensitive access. Service is targeted to begin in 2002.

Teledesic's satellite constellation will orbit about 50 times closer to Earth than traditional geostationary satellites. The Teledesic Network's low orbit eliminates the long signal delay normally experienced in satellite communications and enables the use of small, low-power terminals and antennas, about the size of direct broadcast satellite (DBS) dishes.

For further details, check: **www.teledesic.com.**

Contact: Teledesic, Tel: +1 425 602 0000.

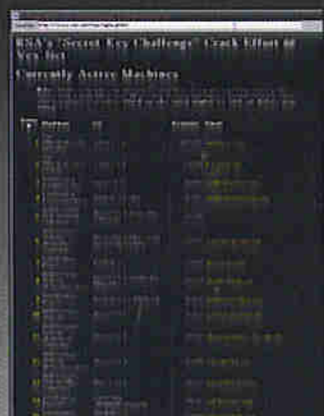


Site Survey

The month's destinations

Music and multimedia fans should trip the light fantastic along to: **http://www.emination.co.uk,** where you'll get a glittering array of the latest and greatest in the music scene today. It's based on the music and lifestyle magazine *Sleaze Nation*, and there's news, reviews and much, much more. Now you don't need to club it – just stay at home and don your anorak in your front room!

Computer users worried about the Millennium Bug syndrome and their computers should visit: **http://www.year2000.com/** to see the latest news on the topic. It's not that 2000 is a long way away (in computer terms, it's at least a whole generation), and it's not that we shouldn't all be worried about it – it's just that one of the main contributors to the site, Peter de Jager, has bought himself a cottage in the depths of Ireland so that he can hibernate in it over the 1999/2000 winter, until the technological bomb has gone off and he can come out from the fallout. Makes you think, doesn't it?



If you're into computer hacking and cracking, and fancy your hand at helping out a team of workers crack the 56-bit encryption mechanism (used by the US government), then point your browser at: **http://www.vex.net/rsa/,** where you'll get details of a client program you can run on your computer. The idea is that if a group of amateurs can crack the code, then professional crackers (read, international governments), with limitless budgets, will certainly be able to do it. Interestingly, if you look at the table of machines currently participating in the crack at the time of writing, you'll notice that a bog-standard, off-the-shelf 200MHz Macintosh is in front of an Intel Pentium Pro running at its flat-out speed of 233MHz, and to get even *that* speed, the Pentium Pro has to use FreeBSD – not Windows – as its operating system. In fact, the only Pentiums to beat the Mac have to be dual-processor machines, neither still running Windows. And yes, there is a recently launched 300MHz Mac – so just wait till it's on the list!

ELECTRONICS and Beyond

in the pipeline

Don't miss another great assortment of entertaining and easy-to-make projects and essential electronics information aimed at the novice constructor.

Simple Iambic Keyer

Speed up your Morse code communication with this simple low-cost iambic keyer designed by David Silvester.

PLUS The Show Must Go On by Alan Simpson takes a look behind the stage at London's National Theatre to inspect the technology in control of lighting effects.

Video Cameras by Reg Miles focuses on how they work and zooms in on the upcoming digital camera technology.

Part 7 of What's in a Name? by Greg Grant discusses which was the first ever 'real' electrical component and who invented it.

Stephen Waddington starts a new series investigating the Digital Economy, and the first part looks at the revolution in magazine production.

The final part of Special Audio Processing ICs by Ray Marston looks at two remote-controlled audio tone/volume ICs and at the MF10C filter chip.

Thunder and Lightning –

The Other Extreme

This intriguing project by Keith Garwell describes the construction and operation of equipment capable of detecting the minute electrical currents omnipresent in our atmosphere – not just during thunderstorms.

Issue 117 on sale Friday 1st August

ELECTRONICS and Beyond

BRITAIN'S BEST MAGAZINE FOR ELECTRONICS

Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering, side cutters, pliers, wire strippers, and screwdriver). Test gear not required and no setting-up needed.

Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

Average. Some skill in construction or more extensive setting-up required.

Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked at Maplin can be easily obtained in a number of ways: ❶ Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, telephone (01702) 554002. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance; ❷ Write your order on the form printed in this issue and send it to Maplin Electronics PLC, P.O. Box 777, Rayleigh, Essex, SS6 8LU. Payment can be made using Cheque, Postal Order, or Credit Card; ❸ Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554000; ❹ If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (01702) 552941. If you do not have a customer number, telephone (01702) 554002 and we will happily issue you with one. Payment can be made by credit card; ❺ If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place your orders directly onto the Maplin computer 24 hours a day by simply dialling (01702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system; ❻ Overseas customers can place orders through Maplin Export, P.O. Box 777, Rayleigh, Essex SS6 8LU, England; telephone +44 1702 554000 Ext. 376, 327 or 351; Fax +44 1702 554001. Full details of all the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Internet

You can contact Maplin Electronics via e-mail at **<recipient>@maplin.co.uk** or visit the Maplin web site at **http://www.maplin.co.uk**.

Prices

Prices of products and services available from Maplin shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%). Prices are valid until 28th February 1997 (errors and omissions excluded). Prices shown do not include mail order postage and handling charges. Please add £2.95 to all UK orders under £30.00. Orders over £30.00 and MPS Account Holding customers are exempt from carriage charges.

Technical Enquires

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics and Beyond*, the Technical Sales Dept. may be able to help. You can obtain help in several ways: ❶ Over the phone, telephone (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays; ❷ By sending a facsimile, Fax (01702) 554001; ❸ Or by writing to Technical Sales, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Don't forget to include a stamped self-addressed envelope if you want a written reply! Technical Sales are unable to answer enquires relating to third-party products or components which are not stocked by Maplin.

Maplin 'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini-Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service return the complete kit to: Returns Department, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Enclose a cheque or Postal Order for the servicing cost (minimum £17) as indicated in the current Maplin Catalogue. If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost, plus parts.

TECHNOLOGY WATCH

with Martin Pipe

The cellphone has certainly come far in the last few years. They started out as bulky and power-hungry analogue carphones that were expensive to install and run. In a recent issue of Electronics and Beyond, we examined the StarTac from Motorola **(http://www.mot.com)** which is still the world's smallest digital cellphone. At the time, it was insanely expensive – we are now pleased to report that the StarTac, in the form of the new StarTac 70 model, is now available at a much more down-to-earth price.

Much of this has to do with increased competition – Sony **(http://www.sony.com)** and Ericsson **(http://www.ericsson.com)** have recently introduced miniature lightweight phones, in the form of the CMD-Z1 and GF788, respectively. All sell for around £200, with airtime contract. The Sony model deserves a special mention, because of its wonderfully intuitive user interface. A thumbwheel on the corner of the phone allows menus and numbers to be selected.

These three phones are digital models conforming to the GSM (Global System for Mobile Communications) standard. Today, digital is now de rigeur – the market is pushing it this way. The analogue (ETACS) cellular standard is more bandwidth-hungry, and the unscrambled signals can be intercepted by scanner enthusiasts. The networks would like everybody to move over to GSM so that the spectrum can be freed to accommodate more digital users, and the threat of fraudulent activity such as 'chipping' eliminated – at least, for now. The reduction in the number of UK analogue users has allowed part of the old analogue band to be reallocated to GSM. Digital satellite phones are set to play an important role in future mobile communications – but for now, they are expensive, bulky and require manually setting up (finding the satellite).

GSM services, run by Vodafone **(http://www.vodafone.co.uk)** and Cellnet **(http://www.cellnet.co.uk)** in the UK, tend to be a popular choice among business users and wealthy (and well-travelled) lifestyle users. The UK PCN services, run by Orange **(http://www.orange.co.uk)** and one2one **(http://www.one2one.co.uk),** have been well-received among consumers – particularly those in bigger towns and cities, where coverage is good. PCN has now been re-named, at least by Orange, to GSM1800.

Indeed, PCN is virtually identical to the original GSM service, at least, in terms of protocol. The main difference lies in frequency; while GSM works at around 900MHz, PCN/GSM1800 operates at 1,800MHz.

Digital services support 'roaming', in which your phone can be on other networks if your 'home' one isn't available, the calls on this network being charged to your existing account. The most common application of roaming is to use a mobile phone abroad. GSM1800 roaming agreements are few and far between, although I will shortly discuss a new technology that will change this. Orange do, however, have agreements with GSM1800 services in Germany, Switzerland, France and Hong Kong. In comparison, tens of GSM networks in mainland Europe, Russia, the Middle East, South Africa, Australia and parts of the USA currently have roaming agreements with Cellnet and Vodafone. There are now 44 million GSM subscribers worldwide, according to the international organisation, GSM MoU **(http://www.gsmworld.com).**

GSM coverage Stateside is limited to major cities along the East Coast, such as New York and Washington. The USA employs a different (and higher-frequency) standard for its GSM implementation, known as GSM PCS1900, which is incompatible with the existing variants of GSM. With at least three incompatible implementations, GSM is clearly not as global as it could be. Cellnet and Vodafone offer schemes whereby one of these phones can be hired at an US airport, and the subscriber-specific SIM (Subscriber Identity Module) card transferred from the user's own GSM phone. The advantage of this approach is that the numbers stored in the user's SIM card can be accessed from the leased phone.

Most of cellulared America uses an analogue system known as AMPS (Advanced Mobile Phone System), upon which our own ETACS is based. Cellnet offers GlobalRoam, a less than elegant – at least, from a technical perspective – but nevertheless ingenious method of ensuring that you can keep in touch while you're in the USA. An AMPS phone is leased to subscribers just before they set off. Cellnet is notified when that person arrives, and all calls to his (or her) GSM number are forwarded to the AMPS phone. Analogue Cellnet subscribers, and those who don't subscribe to Cellnet at all, can also use the service, although they are allocated a temporary number (and separate bill) for the duration of the trip.

Another way of getting round the various standards is to use a dual-mode handset, which will allow roaming over two different digital networks. Vodafone is currently trialling such a handset that will work on both GSM900, and CDMA – one of the American digital standards. The first commercially available dual-mode handset, the data-compatible Motorola 8800 (also badged by Orange as the mr601) will handle not only the GSM1800 standard, but also the original GSM900 standard.

Orange subscribers should hence be able to enjoy the same roaming benefits currently enjoyed by Vodafone and Cellnet users. Orange currently offer the mr601 for a heavily-subsidised price of £150 – the phone is actually worth closer to £600 – whether you're a new or existing subscriber. The new SIM card supplied with the phone will allow roaming between their network and those on GSM. Handy if you want to make a call in areas in which UK Orange coverage is limited but GSM is good, or want to use your phone with GSM networks abroad.

The photograph here shows Fujitsu's neat little 2000 mobile fax machine, which can be used with any PCMCIA modem – including data cards that hook up to GSM 900/1800 mobile phones. It's been designed as a cost-effective and compact alternative to a notebook computer. Unlike a notebook, the Fujitsu 2000 incorporates a flexible A4 scanner for reading paper documents. Note, however, that a computer would allow faxes to be sent directly from the word processor – this alternative is great for handling sketches and handwritten notes prepared in a hurry.

Incoming faxes, and those scanned, can be shown on an LCD screen – there is a zoom facility for enlarging detail. A hard-copy version of the document can be obtained by hooking up a printer via a parallel port – presumably, this could allow the device to transfer data to a PC for disk storage, although no kit is yet available. Up to 30 pages can be stored in the device, which isn't much bigger than a VHS videotape.

The 2000 will also handle e-mail; text entry, as with equipment set-up, involves 'typing' on a rather laborious 'virtual keyboard' that will have people hankering for their PCs. The 528 device is unique, however, and it will be interesting to see how it competes with fax-compatible PDAs such as the Newton, Psion 3a and (more recently) Windows CE models. The Fujitsu 2000's distributor, Hugh Symons Mobile Data, can be contacted on (01202) 718388, or by e-mail as **mobile_fax2000@hughsym.co.uk.**

Martin Pipe welcomes comments and ideas.
E-mail him as: whatnet@cix.compulink.co.uk.

ELECTRONICS and Beyond

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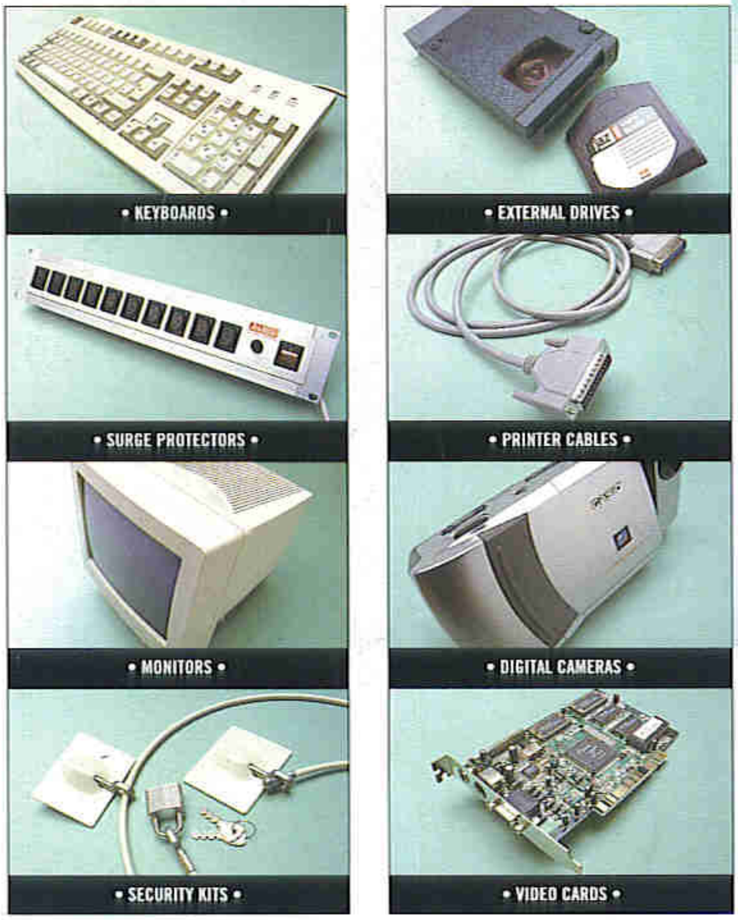
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