ELECTRONICS and Beyond

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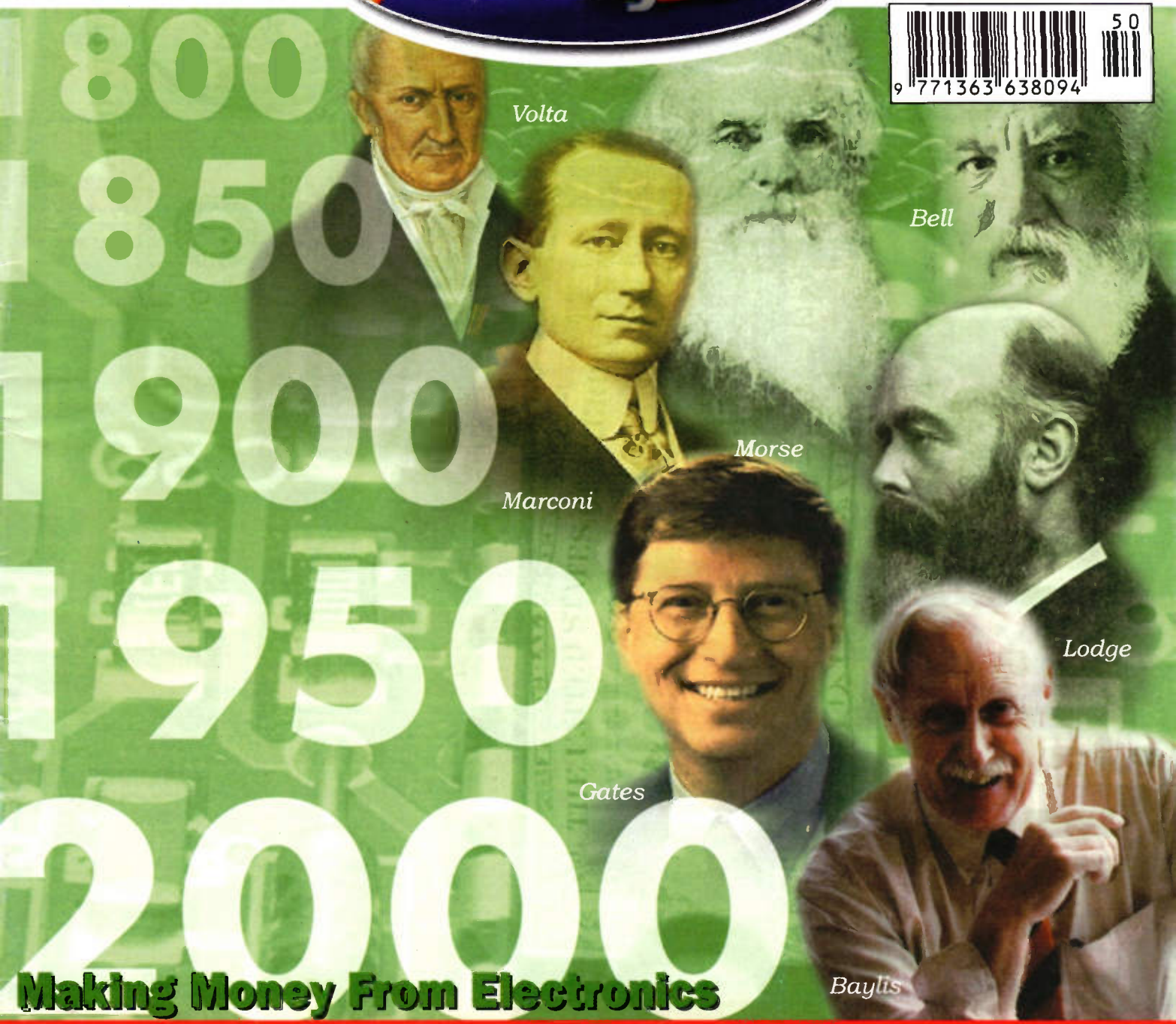
JUNE 2000 NO. 150 £2.65



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- Drill Speed Controller
- 8031 Computer Project

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- Fuzzy Logic
- Research News
- *Early Cancer Detection*

Trevor Baylis - The Modern Day Inventor

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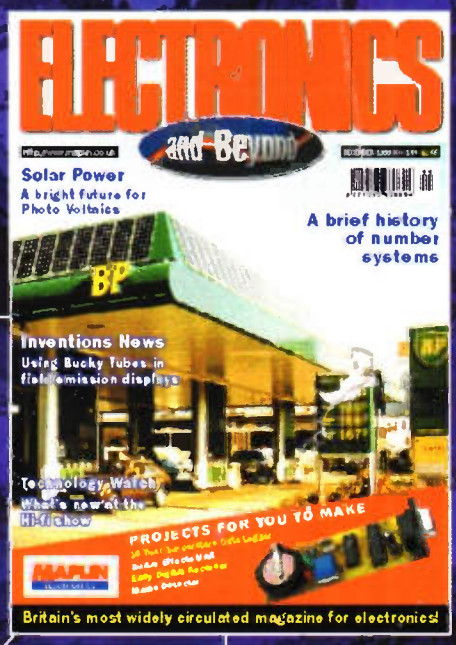

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THE MAPLIN MAGAZINE

ELECTRONICS and Beyond

June 2000 Vol. 19 No. 150

Projects

Features

Regulars

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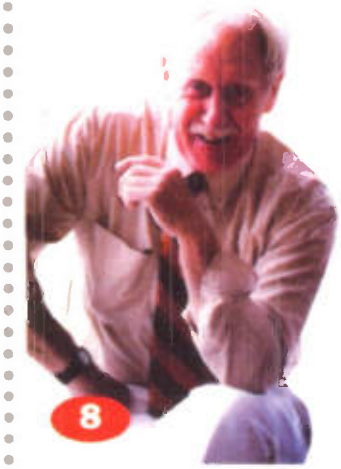

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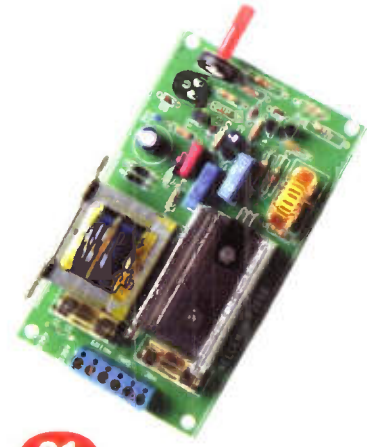

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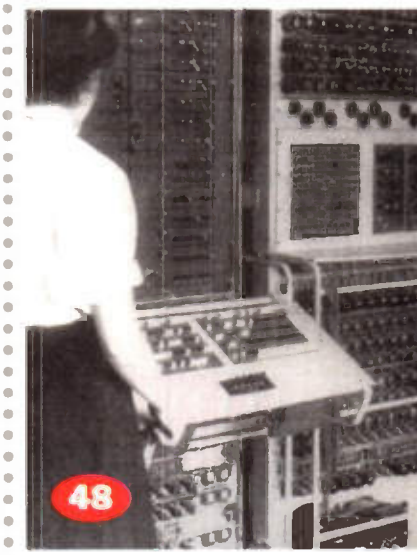

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Editorial
Editor Paul Freeman-Sear BSc (Hons)
Technical Author John Mosely
News Editor Stephen Waddington BEng (Hons)
Technical Illustration John Mosely

Production
Design Layout Artist Jenny Bewers
Published by Maplin Electronics plc., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Tel: (01702) 554155. Fax: (01702) 554001.
Lithographic Reproduction by Planagraphic Studios, 18 Sirdar Road, Brook Road Ind. Estate, Rayleigh, Essex SS6 7UY.
Printed by St Ives (Gillingham) Ltd., Grant Close, Gillingham, Kent, ME8 0QB.

Management
Manager Paul Freeman-Sear BSc (Hons)
Marketing Services Manager Steve Drake

Subscriptions
Maureen Harvey
Tel: (01702) 554155 Ext. 311.

Advertising and Circulation
Maplin Electronics plc., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Tel: (01702) 554155. Fax: (01702) 554001.

UK Newstrade Distribution
Maplin Electronics PLC.

Export Distribution
Comag Magazine Marketing Tavistock Road, West Drayton, Middx, UB7 7QE

ELECTRONICS and Beyond

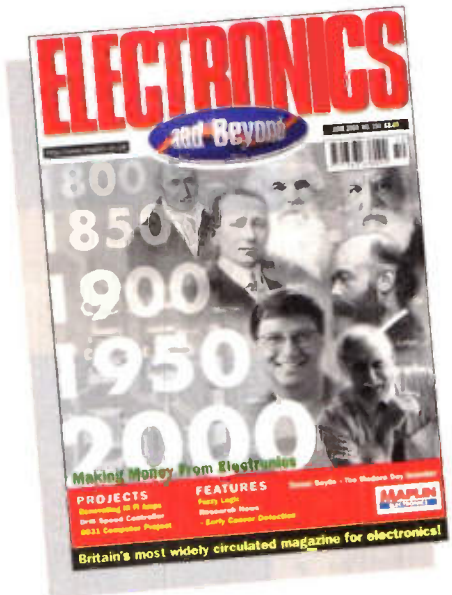
I recently spent a very pleasant and enjoyable day in the company of Trevor Baylis. This very likeable character is best known for his 'clockwork' radio, and perfectly epitomises the old school of inventors. You can read more about the man and his life on page 8.

If Trevor Baylis represents the old school of inventors, then Bill Gates most certainly represents the new school. The Sunday Times newspaper's Rich List for 1999 comprises 1,093 people of which almost 1 in 10 have derived their wealth from computers, electronics, software and mobile phones. A decade previously, there were less than 10 tycoons in these fields. Gregg Grant, in the first part of his article, Money From Electronics recounts the beginnings and the radio rich men. Perhaps there is hope for us yet!

Fuzzy Logic is a topic that many of us may find difficult to understand and to get to grips with. Hopefully, Douglas Clarkson's article Fuzzy Logic: The Basics may help you to understand this 'strange' speciality subject. By keeping the text relatively simple and using practical examples, Douglas has produced an interesting read.

It may seem strange to accept the idea of antique computers, but Mike Bedford in his article Antique Computers Reborn talks about several groups of people who are attempting to create those wonderful, groundbreaking machines of yesteryear.

We hope you enjoy your read in this 150th edition.



Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

NAgency Announces Fixed Wireless Opinion

The Radiocommunications Agency has announced the result of the November 1999 consultation paper on the future of the former Ionica frequencies in the 3.4GHz band. Eighteen responses were received from telecoms operators, service providers, consultants and equipment suppliers. A summary of these is on the Radiocommunications Agency Web site at <www.radio.gov.uk/document/consult/3_4ghz/response.htm>.

The consultation asked whether the service should be used to provide voice or other additional services and whether operators should be licensed to provide services on a national, regional or sub-regional basis?

The majority of responses were in favour of permitting voice and additional services on these frequencies, and the majority of responses that expressed a preference asked for the spectrum to be licensed on a national basis.

For further details, check: <www.radio.gov.uk>.
Contact: Radiocommunications Agency. Tel: (020) 7211 0211.

MGI Licenses Sony for Digital Cameras

MGI has licensed Sony to use MGI PhotoSuite and MGI VideoWave in its new range of high-performance Cyber-shot cameras. The Cyber-shot range includes the DSC-S70, the only digital camera to combine 3.3 mega-pixel resolution with advanced Carl Zeiss optics.
For further details, check: <www.mgisoft.com>.
Contact: MGI Software. Tel: (0800) 973830.

Mobile E-commerce is Over Hyped Says Ovum

Potential mobile e-commerce players should plan to provide genuinely unique and compelling services, rather than trying to excite the market with over-hyped messages about cool new technology. Otherwise they will find it hard to change the habits of an unimpressed buying public. So says a new report, Mobile E-commerce: Market Strategies, by independent research and consulting company Ovum.

"It's debatable whether ordinary consumers are actually demanding mobile e-commerce services right now," said co-author and senior Ovum analyst Duncan Brown.

"It's more a case of suppliers sensing an opportunity to make money, and pushing the idea at them. In fact there isn't much, if any, money to be made in the short term. Business users, rather than the mass market, will be the first serious adopters, but even they won't pay a premium for existing services, which are easier and cheaper to access using the phone or a PC. So if suppliers are to survive and prosper in the long term, their early offerings will have to be very targeted, and very compelling."

The current climate has all the frenzy, uncertainty and ill preparedness of a gold rush, according to the Ovum report.

To avoid investing in applications that sound impressive on paper but do not attract user take-up, Brown has this advice to offer: "Potential mobile e-commerce players have to realise that at this point in time, good substitutes for their services already exist - it's only the delivery method that has changed.

"Old habits die hard. For instance, what's to persuade someone to order a pizza using a mobile application, rather than just picking up the phone? There would have to be a significant value-add to change habits: perhaps discounts, an up to date menu on screen - easy selection of pizzas and toppings with a few key presses - and no waiting for engaged phones or overworked counter staff."

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

Contact: Ovum. Tel: (020) 7551 9031.

iForce Initiative Drives Sun Customers to New Markets

Sun Microsystems has announced the iForce initiative, a far-reaching program designed to provide customers with the relationships and expertise they need to get their businesses dot-commed quickly.

The iForce initiative brings together under one umbrella all of Sun's dot-com programs, products, services and solutions aimed at customers ranging from startups to large enterprises. As part of the announcement, Sun said that it will also invest over £180 million to help iForce partners go to market.

With the launch of its iForce initiative, Sun announced a series of new or enhanced programs aimed at improving and accelerating companies' dot-com processes. These programs include Sun Startup Accelerator, Startup Essentials ISV and e-integrator components, iForce road map, iForces Ready Centers, iForce solution sets and iForce services.

In a related announcement, iPlanet E-Commerce Solutions, a Sun-Netscape Alliance introduced its 100 Days to Dot-Com program, designed to extend coverage of the iForce initiative to new partners and other platforms.

For further details, check: <www.sun.com>.

Contact: Sun. Tel: (020) 7628 3000.

NEWS BYTES

IBM and TDK to Develop Bluetooth products

IBM and TDK are to develop an array of Bluetooth wireless technology solutions for the award-winning ThinkPad family. As part of the agreement, IBM will work closely with TDK to develop Bluetooth technology for IBM's forthcoming line of ThinkPad notebook PCs.

Bluetooth is a short-range wireless communications standard which uses the 2.4GHz radio frequency. It is designed to allow transmission of data within short range providing a low power, low cost link between Bluetooth enabled electronic devices such as computers, printers and mobile phones.

For further details, check: <www.ibm.com>

Contact: IBM, Tel: (020) 8818 4000.

Virtual Stuntman wins Smart Forsight Award

A project to develop ground-breaking, highly realistic computer simulations of human and animal figures has been announced as the national winner of the Smart Foresight Award.

The Interactive Virtual Human project, run by innovative software company MathEngine, will take animation technology far beyond that seen in acclaimed TV programmes such as Walking with Dinosaurs.

By exploiting the concepts of advanced physics in computer animation, MathEngine's system will be able to simulate accurately - and in three dimensions - the complex natural behaviour of living beings.

For further details, check: <www.mathengine.com>.

Contact: MathEngine. Tel: (01865) 799410.

Jaro Components Develops New Resistor Technology

Jaro Components has announced a new technologically-advanced RM, (carbon-ceramic) and RO, (carbon-polymer) series of carbon composite resistors that can replace 1W and 2W carbon composition resistors, which are typically difficult to source.

These new compact resistors offer enhanced surge performance over other resistor types, and provide improved environmental stability in circuitry subjected to high peak power or high energy.

For further details, check: <www.jarol.com/rml.jpg>.

Contact: Jaro Components, Tel: +1 561 241 6700.

NEWS BYTES

Broadcom Aquires 3D Graphics Developer

Broadcom has acquired Stellar Semiconductor, a Silicon Valley developer of 3D graphics technology. The acquisition expands Broadcom's portfolio of graphics and digital video technologies and will enhance Broadcom's cost-effective, high-performance system solutions for set-top boxes, digital TVs and Internet appliances.

Stellar has developed a patented, 3D visual processing architecture called PixelSquirt that offers significant image quality and cost advantages over traditional 3D architectures. Unlike other architectures that render all the hidden and visible pixels in a scene, PixelSquirt renders only the final visible pixels.

As a result, PixelSquirt requires up to 80% lower memory bandwidth and up to 66% smaller memory size than traditional architectures, significantly reducing system video memory cost.

For further details, check: <www.broadcom.com>.

Contact: Broadcom, Tel: (0114) 2464832.

Microsoft Unveils Mobile Web Access Plans

Microsoft is seeking to expand its Web reach by introducing a system that enables wireless appliance users to send and receive e-mail, check stock quotes, and make travel arrangements through the Microsoft Expedia Service.

The company has enlisted Nextel Communications and AirTouch Communications to distribute its new interactive service, named MSN Mobile 2.0. The service, an upgraded version of Microsoft's existing one-way wireless Web service, is set to become available in April.

In a separate deal, Microsoft will collaborate with Qualcomm to use the latter's CDMA technology to develop smart phones and wireless pocket personal computers.

For further details, check: <www.microsoft.com>.

Contact: Microsoft, Tel: (0870) 6010100.

IBM Advance in Nanotechnology

IBM researchers say they have discovered chemical reactions that cause arrays of tiny particles (so tiny that they are 1/20,000th the width of a human hair) to assemble themselves in precise formations. It's an achievement that could lead to the development of terabyte disk drives with more than a hundred times the capacity of typical hard drives today.

For further details, check: <www.ibm.com>.

Contact: IBM, Tel: (020) 8818 4000.

IBM Announces Highest Capacity Hard Drive

IBM has announced two new products that set world records for data storage - the highest capacity hard drive and the greatest real density of any hard disk drive product.

The 7,200 rpm Deskstar 75GXP for desktop computers holds a whopping 75-gigabytes (GByte) of data, more than 10 times the capacity of drives found in the average home PC.

Users will benefit enormously from Deskstar 75GXP's ability to store more movies, pictures, music and business information on their PCs. A single drive can now store the equivalent of up to 18 DVD movies in MPEG3 format, 159 music CDs or the data contained in a stack of documents 20 times taller than the Washington Monument.

These are the first IBM desktop drives to use glass disk platters instead of aluminium. The smoother and more rigid glass disks allow the recording head to read smaller bits of information that are packed more closely together. In addition, glass disks are more stable at higher speeds.

In addition, the new products are the first IBM desktop drives to use load/unload technology. This feature parks the recording heads off the disk surface when not in use, dramatically increasing the amount of shock the drive can handle when not in use.

For further details, check: <www.ibm.com/harddrive>.

Contact: IBM, Tel: (020) 8818 4000.

New Rio Handles Multiple Standards

Diamond Multimedia has launched its third generation Rio digital audio players and announced support from major music labels.

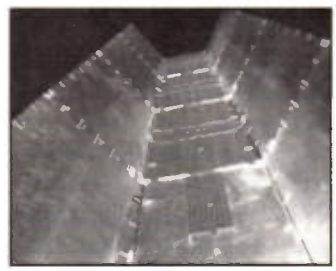
The new Rio players not only support SDMI, digital rights management from InterTrust Technologies and Microsoft's Windows Media, but also the MP3 and AAC audio codecs.

Consumers who purchase a new Rio can expect to see music from several major music labels bundled in the box, on the player and on the Web.

For further details, check: <www.diamondmm.com>.

Contact: Diamond Multimedia, Tel: (01189) 444444.

Active Antennas and Digital Processor are Satellite Breakthroughs



Two innovative technologies for mobile communications debuted on the ICO F-1 satellite, built by Hughes Space and Communications (HSC) launched in March.

Hughes has modified its popular HS 601 spacecraft to build a network of 12 medium-earth-orbit satellites for ICO Global Communications.

The satellites use a unique active phased-array antenna design and a state-of-the-art, digital beam-forming processor developed by HSC.

The ICO satellites are about 25% taller than typical HS 601s, bringing the new design to roughly 5m high to accommodate the innovative transmit and receive antennas.

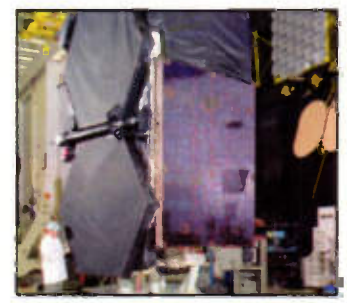
These S-band active direct radiating arrays are the direct air link to users. They form multiple beams for high-gain performance and, with multiple satellites in orbit, provide full earth coverage.

A digital beam-forming processor drives the antennas. This smart processor, designed in the mid-1990s, is the most complex and capable ever flown on a commercial satellite.

The processor constantly changes the beam configuration to match fluctuating usage patterns and make the most efficient use of the bandwidth available. This gives ICO unprecedented flexibility to meet ever-changing market demands.

For further details, check: <www.hughespace.com>.

Contact: Hughes Space, Tel: +1 310 364 6000.



Clean Air from Sharper Image

Sharper Image Corporation has launched the Ionic Breeze Personal Air Purifier, the most helpful travel accessory for anyone desiring a breath of fresher, cleaner air while spending hours in closed, crowded, parched environments, like airplane cabins or sealed offices.

Created by Sharper Image Design, the Ionic Breeze Personal Air Purifier is battery-operated, compact, lightweight, portable and discreet. Worn around the neck, it looks like a small binocular. It creates an individual zone of comfort by generating a breeze of negative ions that help to remove positively charged airborne irritants.

Cleaner, fresher air is electronically propelled toward the wearer's mouth and nose by exclusive, patented Zenion Effect technology, which moves air in the same manner as a fan, but without moving parts.

For further details, check: <www.sharperimage.com>.

Contact: Ionic Breeze, Tel: +1 650 344 4444.

3Com Makes Way for Cisco

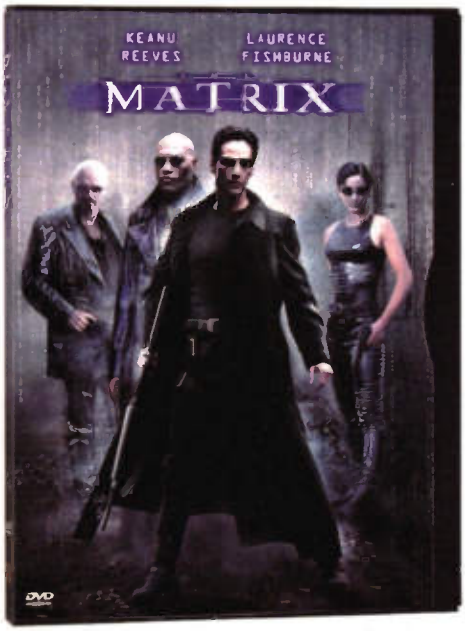
3Com, which recently spun off its successful Palm unit as a separate company, has decided to sell off or close its modem business and discontinue its high-end networking products, effectively ceding to Cisco Systems the market for corporate networks.

3Com will now concentrate all its resources on three distinct networking markets: consumers, commercial customers - particularly small and medium-sized locations - and network service providers. For these customers 3Com delivers seamless, rich connectivity, anytime anywhere, leveraging its leadership in the following emerging high-growth technologies: IP telephony, broadband access, wireless access and web-based solutions.

For further details, check: <www.3com.com>.

Contact: 3Com, Tel: (0118) 922 8200.

Unravelling Mysteries Behind the Matrix



Poised to repeat their online hits from late last year, Warner Home Video (WHV) has announced a second event featuring the web-enabled The Matrix DVD. This time it spotlights the Academy Award-nominated special effects and technical wizards who helped mastermind the hit futuristic action-thriller. This has become the number one best-selling DVD of all-time.

From April, users all over the world will again share the unique opportunity of simultaneously watching The Matrix while chatting online with its creators - as they did this past November with writer/directors Andy and Larry Wachowski.

Now, three more filmmakers will participate: Editor Zach Staenberg, Visual Effects supervisor John Gaeta and Sound Designer/Supervising Sound Editor Dane Davis.

Having sold more than two million units, The Matrix is the highest-selling DVD of all time. It has sold two and one half times more units than the next highest selling disc.

For further details, check: <www.warnerbros.com>.

Contact: Warner Home Video, Tel: (020) 7434 3334.

NEWS BYTES

Microsoft aims to Do Battle with X-Box

Microsoft has taken the wraps off its X-box video game console, signalling its intent to invade and conquer the £12 billion worldwide video game market next year.

The timing of the X-box launch, however, means that the software giant will be playing catch-up with Nintendo's 128-bit Dolphin game machine, to be launched later this year, and Sony's PlayStation2.

The X-box features a 600MHz processor, 64MB of RAM, and an advanced 3D graphics chip, and will be able to play DVDs and connect to the Internet, similar to the PlayStation2.

For further details, check: <www.microsoft.com>.

Contact: Microsoft, Tel: (0870) 6010100.

Intel Scoops up Giga

Intel has acquired Giga, a Danish optical data communications chip firm, for approximately £780 million in cash in a move to expand its ability to deliver chips for the high-speed data and communications network market, and reduce its reliance on revenues from its core microprocessor business.

Intel has made several acquisitions of data communications chip companies over the last year: Level One Communications last March for £1.3 billion, Dialogic in June for £480 million, and DSP Communications in October for £1 billion.

For further details, check: <www.intel.com>.

Contact: Intel, Tel: (01793) 403000.

HP has Garage Initiative to help Start-ups

Called its Garage Program to honour the many high-tech companies that got their start in somebody's garage a new package of products and services from Hewlett-Packard will provide a turnkey solution of technological, financing, and marketing assistance to Internet start-up companies. The assistance will include everything from Web site development to the acquisition of venture capital.

For further details, check: <www.hp.co.uk>.

Contact: HP, Tel: (01344) 773100.

NEWS BYTES

New Fibre Optic Record

Scientists at Lucent's Bell Labs have set a new record for transmitting data over fibre-optic cable by moving 3.28 terabits per second of data over 300km of Lucent's TrueWave optical fibre.

At this rate, Lucent's fibre could transmit three times the volume of daily Internet traffic for the whole world in one second.

Within years, fibre-optic cable could move tens of thousands of terabits per second of data. This tremendous bandwidth growth will be fuelled by the speed of lasers used to encode data and the number of wavelengths a single fibre can carry at once.

For further details, check: <www.lucent.com>.

Contact: Lucent, Tel: (020) 7647 8000.

Xerox Propels Production Publishing into the Internet Age

Xerox is reshaping the future of the printing and publishing industries with a range of new high-end digital printing presses and software products that make it easier for graphic arts professionals to do business over the Internet.

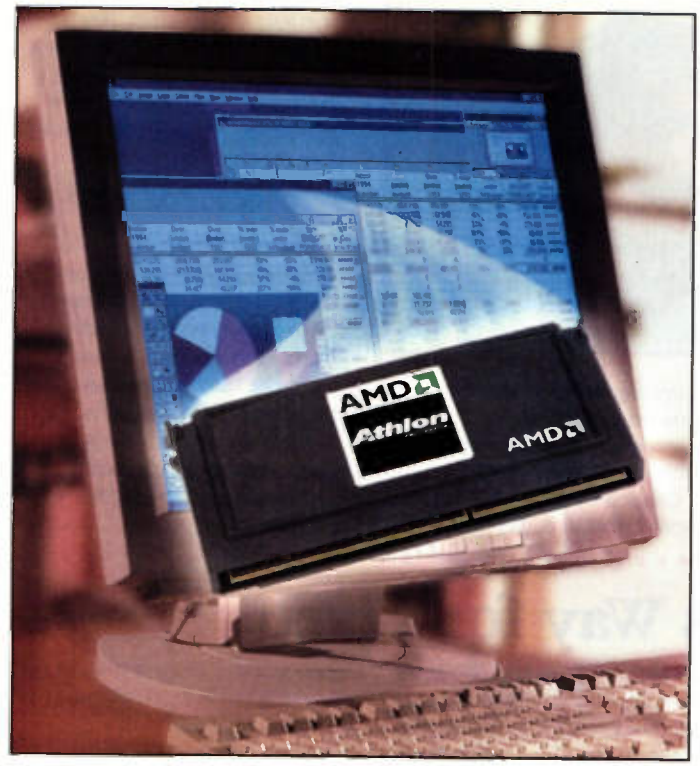
The products - which strengthen the company's position as the leader in digital production printing and publishing - include the Xerox DocuColor 2000 Series and Xerox DocuTech 2000 Series printing systems. Plus components for high-speed image scanning; and software tools that enable these printing systems to be connected to the Internet for global document distribution and e-commerce applications.

They address the growing use of the Internet by the printing and publishing industries, as well as high market demand for colour print applications not possible on traditional, offset printing presses. These applications include book publishing on demand, and the high-volume production of customised documents such as personalised catalogues, bank statements and marketing brochures.

For further details, check: <www.xerox.com/xps>.

Contact: Xerox, Tel: (01654) 702400.

Athlon Processor Rockets to 1GHz



AMD has started shipping 1GHz AMD Athlon processors. The first commercially available systems based on the 1GHz AMD Athlon processor will be available from Compaq and Gateway.
For further details, check: <www.amd.com>.
Contact: AMD, Tel: (01276) 803299.

Cryogenic Detectors Probe Evidence for Dark Matter

Researchers from 10 academic institutions have achieved the world's best discrimination in the search for dark matter, which scientists have postulated makes up more than 90% of the mass of the universe.

The collaboration, called Cryogenic Dark Matter Search (CDMS), uses an entirely new type of detector technology that employs crystals kept at cryogenic temperatures to detect potential dark matter particles.

This powerful technology derives its advantage from being able to distinguish background events that result from many of the known particles interacting in the crystals from those that are likely to be dark matter interactions.

This discrimination allows an unambiguous identification of events in the crystals caused by any new form of matter.
For further details, check: <xxx.lanl.gov/archive/astro-ph> or <www.standford.edu>.
Contact: Stanford University, Tel: +1 650 723 2300.

District Heat Main Powered by Renewable Energy

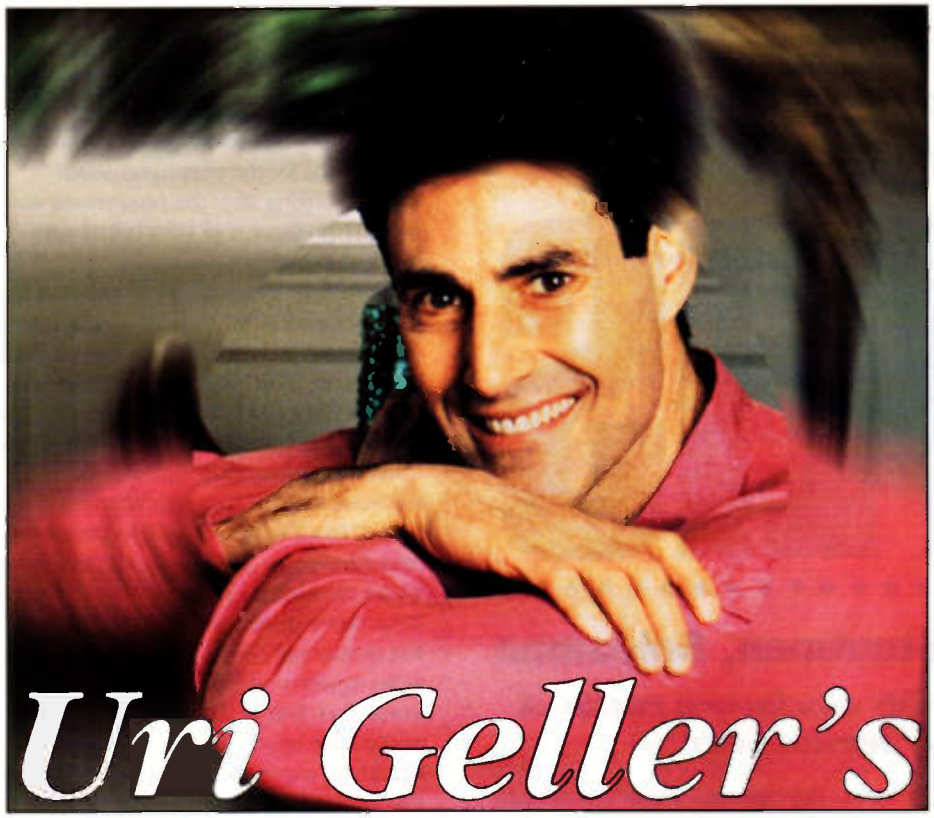
The Centre for Alternative Technology (CAT), Europe's leading eco-centre, is currently building the UK's first district heat main based on integrated renewable energy systems.

The project, which could easily be replicated, will link an existing woodchip boiler to a solar water heating system installed in the Autonomous Environmental Information Centre (AtEIC) - CAT's innovative new building project. The heat main will be linked to all seven major buildings at the centre and allow for heat-trading across the site.

The design aims to demonstrate how renewable energy resources can be integrated to supply both heat and power to any area where there is a high density of buildings such as industrial centres, business parks, a village or a town.

Heat grid's are common in Europe but only a couple exist in Britain, most notably in Sheffield, and are often used to distribute heat produced by power stations.

However, fossil-fuelled power stations have increasingly moved away from community centres, making it less viable to transport the heat, which is then wasted as it is released into the atmosphere. But a district heat main based on renewables may overcome these obstacles while utilising wasted energy.
For further details, check: <www.cat.org.uk>.
Contact: Centre for Alternative Technology, Tel: (01753) 512600.



Uri Geller's EXTENDED REALITY

The Twin Connection

Are you an identical twin? Or a parent or close relative of a pair? If so, you may be getting tired of people asking if there really is a special link between them, because it seems that in the majority of cases there isn't, at least no more than there can be between any two people who are particularly close to each other. In fact, there have been scientific experiments carried out that showed twins to be no more special - intercommunication-wise, than anyone else.

Yet this is not the whole story, as I discovered when I dropped in recently on one of my regular consultant researchers, who always has something new for me. That Morning, I had seen a piece in one of the dailies about a twin who seemed to know that his brother had been involved in an accident, although there seemed no normal way he could have known.

Almost the first thing my friend asked me was did I know any twins, because he was doing a research project on them and wanted to collect all the cases he could? (He already has a fat file of them). As it happens, I didn't as far as I knew, and nor did he until recently, and I was surprised to learn how little research has ever been done on what could be quite an important matter.

The first person, I learned, who even suggested that twins might be telepathic was the novelist Alexandre Dumas (senior). In 1844 he published a novel called The Corsican Brothers in which the heroes are a pair of identical twins, one of whom had this to say:

"We had to be cut apart with a scalpel, which means that however far apart we are, we still have one and the same body, so that whatever impression - physical or mental one of us receives has its after-effect on the other."

Later in the story his brother is killed in a duel (in Paris). And at the same moment he falls from his horse (while riding in Corsica) after "receiving such a violent blow that I passed out". Indeed, he thought he had been shot, and when he found he hadn't been, he told his companion "in that case it's my brother who has just been killed". As indeed he had.

The Corsican Brothers never became a best-seller like The Three Musketeers or The Count of Monte Cristo. And the critics didn't take much notice of it. It is only mentioned in passing in one of twelve biographies of Dumas. Nobody seems to have followed up the suggestion that twins might have a special link until 1883, when Francis Galton published his enquiry Into Human Faculty. This book included five pages of anecdotal evidence and Galton reckoned that about one pair in three of identical twins really did have a special link between them. (Later research suggests that he was right).

A few years later, three founder members of the (then) newly founded Society for Psychical Research brought out a huge volume entitled Phantasms of the Living in which they included several detailed accounts of inter-twin communication at a distance. You might have thought that somebody would have followed up with a properly conducted survey of a large sample of twins, but nobody did. In fact it was more than fifty years later before any respectable scientists took any notice of the subject

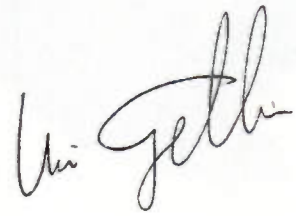
The one who finally did was Horatio Newman, professor of zoology at The University of Chicago and a twin himself. "One cannot," he wrote, "associate closely with one-egg twins [i.e. monozygotic or identical twins] without soon discovering that many of them regard themselves as endowed with something like telepathic powers." Two of his graduate students happened to be identical twins, and "both of these hard-boiled critical biologists strongly favour the view that there is some subtle affinity between one-egg twins that makes it possible for one to know what the other is thinking about. They themselves have almost daily supported the view that they are in communication without employing the ordinary media of exchange in common use".

Almost daily, indeed Professor Newman is generally regarded as the pioneer of modern twin research, so how come nobody seems to have taken up his suggestion that the scientific community should have a look at twin communication until 1961. Nearly twenty years after he wrote the book from which the above quote is taken? In a future column I will be telling you about the important discoveries reported in that, year by a team of psychologists from Toronto - findings that seem to have been swept under the rug. I'll also be telling you about some remarkable recent cases that are strikingly similar to that of the fictional Corsican twins, and explaining why some twins seem to be telepathic while others do not.

Meanwhile, if you are a twin or are close to a Pair, please write or e-mail me to let me know if you have had any experience of unusual communication. I'll pass your letter on to my colleague who will contact you. Please indicate if you wish to remaln anonymous.

Uri Geller's latest book MindMedicine is published by Element Books at £20.00, and his novel Dead Cold is published by Headline Feature at £5.99.

Visit him at www.uri-geller.com
and e-mail him at urigeller@compuserve.com

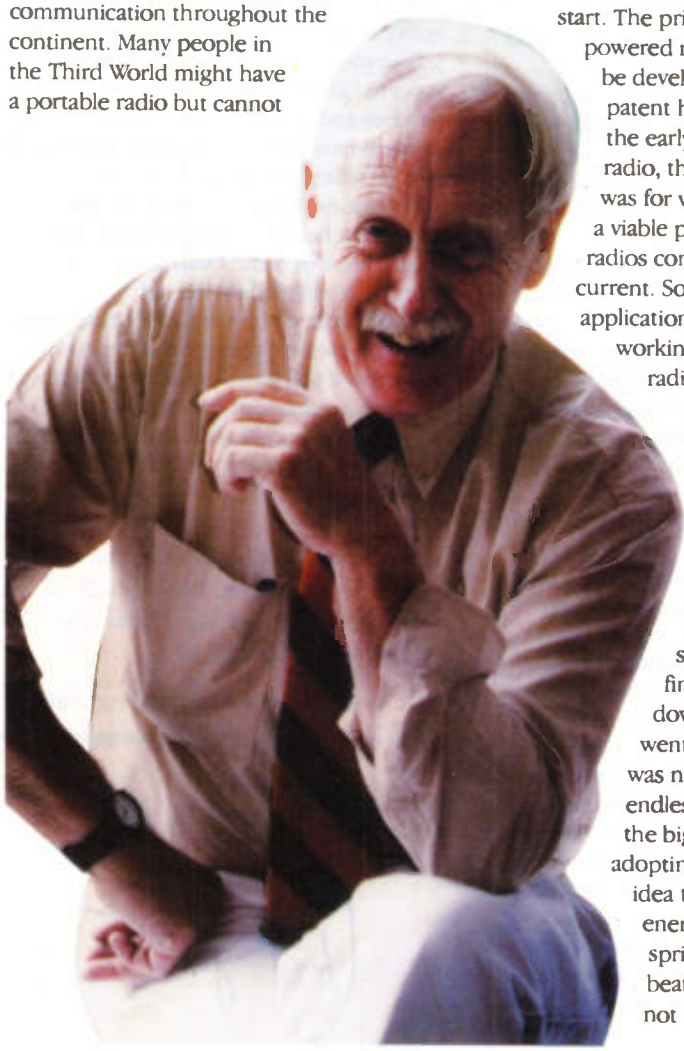


Trevor BAYLIS

Inventor, Showman, Stuntman, Salesman

The man most noted for his clockwork radio. A report by Paul Freeman-Sear.

Few inventors most recently have gained recognition such as Trevor Baylis. For he is the man that most people regard as the 'clockwork radio' man. The original idea for this came about when Trevor was watching a TV programme about AIDS in Africa. The AIDS problem was exacerbated by a lack of communication throughout the continent. Many people in the Third World might have a portable radio but cannot afford to buy batteries. Trevor immediately thought of a solution to this problem. In a typical Trevor Baylis way he went straight to his workshop and started to put something together. Within the hour he had an old transistor radio crackling into life powered by a clock spring and a generator. Audio power didn't last all that long but it was a start. The principle of a clockwork-powered radio worked and it had to be developed. Although another patent had been filed way back in the early fifties for a clockwork radio, the wind-up mechanism was for valve radios. This was not a viable proposition because valve radios consumed too much current. So Trevor filed a patent application in November 1991 for a working clockwork transistor radio.



No Takers

The next stage was to take his working prototype to many multi-national companies to see if they would take the idea. We shouldn't be surprised to find that he was turned down again and again. This went on for two years. Trevor was not satisfied with the endless lists of rejections from the big companies over adopting a very simple but neat idea to power a radio from the energy stored in a steel spring. Trevor was not to be beaten and was determined not to let this one go. Then came a stroke of luck. At that time he also happened to be doing a radio programme and through producer contacts managed to get a slot on the Tomorrow's World TV programme. This seemed as if this was the magical key, for the telephone never stopped ringing after the programme was aired. From there it all snowballed into offers of help.

Trevor was somewhat more cautious this time for previously he had invented a series of some 200 small gadgets for the disabled. They were called 'Orange Aids'. That development was to be lost to city financiers and it was a lesson that Trevor never forgot.

But in a true spirit of helping out someone less fortunate than himself, Trevor agreed that it would make good sense to manufacture his clockwork radio in a factory where disabled people could be employed. What better place than in South Africa where it would be closest to where the radio would be required. The company would then take on disabled people who would have otherwise had no prospect of a job. The company was to be called Baygen, the name being derived from Baylis Generators. At the end of four years of development, the radio now lasted half an hour with one complete wind and it also gave the African people higher volume than normal requirements. Today the 'radio without batteries' is in continuous production. The idea has now been developed into a variety of formats and the concept of wind-up power is now being rolled out into many other consumer items including torches, yachtsman's GPS systems and 'wind-up' mobile phones.

Always the Inventor

As a child, Trevor grew up in a rough but make-do world of the London suburbs during the Second World War. Trevor was a practical lad and didn't get the self-fulfillment and satisfaction out of an academic school environment. What gave Trevor a buzz was to see his practical creations come to life. During the war years there was a scarcity of just about anything, so childsplay consisted of making your own entertainment. This would often involve making things out of anything Trevor could get his hands on. Impressed and influenced at the time by the power of bombs, bullets, shrapnel and explosions, the idea of making gunpowder was quite appealing. Experimenting with different proportions of chemical he eventually came up with the correct formula for an explosive mix. What could be done with the powder? Fire it in a cannon thought Baylis. So the next step was to make a cannon so he could blow his neighbour's chimney pot off!

Another one of Trevor's early achievements was to make a model diesel engine from scratch. His dad was always around to give him an encouraging hand in the workshop.

Now this project was to be an example of his persistence and determination for the model engine didn't work first time and it took many years to get the piston and the cylinder bore to be an exact fit before it did finally work.

Trevor passes the Physical

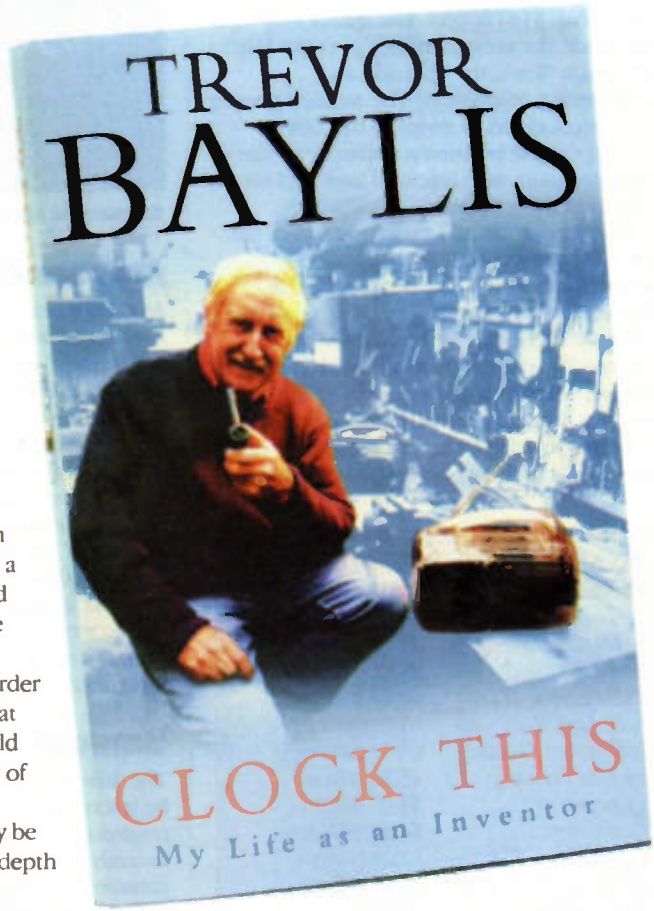
As a conscript to the British Army and at that time being very physically fit, Trevor then became a PT instructor, but it wasn't long before he also took charge of adventure training. This was to have many benefits for Trevor because he soon found he could order up any supplies that were deemed necessary for the training sessions. This naturally included many workshop tools like lathes, drilling and milling machines to build go-karts and canoes.

Stuntman or Escapologist

Trevor was particularly keen on swimming when he was a young lad and he combined that love for water when he joined a swimming pool company to sell pools. In order to get customers attention at exhibitions around the world he would perform a variety of diving stunts to draw the crowds. This might typically be to dive from 18ft into a 3ft-depth pool. One plunge pool was typically of Trevor's own making. His infectious enthusiasm for experimenting would mean that many modifications to the pools filtering systems would be devised and implemented by himself. The showman activity would also lead to Trevor performing many daring stunts including being tied up and escaping from a nailed coffin underwater.

It's the PPC

More recently Trevor has moved on to forming his own company called PPC, The Personal Power Company. As the name suggests the inventions that surround the company title are connected with generating electrical power on the move. Some ideas have been around for a while (See Electronics and Beyond, 'Wired Man' January 1999) but recently Trevor has taken out patents on effectively any way to generate electricity from footpower or shoe power and is currently working on a solution to the problem. To that end Trevor has suggested that a challenge should take place this summer. He is intending to walk part of the way across an African desert and the electricity generated from his shoes would power up a mobile phone to establish a communication. A first for a walking powered mobile phone and a tantalising challenge!



'Clock This - My life as an Inventor' by Trevor Baylis is published by Headline and is priced at £18-99 ISBN 0-7472-7381-2

Inventors Academy

Trevor has always wanted to launch an Inventors Academy, a place where budding inventors can be given advice on how to get their ideas protected and to provide help to get financial backing. For this is the area where would-be inventors have the greatest difficulty. However, in order for the Academy to survive it needs financial input. Trevor suggests the Acadamy should be launched from govenment grants but would eventually be self financing. Some of that finance, it is proposed, would come from the inventor's rewards, as it was the Academy that provided a convenient launch pad in the first place.

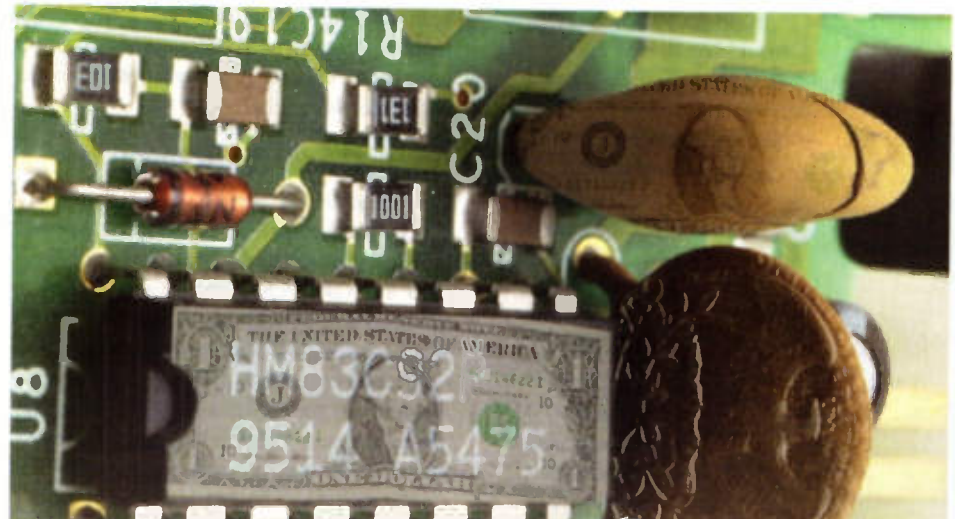
The aim of the Academy is to:

1 'obtain maximum financial and other benefits for the inventor and find the best partner to go forward with the invention.'
2 'with help from government, attract these new partners to manufacture British inventions in the UK'

If an inventor's idea were found to be commercially useful by a team of Academy consultants, the inventor would be invited to join the Academy. Ultimately the inventor's intellectual property would be sold off at auction to the highest bidder. The Inventors Academy is still in its infancy and has yet to become firmly established but when it does it could be a major force in helping more radical advancements in science and technology to quickly come to fruition.

Backing the inventor or the company?

Getting financial backing has always been a problem particularly in the UK, probably because large corporate companies have in the past put inventors firmly under the 'nutter' category - full of crackpot ideas. More realistically it's probably that the British tend to take the conservative line of safe development for a more secure line of investment. As is now all too familiar, a radical approach to problem solving results in high risk, and as we know high risk can sometimes provide high return. Afterall, all developments must start with inventions. We are seeing an interesting variation of this in speculative investment in 'dot com' companies. This is based on the huge expectation to perform well in the future. If this can happen, then there is no reason why there shouldn't be speculative investment in an inventor. Just as publishers put a lot of trust in popular authors to produce a series of highly successful books by providing financial advances, the same could be true for inventors who have early credibility. Only time will tell.



Money from ELECTRONICS

In part 1, Gregg Grant recounts the beginnings, and the radio riches.

For Starters

So it's behind us. The triple psychological bypass that is: new year, new century, new millennium. As good a time as any to take a backward glance at what must be reckoned to be the century of electronics. There is no aspect of our lives that this multi-disciplined profession has not invaded, from the children's play area to the kitchen, from the workplace to our leisure activities.

Little wonder therefore that electronics is - possibly - the world's major business activity and promises to remain so for some years to come. The semiconductor industry alone is worth more than $130 billion. The question is who has made the serious money over the last 100 years. Was it the scientific and engineering originators? The monied people they encouraged to invest in the new industry in the beginning perhaps? Or the entrepreneurs who followed later and saw a money-making opportunity? Who?

The Sunday Times newspaper's Rich List for 1999 comprises 1,022 men and 71 women, a total of 1,093 people. Of this figure, 73 are in computers, electronics and software and a further 13 are in mobile phones. This amounts to almost 1 in 10 on the list, whereas a decade previously, there was less than 10 tycoons in these fields.

Microsoft's Bill Gates leads the 50 richest individuals in the world category, with a reputed wealth of £36.25 billion. Microsoft men, Paul Allen and Steven Ballmer also hold positions 7 and 20 respectively. Also in at number 18 is Michael Dell, of Dell computers. The highest 'electronics' man on the list is Intel's Gordon Moore, of Moore's Law fame. He is placed forty-second, with some £4.37 billion. America's richest individuals list is also headed by the Cyber Pope, and a further dozen people on this list made their money from one of the electronics disciplines. This is outlined in Table 1.

So much for the here and now. What about the past? Were the pioneers of - for example - the battery, the telegraph, trans-oceanic cables and radio communications among the seriously rich of their day? No, is the short answer. Almost all of them weren't. None of the great electrical originators appear in the 20-Richest list for 1899, even by default. So what sort of money did the early experimenters make, if any? This is a far from easy question to answer. To begin with, where does one start?

Position in America's Richest 50 List	Individual	Discipline Within Electronics	Net Worth in '99
No. 1	Bill Gates	Software	£36.25 billion.
No. 4	Paul Allen	Software	£13.75 billion.
No. 9	Michael Dell	Computers	£8.12 billion.
No. 10	Steven Ballmer	Software	£7.5 billion.
No. 19	Gordon Moore	Integrated Circuits	£4.37 billion.
No. 26	Craig McCaw	Mobile Phones	£3.81 billion.
No. 32	Larry Ellison	Computers	£3.06 billion.
No. 34	Martha Ingram	Computers	£2.93 billion.
No. 37	Waitt Brothers	Computers	£2.68 billion.
No. 41	Ross Perot	Computers	£2.31 billion.
No. 46	William Hewlett	Electronics	£2 billion.
No. 48	James Goodnight	Software	£1.87 billion.

Table 1. Twelve Electronics Billionaires

Alessandro Volta

Alessandro Volta

As good a year as any - in my view - is 1800, the year in which the Italian physicist Alessandro Volta made electricity portable. Towards the evening of his life, Volta's salary as an academic - he was Professor of Experimental Physics at Pavia - was enhanced somewhat by the granting of an annuity from the French emperor Napoleon in 1809. He was also drawing a salary as a Senator of the kingdom of Italy.

Thus although he didn't directly benefit from his invention, the final two decades of his life were comfortable enough. Throughout the entire period, Volta had the income of a moderately wealthy man.

Samuel Morse

The American domination of electronics can be traced back to Samuel Morse, the originator of the eponymous code, only recently declared obsolete. Morse not only patented his code in America - the patent dated from June 1840 - he also attempted to do so in the United Kingdom (UK). Although he was thwarted in this by objections from both Wheatstone and his

partner Cooke - who had already patented their own system - he didn't greatly suffer financially.

Samuel Morse

In 1843, after a lengthy fight in Congress, Morse was voted - by the narrowest of margins - the sum of $30,000 or roughly £6,000 to set up an experimental, 40-mile telegraph circuit between Baltimore and Washington. A decade later, in the United States Supreme Court, Chief Justice Taney decided that Morse was indeed the sole inventor of the telegraph. As a result, the telegraph companies in America began to pay him long overdue royalties.

On his death in 1871, Morse's estate was valued '. . . at half a million dollars - a respectable sum, though less than the fortunes amassed by the entrepreneurs who built empires on the back of his invention.' [1] A part of this estate was the 400,000 French francs - at this time amounting to some US $80,000 - awarded to Morse by the governments of France, Austria, Belgium, Holland, Piedmont, Sweden, Turkey, Tuscany and Russia in lieu of unpaid royalties.

The reason so many states were involved was that the payment was a share, based on the number of Morse telegraphs operating in each country!

Charles Wheatstone

Already it can be seen that patents - or the lack of them - would be the key to making a moderate killing in the new technologies based on electrical power. No one exemplifies this more than Charles Wheatstone.

Quite apart from having a fair claim to being the inventor of the first telegraph system in daily use anywhere in the world Wheatstone, like his near-contemporary Thomson, was a prolific inventor in other areas of science and technology.

Among the other inventions for which he held patents were the Rheostat, a Solar Clock, the Concertina, one of the earliest of Electrical relays, a Stethoscope and a typewriter. In fact his inventions could fill a small volume! Wheatstone's telegraph instruments were well designed and accurately made, and so his original telegraph line between Paddington and West Drayton was a tremendous technical success. Consequently, in 1843, the line was extended to Slough.

Two years later the telegraph had unquestionably arrived as a long distance communications medium and in 1846, the Electric Telegraph Company was formed. Wheatstone sold his patents to the company, which brought him the healthy sum of £30,000. Less than a quarter of a century later, the government for a staggering £8 million bought out the telegraph companies!

Undoubtedly Wheatstone's greatest invention was his Automatic Telegraph equipment of 1859. Both the original model and its derivatives would remain in service for more than fifty years.

Wheatstone was like Thomson in another way too - he was a great public man sitting on, or frequently chairing, an extensive variety of committees. Indeed this was the period when committees became firmly established as a way of looking into particular problems of national importance. This development prompted the constitutional expert Walter Bagehot to remark that the British way of doing things was a committee, since we appeared to be born with a belief in green baize, clean pens and 12 men with grey hair!

Knighted in 1868, Wheatstone was also a Fellow of the Royal Society and a foreign corresponding member of the French Académie des Sciences and - on his death in Paris in 1875 - he had '. . . a respectable fortune from the sale of his various telegraphic patents.' [2] Indeed he'd be one of the few inventors to make a reasonable return from the fruits of his inventive skills.

William Thomson

Undoubtedly one of the great driving forces of communications theory and practice in the middle years of the last century Thomson, as a student at Cambridge, was frequently short of money. Indeed at one period he wrote to his father that he had only the equivalent of 13 pence to his name!

Yet at his death in 1907, at the age of 83, he left an estate valued at £162,000, a hefty sum at the time. How had he done it?

Firstly by applying his very considerable scientific abilities to investigating technical problems and coming up with viable solutions which could be readily implemented.

Secondly, it could be said, by driving a hard bargain and finally, by carefully maintaining his public profile as one of the nation's - indeed the world's - most distinguished scientists. The result of this application was some 70 patents and considerable prestige.

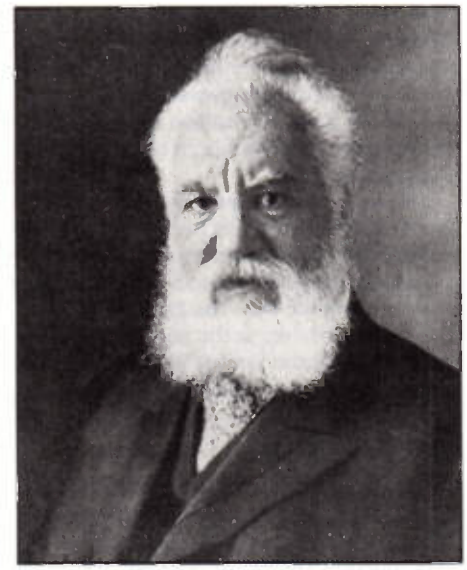
Two of his most famous patents - and lucrative ones as well - were those for the Mirror Galvanometer and the Syphon recorder, both of which were used extensively in submarine telegraphy. Indeed by 1875, Thomson had '. . . for some years past . . enjoyed a very large professional income.' [3] That he drove a hard bargain could be testified to by another able electrical engineer and founder of his own company, Sebastian de Ferranti.

At the early age of 14, Ferranti had invented a dynamo, on which he began to take out a patent. In the course of this, the youngster found that the same idea had also occurred to Sir William, as Thomson had become, in recognition of his work on the Atlantic telegraph cable. Consequently they took out a joint patent in 1884, for the Thomson-Ferranti Alternator. The terms of the arrangement guaranteed Sir William a minimum royalty of £500 per annum. So much for encouraging young engineers!

No matter, Ferranti bore him no grudge, indeed quite the reverse. With Sir William as its main technical advisor, the young firm of Ferranti soon made a name for itself in the electrical - and later electronic - engineering business.

His public profile was enhanced further in 1892, when he was raised to the peerage for his scientific achievements, becoming Lord Kelvin of Largs. His other inventions included the Kelvin Temperature Scale, a Marine Compass, his Electrostatic Voltmeter of 1887 and a Tide Predictor. His chairmanship of a variety of scientific committees and the sending of the earliest, paid, radio telegrams In 1898, maintained his public and scientific eminence.

All of which resulted in a number of directorships, which augmented his salary as Professor of Natural Philosophy at Glasgow University, a position he had held since the age of 22 and from which he would retire in 1899, after more than half a century in the post! It would be no exaggeration to say that he was one of the most financially successful scientists of his day.



Alexandra Graham Bell

The Star-Spangled Scotsman

The single most lucrative patent ever issued was United States patent No. 174,465, granted to Scottish immigrant Alexander Graham Bell on March 7th, 1876. The device in question of course was the Telephone.

Bell was lucky from the outset. He found two wealthy men to back him during the course of his research, one of whom - Gardiner Greene Hubbard - was a patent lawyer.

As a result of Hubbard's advice Bell worked '. . . exclusively on technology that would generate telegraph messages - and profit.' [4] Consequently his patent described the basics of telephony without once employing the word Telephone. Moreover, since the language was clear and concise, it became all but impossible to design a telephone without infringing Bell's excellently crafted patent.

Whilst this did not stop challenges to his work, it did ensure that whoever took Bell on had a fight on their hands.

Towards the end of 1876 the head of the Western Union Corporation - the only major telecommunications outfit in the United States (US) at that time - one William Orton, turned down an offer to buy the rights to

Bell's telephone for US$100,000. This turned out to be one of the great mistakes of the 19th century for, in the course of the following year, the device began to take off with some 800 already in use.

In July 1877, Bell gave his bride a wedding present of 1,497 shares in his telephone company. Although the new company was initially harassed by Western Union to such a degree that few others were prepared to buy its shares, it eventually surmounted this crisis. A successful patent action against Western Union helped the stock's position considerably.

By 1879, a Bell share was worth $300 and Bell and his wife held stock worth $200,000. At the end of that year Bell stock was changing hands at $500 a share and the court settlement had given Bell Telephone title to a monopoly, for the following 14 years.

The patents began to run out in 1893-94. This was the end of a period that would never be repeated. American Bell Corporation had, over the proceeding years, been one of the best investments ever, paying out some $26 million in profits to stockholders, among whom of course was Bell and his wife.

Shortly a new communicative medium would appear on the scene: radio. Here too a number of lone inventors would contribute ideas and devices as well as make money along the way. The great years however were over as the corporation - epitomised by the likes of Western Union - began to exercise its financial muscle.

Early Days

Among the early attempts to develop radio waves as a long distance communications medium, were those of the Italian amateur experimenter Guglielmo Marconi, the Canadian physicist Reginald Fessenden and the American inventor Lee de Forest. Marconi had used '. . slabs of sheet iron to increase the transmitter spark's wavelength' [5] and did so by placing one slab on the ground and holding the other above his head.

This resulted in the one thing Marconi desperately sought: a considerable increase in range such that his previous achievement of 100 metres was now a range of 1km. By 1904, all three men had formed their own companies which, at this time, '. . were in financial difficulties of one sort or another.' [6]

Fessenden had already approached the American Marconi company concerning a merger and by 1906, de Forest's company was in deep financial trouble. The Marconi company itself was in no great shape either and in March 1908, the board accepted the Managing Director's resignation and Marconi replaced him.

Marconi and His Companies

The first company Marconi set up was the Wireless Telegraph and Signal Company Limited of 1897, created in part by the success of his establishing communication between the Italian cruiser San Martino and the San Bartolemeo naval yard at Spezia, a distance of some 18km. The company's

Guglielmo Marconi

object of course was the commercial development of Marconi's equipment and to this end, the inventor himself was awarded £15,000 for his patents. From this sum, Marconi paid the company's formation costs.

The new company was capitalised at £100,000 and Marconi was given 60,000 of the 100,000 one-pound shares. The remainder were placed on the market and from the money raised, Marconi was paid and a working capital of £25,000 provided. Initially, the prospects looked rosy and two months later, Marconi established communication between Bath and Salisbury, a distance of 34 miles.

Three years later the company was reconstituted as Marconi's Wireless Telegraph Company Limited, a board decision which Marconi did not like. This would be the company's title until, in 1963, it was simplified to The Marconi Company Ltd. Before the outbreak of the Second World War however, there were Marconi subsidiaries and associated companies all over the world.

The Great Scandal

This matter revolved around the fact that, in 1912, the Postmaster-General accepted the British Marconi Company's tender to build the first six stations of a wireless chain to link up the countries of the British Empire.

The Marconi negotiator was the company's managing director, Godfrey Isaacs, the brother of the Attorney-General, Sir Rufus Isaacs. However, soon opposition to the contract mounted as rumours emerged of government ministers indulging in corruption in their granting the contract to Marconi as well speculating in Marconi shares. These rumours were given added momentum by the share-trading facts.

In August 1911, the company's shares were trading at £2.8s.9d. By December they had climbed to £3.6s.3d and in March 1912, when the contract was signed, they raced to £6.15s. In the following month they reached £9 just as a new issue of shares in the Marconi Company of America were placed on the market. Like their British counterparts, the American shares experienced a rapid boom prior to their falling back sharply.

After a great deal of press speculation, innuendo and debate, it transpired that ministers had indeed been speculating in the shares of the American Marconi company. Those involved were the Chancellor of the Exchequer Lloyd George, the Liberal Party Chief Whip Lord Murray and the Attorney-General, Rufus Isaacs. Although the affair eventually blew over after a government enquiry, it didn't do the Marconi Company any favours.

Another imbroglio involving Marconi was the creation of the British Broadcasting Corporation, the BBC. This affair - involving the conflicting interests of the Post Office, the radio equipment manufacturers' such as Western Electric, Metropolitan-Vickers and , naturally, Marconi as well as the government of the day - did none of the protagonists any credit. Marconi had demanded that they build all the transmitters required for the proposed new service and, initially, refused to allow its competitors to use any of the 152 patents it held.

Eventually, it was agreed that listeners to the new broadcasting stations would pay for an annual licence costing 10s - 50p in today's money - half of which would go to the BBC. The receiving equipment, however, carried a double tariff one of which - a charge on the receiver's components - would also go to the BBC. The other - a charge of 12s 6d on each valve holder - would pass to the Marconi Company as a royalty for their allowing their patents to be used.

The Brownie Wireless Co. Ltd challenged Marconi's royalty position in 1928, and the Controller-General of Patents found Marconi to be abusing their monopoly and recommended a smaller royalty. Marconi's promptly appealed and won. In the following year a new, five-year, agreement was drawn up which stipulated that the royalty was still payable even when no patented components were used! Moreover, since the majority of the patents that were being used would run out in the course of the five-year period, this appeared to be a final money-grabbing scam on Marconi's part.

Indeed patents always seemed to spell trouble of one variety or another for Marconi's, another example being HMV's purchase of the Marconi subsidiary Marconiphone in early 1929. The agreements concerning patents had not been clarified and a dispute developed over the new owner's right to patents that Marconi had acquired from other manufacturers' under business agreements in force at the time of HMV's takeover. It would be May 1931 before Marconi's admitted that they were - once again - in the wrong!

Towards the end of his life, Marconi became worried about his personal finances, despite his sharing the 1909 Nobel Prize in Physics, which brought him a considerable sum of money. Indeed his financial fortunes seemed - like that of his companies - to wax and wane periodically and, not infrequently, it was difficult to determine where company monies began and personal wealth ended and vice-versa. This is a subject that his biographers appear to have largely left alone.

Oliver Lodge

Oliver Lodge

Another great radio pioneer was the British physicist Sir Oliver Lodge. With his friend and collaborator Alexander Muirhead, he filed a number of wireless patents in 1897 before creating '. . the Lodge-Muirhead Syndicate for the commercial exploitation of wireless.' [7]

Among the patents was one for frequency tuning, essential for the accurate, interference-free transmission and reception of radio signals. This patent expired in 1911, but Lodge applied for an extension, which was opposed by the Government of the day. The Marconi Company sat on the sidelines, watching developments - and no wonder, for Marconi had filed his now-famous patent No. 7777, for 'improvements in apparatus for Wireless Telegraphy,' which was based very much on Lodge's earlier work.

The case was presided over by Lord Parker, who decided for Lodge, and extended the patent for a further seven years. For this period, the patent was bought by the Marconi company for more than £20,000 which, as Lodge himself noted '. . renumerated me at the rate of £1,000 a year for seven years, less income tax.' [8]

However, there was a price to pay - the major condition of the Marconi company's offer was that the Lodge-Muirhead syndicate give up all its activities in the radio field. Lodge was not too distressed by this, because he looked on the court's judgement as having given him priority for scientific discoveries that had been taken up without approval by Marconi.

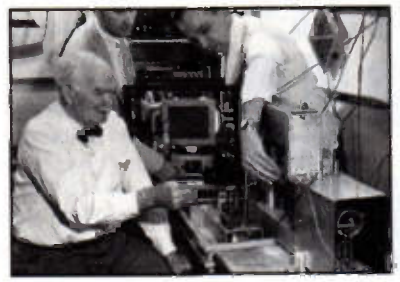
Although the monetary reward could hardly be considered generous, Lodge was content, as he was reasonably comfortable financially. Like Kelvin, he drew an academic salary as the Lyon James Professor of Experimental Physics and Mathematics at Liverpool University. Alexander Muirhead went on to found his own company, manufacturing some of the best telegraphic equipment in Britain. The company - Muirhead Ltd - still trades today, having a formidable reputation in facsimile engineering.

Lee de Forest

The inventor of the triode valve was a classic example of the varying fortunes of a lone inventor. The founder of a number of companies throughout his long life, his first venture began trading in 1900. Two years later a Wall Street financier helped him start the American de Forest Wireless Telegraph Company, capitalised at US $3 million.

Although the new outfit enjoyed some early successes with naval and military contracts, its soaring ambition led to its downfall. As a result the shareholders of de Forest's company closed it down in 1907, and disposed of all its assets, with the exception of de Forest's patents, which included that for the triode valve.

Unconcerned by this, de Forest set up another company, the de Forest Radio Telephone Company, with a working capital of US $2 million. It too enjoyed some success before going out of business in 1911. Two years later, de Forest's fortunes took a turn for the better when the American Telephone and Telegraph Corporation - shortly to become the mighty AT&T - bought the rights to the triode valve as a telephone repeater amplifier, for some $50,000. Later on, the same company bought rights to the valve's use as a radio component also, forking out $90,000 for the privilege!



Always sensitive to patent litigation, de Forest nevertheless fought his corner tenaciously when necessary. One of his battles for example concerned holding the rights to the triode valve as an oscillator. Four men fought over this matter, in which de Forest finally triumphed although as he did so, he found himself involved in yet another patent battle, one that would subsequently prove to be the longest such case in the history of the American electronics industry. This was the long, gruelling fight with that great engineer-inventor Edwin H. Armstrong.

The First Radio Millionaire

Edwin Howard Armstrong was the first man to make a million from radio invention, so far as can be determined. Some time between 1912 and 1913, he discovered the feedback, or regenerative, effect of the triode valve, at the early age of 22.

Sadly, he was slow to patent his discovery and shortly found himself in a patent war with de Forest. Eventually, in 1934, the Supreme Court found in favour of de Forest.

Before this Armstrong had won the first round of the contest in 1917, a victory which prompted de Forest to sell all his patents, and any further valve developments he might make, to AT&T for the substantial sum of $250,000!

By 1920, Armstrong had patented his Superheterodyne Principle, which remains to this day, the basic architectural layout for all radio receivers. He sold this patent - along with the Regenerative Principle - to Westinghouse for more than $335,000, yet retaining the royalties earned from the use of these ideas by amateurs.

In the following year Armstrong sold another of his patents, the one for super-regeneration, to the Radio Corporation of America (RCA), who, in return, gave him a large helping of RCA shares. It was this arrangement that made him a millionaire.

Armstrong's final technical triumph and - it must be said - personal tragedy, came in 1933 with his invention of Frequency Modulation, or FM, an achievement that brought four new patents and years of patent litigation!

Paradoxically, RCA began the 'war' by refusing to recognise any of Armstrong's patents and - no doubt fortified by this stance - smaller companies such as Zenith swiftly fell in behind the giant of American broadcasting.

Armstrong began his legal challenge in 1948, by going for RCA. Five years later he began 20 further suites against other manufacturers and companies. By January 1954, this great engineer-inventor had had enough. He leapt to his death from his 13th floor New York apartment. A further 13 years would pass before his widow was awarded $10 million of overdue payments and royalties, as well as a million dollars from RCA.

Armstrong however had the last word. Just before his death he gave $50,000 to his alma mater, Columbia University, to underwrite research into the success - or failure - of the law in adjudicating in technical matters!

Shortly, the pressures of a world war would introduce a new electronic device to the world: the computer. This piece of equipment would enjoy such a spectacular growth that - to this day - it is still making a great deal of money for many talented individuals. Who, though, made the serious dosh out of this universal workhorse?

References

1: Standage, Tom (1998): The Victorian Internet. Weidenfeld & Nicolson, London. Ch 12, Page 181.

2: Ibid [1], Ch 12, Page 189.

3: Thompson, Silvanus P. (1910): The Life of William Thomson, Baron Kelvin of Largs. McMillan & Co. Ltd., London. Volume II, Ch 16, Page 650.

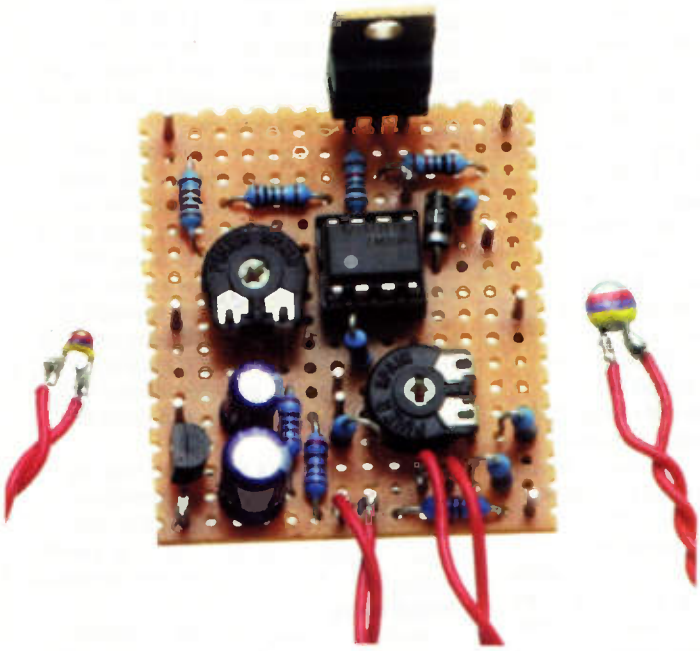
4: Grosvenor, Edwin S and Wesson, Morgan (1997): Alexander Graham Bell: The Life and Times of the Inventor of the Telephone. Harry N. Abrams Inc., New York. Ch 3, Page 51.

5: Aitken, H.G.J. (1976): Syntony & Spark. Wiley Interscience, London. Page 192.

6: Jolly, W.P. (1972): Marconi: A Biography. Constable, London. Ch 10, Page 167.

7: Jolly, W.P. (1974): Sir Oliver Lodge: Psychical Researcher and Scientist. Constable, London. Ch 9, Page 126.

8: Ibid [3], Ch 12, Page 186.



Temperature SWITCH

Gavin Cheeseman describes a compact and versatile temperature switch with integral preset to set the switching point

Introduction

This article describes a simple circuit that switches an output when a set temperature is reached. The switching point may be set using an integral preset control. Unlike a standard thermostat the circuit also features a second reference probe that can be used to determine the switching threshold. Although not intended for precision applications, the Temperature Switch may be used to perform a wide range of temperature control functions.

Circuit Description

The circuit uses thermistors to measure the temperature. The resistance of the thermistor is dependent on temperature and by connecting the device in the circuit such that it forms part of a potential divider, it is possible to derive a voltage that is relative to temperature. A comparator is used to compare this voltage with a reference voltage and the state of the circuit output is dependent on the relative levels.

Figure 1 shows the circuit diagram of the temperature switch. Power is connected on terminals P1(+V) and P2 (0V). Regulator RG1 regulates the power supply voltage to 5V with capacitors C1 to C3 functioning as power supply decoupling. Comparator IC1 provides a switching function. The voltage levels present at the two inputs determine the state of the IC output. IC1 pin 2 is the non-inverting input and in use is connected via R7 to one of two potential dividers, which determine the switching threshold level. Resistor R8 together with variable resistor VR2 Introduces a degree of hysteresis to ensure a clean switching action. VR2 allows the amount of hysteresis to be adjusted. When terminal P5 is connected to P4 the user may set the switching threshold via VR1. Alternatively if P5 is connected to P3 the threshold level depends on the resistance of thermistor TH1; the temperature of the component determines this. Thermistor TH2 forms the main temperature probe. As with TH1, the thermistor is connected as part of a potential divider resulting in a voltage level that is dependent on temperature. This level is applied to the inverting input of IC1 on pin 3. Whilst the voltage level at IC1 pin 3 is greater than that on pin 2 the IC output remains low. However if the level on IC1 pin 3 falls below

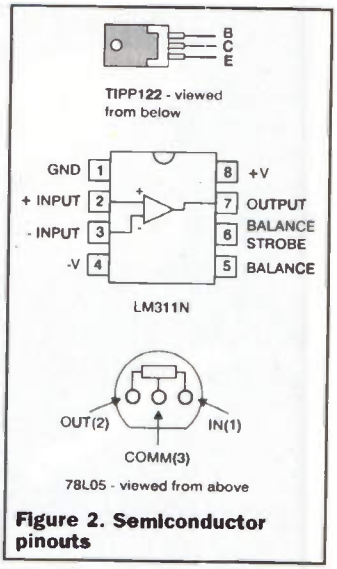


Figure 2. Semiconductor pinouts

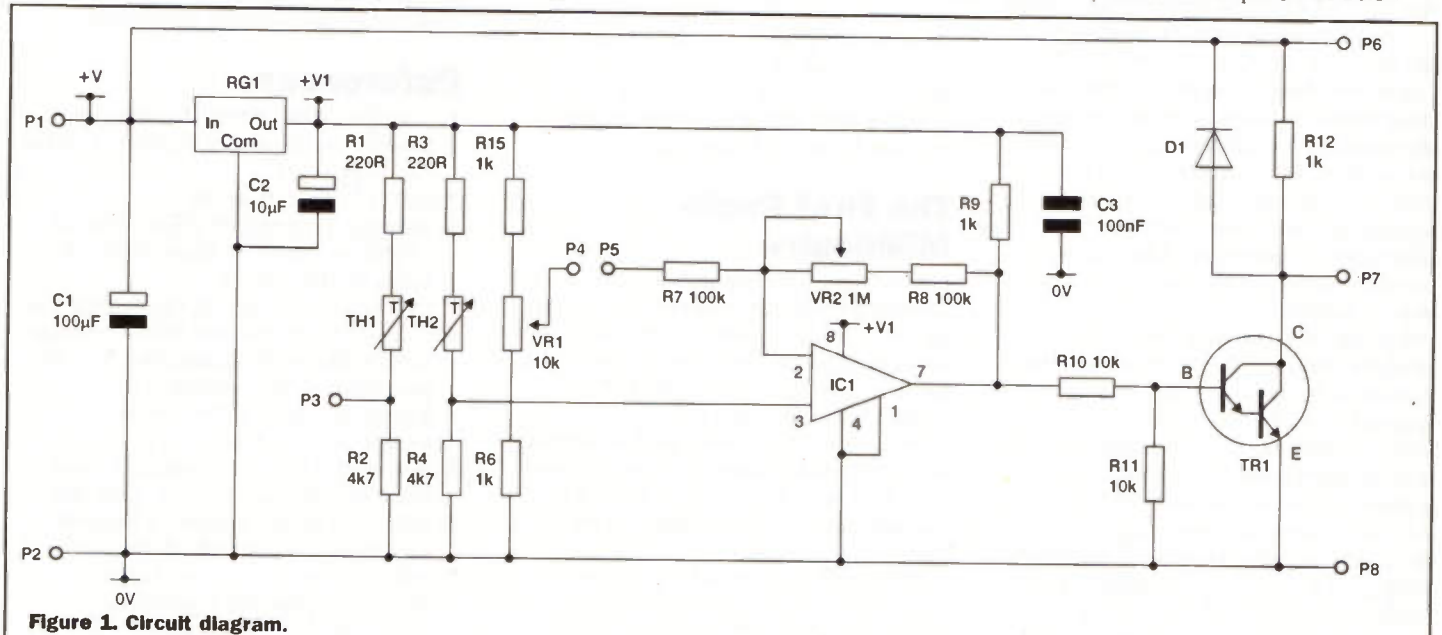


Figure 1. Circuit diagram.

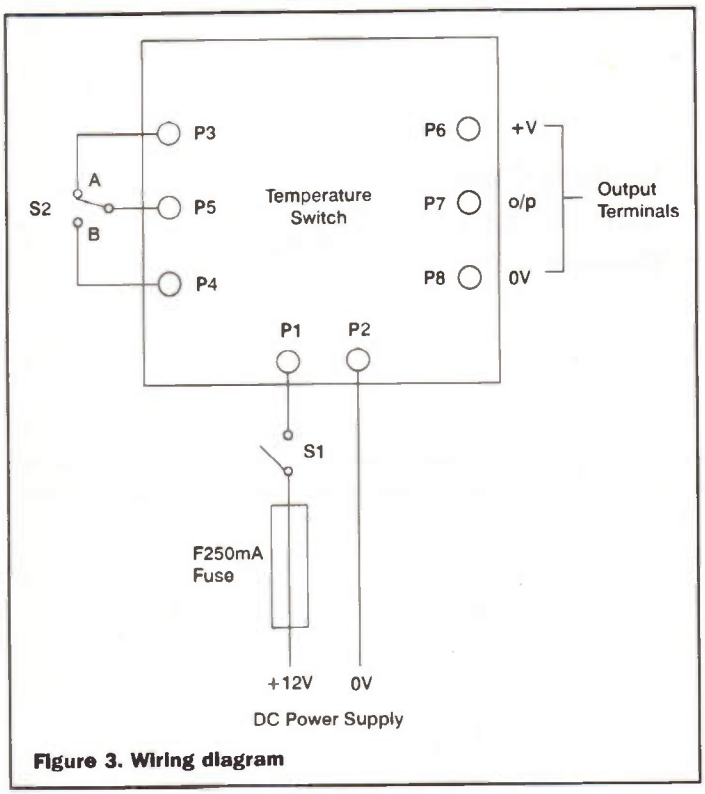


Figure 3. Wiring diagram

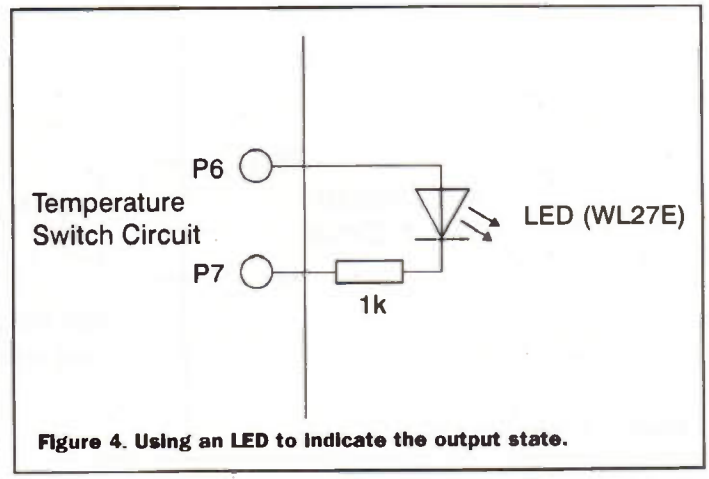


Figure 4. Using an LED to indicate the output state.

that on pin 2 the IC output switches to a high condition. In this state TR1 turns on, pulling terminal P7 low. A relay or other load may be connected between terminals P6 and P7 as required.

Constructing the Temperature Switch

The circuit is simple to construct and is not particularly layout critical. Matrix board is a suitable construction medium. Please make sure that you fit the polarised components such as semiconductors and electrolytic capacitors observing the correct polarity as wrongly connected components will not function correctly and may explode. Figure 2 shows semiconductor pinout information. The negative terminal of electrolytic capacitors is usually indicated by a minus (-) symbol on the component body adjacent to the negative lead.

Thermistors TH1 and TH2 may be wired off board using suitable lengths of hook-up wire. If the connection between the thermistor and the circuit board is longer than a few centimetres, then screened lead should be used. Although terminals for the thermistors are not shown on the circuit diagram, PCB pins may be fitted to provide a secure connection point.

Depending on what you intend to connect to the output of the circuit, TR1 may require a heatsink to aid heat dissipation. Heatsinking is not necessary for low current loads such as most small relays but is essential at higher current levels. Therefore, even if you are only going to switch a few mA, the transistor is probably best mounted close to the edge of the circuit board so as to facilitate the attachment of a heatsink if it is needed at a later stage. PCB mounting preset variable resistors are specified for VR1 and VR2; however, panel mounting potentiometers of the same value may be used if the controls are likely to require regular user adjustment.

After fitting and connecting the components, take time to double check your work. It is much better to discover any mistakes at an early stage than to power up the circuit only to find that components have been permanently damaged.

Testing

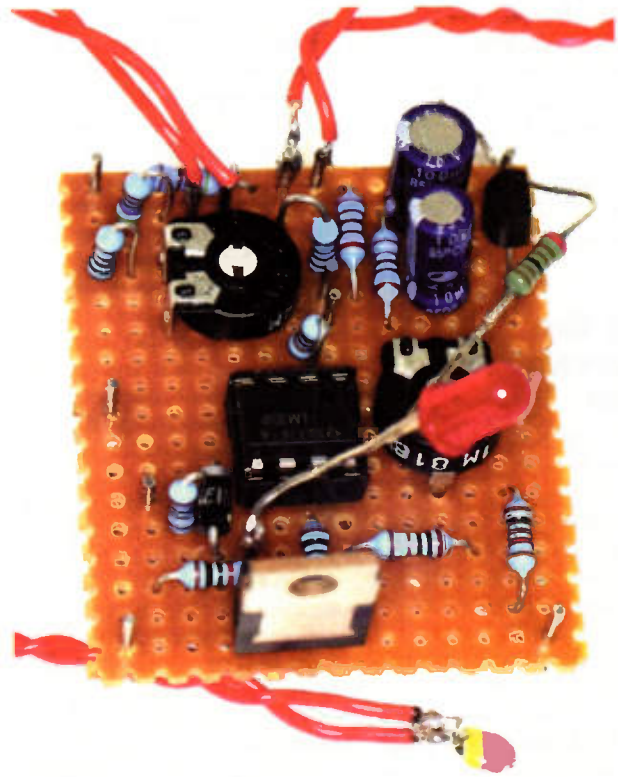
Figure 3 shows the wiring diagram for the temperature switch. It is relatively simple to test the basic functionality of the circuit. You will need some method of indicating the state of the output on terminal P7. If available, an oscilloscope or multimeter will suffice. If not, an LED with a suitable limiting resistor may be used as shown in Figure 4. You may wish to connect the LED as a permanent indicator.

The circuit is designed to operate from a 12V DC power supply. Without a load attached, normal current consumption is in the region of a few mA. When a load is connected, the current will increase depending on the load resistance.

To initially test the circuit set switch S2 to position 'b' (refer to Figure 3). Connect a suitable power supply and close S1. In this mode only TH2 is used to measure the temperature. Allow the thermistor to reach ambient room temperature before commencing testing. At this stage the state of the output is unimportant. Set VR2 to the maximum resistance position and try adjusting the setting of VR1. The state of the output on terminal P7 should depend on the setting of the preset. Set VR1 so that it is just inside the region where P7 switches to the low state (LED on). Gently warm TH2 by a few degrees C. The output (P7) should switch to the high state (LED off).

Once the output has switched, allow the thermistor to cool. As the device returns to its original temperature the output should switch back to the low state (LED on). Before the output will revert to a low condition it will be necessary for the thermistor to cool to a temperature somewhat less than the point at which the output switched high. This is because of the hysteresis designed into the circuit. Adjusting preset resistor VR2 will vary the degree of hysteresis. Change the setting of VR2 and repeat the test procedure. Lower resistance settings should result in a greater difference between the temperature at which the output switches high and that where it switches low.

Change the setting of switch S2 to position 'a' and return VR2 to the high resistance



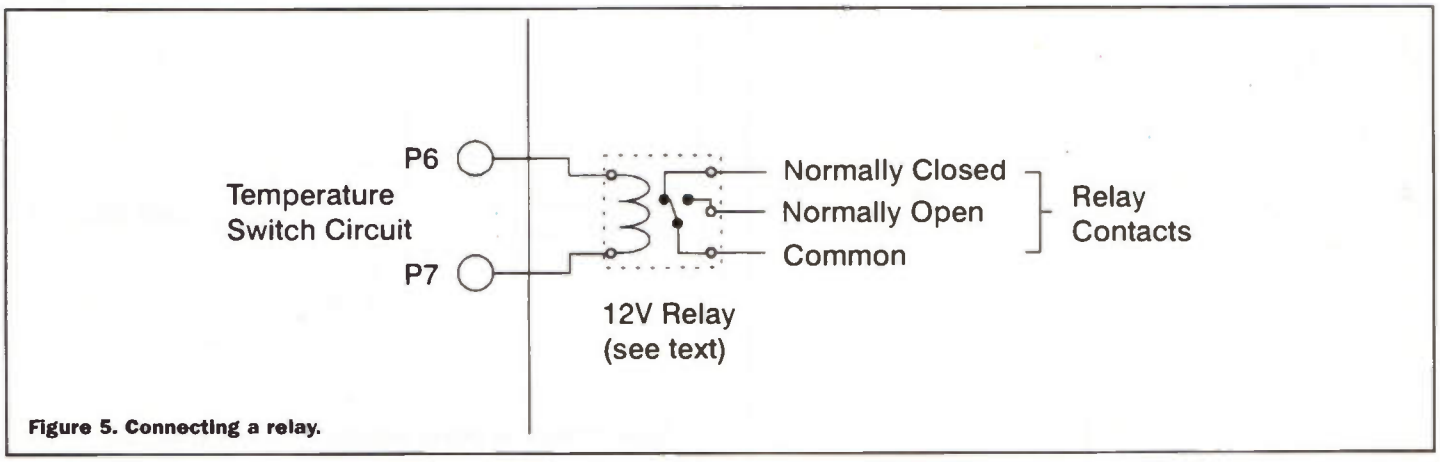


Figure 5. Connecting a relay.

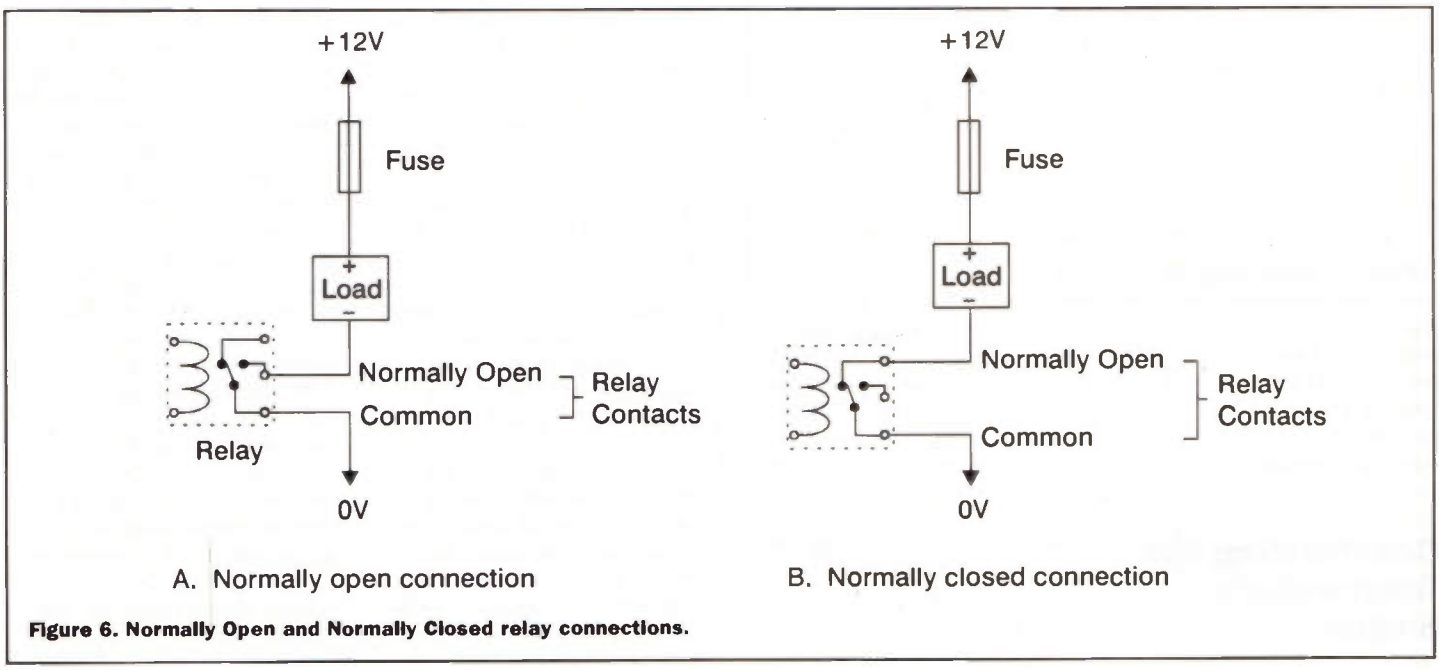


Figure 6. Normally Open and Normally Closed relay connections.

position. In this mode the switching threshold of the circuit is determined by the resistance of thermistor TH1 as opposed to the setting of VR1 (VR1 is not used). The temperature of the two thermistors is compared. If the temperature at TH2 is sufficiently higher than that at TH1, the output (P7) should switch to high (LED off). There will be some variation due to tolerances.

Using the Temperature Switch

The circuit can be used in a wide range of applications requiring temperature controlled switching. Loads that are suitable for 12V DC operation may be connected directly between terminals P6 and P7 as long as the current drain is not excessive (the load current should not exceed 200mA). Please make sure that the load is connected observing the correct polarity where applicable (P6 positive). Higher current loads may be directly connected to P7 but because the main fuse is rated at 250mA, a separate (fused) +12V supply will be required. When the load is connected to a separate positive supply line, D1 and R12 should be omitted. If the load is inductive a suitable diode should be connected across the load to limit voltage transients. As with D1, the diode should be connected such that it is reverse polarised (cathode positive).

As mentioned, TR1 may require a heatsink depending on the current consumption. Readers are referred to the manufacturers data for TR1 (TIP122) when determining precise heatsinking requirements. In most cases it is probably best to use a suitably rated relay to switch high current loads. Figure 5 illustrates how to connect a typical relay. Similarly, if the load requires a voltage other than 12V DC, use of a relay or other isolated switching device is essential. Specific relays have not been discussed here as many different types are available (see current Maplin catalogue). It is important to make sure that the relay is correctly rated for your application. The coil should be suitable for operation from 12V (<200mA). The contacts must be capable of handling the voltage and current levels you intend to switch. It may be necessary to fit a suitable RC network to the contacts to prevent excessive arcing. Additional fuse protection will normally be required for the load.

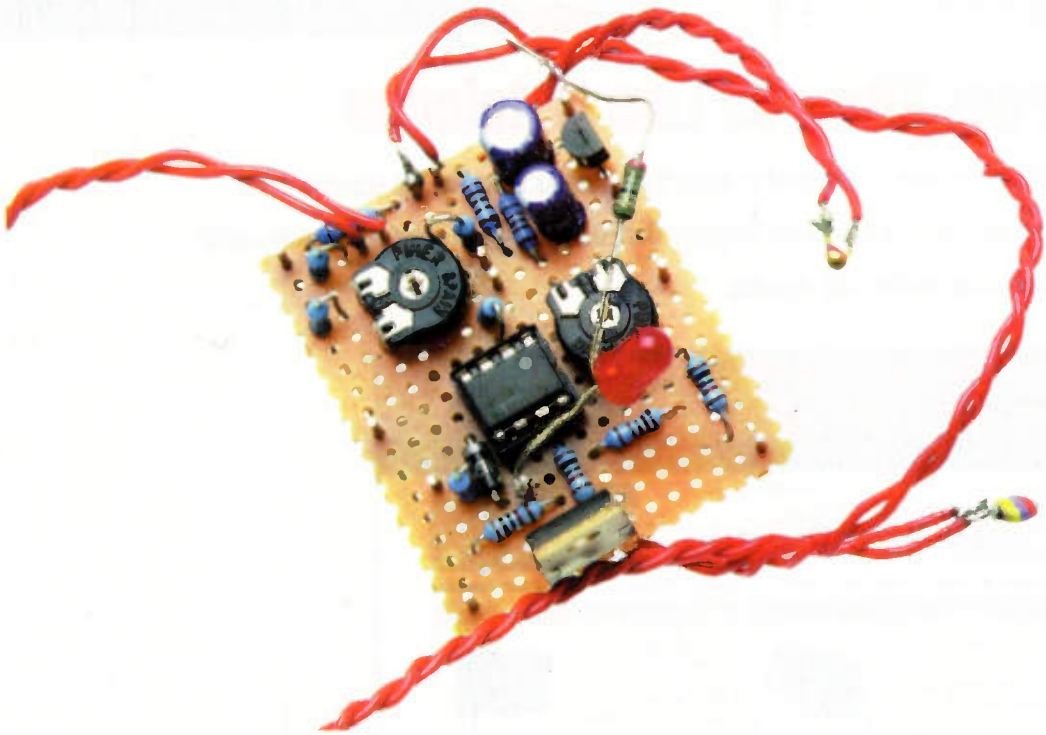
The relay contacts are connected in series between the power supply and the load in a similar way to a standard switch. Relays of the type illustrated in Figure 5 feature both normally open and normally closed contacts. Figure 6 shows typical connection configurations using the example of a polarised load operating from a 12V DC supply. In example 'A' power is connected to the load when the relay is energised. Conversely in example 'B' power is disconnected from the load when the relay is active.

Important Note

Under no circumstances should the temperature switch be directly connected to the 230V mains supply. Even when using a relay, there are significant hazards relating to mains operated equipment. Unless you are fully familiar with the relevant European electrical safety standards, professional advice should be sought before attempting to switch voltages exceeding 50V. The temperature switch should not be used in safety critical applications where incorrect operation may result in a hazard.

Application ideas

One advantage of this circuit over many thermostats is that the temperature probes (thermistors) may be positioned remotely from the control circuit. So the two probes can be in completely separate locations. In this way it is possible to control the



temperature at one place such that it tracks the temperature at another. Similar arrangements may be used to control the temperature of fluids in two separate containers. It would of course be necessary to ensure that the temperature probes, control circuit and wiring are suitably protected so that they do not come into direct contact with the fluid.

The Temperature Switch may be used to regulate the temperature within a piece of equipment in order to help maintain stable and reliable operation. For example the circuit may be used to switch on a fan when a given temperature is reached. This helps to ensure that the components are operating at the optimum temperature and may, in some circumstances, result in increased service life. Similar arrangements can be advantageous where the equipment contains oscillators or other circuits that benefit from operating in a temperature controlled environment. The relevant components are normally contained in a separate enclosure to the rest of the circuit. A small heating element may be used to raise the temperature within the enclosure by a few degrees C above ambient temperature. The temperature of the circuit can then be maintained within specific limits independent of the external environment using a circuit such as the Temperature Switch. Of course, depending on the level of hysteresis, there will always be some fluctuation in temperature. To reduce this effect, VR2 should be set to provide the minimum degree of hysteresis. If even less hysteresis is required, The value of resistor R8 may be increased. However, if the hysteresis is reduced too much the circuit may no longer provide a clean switching characteristic.

Simple Temperature Alarm

In another application, a small piezo buzzer may be connected to the circuit creating a simple temperature alarm. The alarm will sound if the temperature falls below the threshold level set by VR1. When correctly set up, this type of arrangement may be used to provide a warning if the temperature drops, increasing the probability of ice. Conversely the output sense may be reversed using a relay, if you want the buzzer to sound when the temperature increases beyond a predetermined level.

Temperature range

The operating range of the circuit is mostly dependent on the type of thermistors used. The thermistors specified theoretically operate between approximately -40°C and +125°C, but the circuit was designed for use around the centre of this range. In practice, accurate threshold setting may be difficult, at the high temperature end. The values of resistors R1-R4 may be adjusted to optimise operation over different parts of the specified temperature range. It is advantageous to keep power dissipation to a minimum. Where lower resistor values are used, care should be taken not to exceed the maximum power ratings for the thermistors (250mW). The temperature rating of the wiring etc. used to connect the thermistors to the circuit must also be taken into consideration. The Temperature Switch control circuit is intended for operation at room temperature and should not be exposed to excessively high or low temperatures.

The circuit is not calibrated. In the 'two probe' mode calibration is not usually needed. When using a single probe, it may be necessary to calibrate the circuit depending on the application. If necessary, it is possible to calculate the approximate setting of VR1 so that the circuit switch will switch at a specific temperature. The resistance of the thermistor corresponding to a given temperature may be approximated from manufacturers' data for the thermistor in use. However, in practice probably the easiest way to set up a simple circuit of this type is by trial and error. Warm the thermistor to the temperature at which the circuit is required to switch, then adjust VR1 until the output changes state. If you have access to a thermometer, the various settings of VR1 corresponding to different temperatures can be marked. This is useful where VR1 is a panel mounted control. The accuracy of the temperature switch is dependent on component tolerances. The components specified are suitable for many general-purpose applications but if more accuracy is required, closer tolerance components may be substituted.

PROJECT PARTS LIST

RESISTORS:			
R1, 3	220R	2	M220R
R2, 4	4k7	2	M4K7
R5, 6, 9, 12	1k	4	M1K
R7, 8	100k	2	M100K
R10, 11	10k	2	M10K
VR1	Hor Encl Preset 10k	1	UH03D
VR2	Hor Encl Preset 1M	1	UH09K
TH1, 2	Thermistor 4k7	2	FX21X
CAPACITORS:			
C1	GenElect 100µF 16V	1	AT40T
C2	GenElect 10µF 63V	1	AT77J
C3	Minidisc 0.1µF 16V	1	YR75S
SEMICONDUCTORS:			
RG1	78L05ACZ	1	QL26D
IC1	LM311N	1	QY09K
TR1	TIP122	1	WQ73Q
D1	1N4007	1	QL79L
MISCELLANEOUS:			
	DIL Socket 8-Pin	1	BL17T
P1-8	Pin 2145	8 Pins	FL24B
	20mm QB 250mA 10 PK	1 Fuse	GJ84F

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Software HINTS & TIPS

by Mike Bedford

Processing scientific documents requires some special skills. Here we look at how to create and edit equations in Word 97.

A while ago we investigated how to create professional looking mathematical and scientific documents in Word. One area we touched on was equation editing but since this is so important to technically minded users, we've decided to address the subject in a bit more detail here. Traditionally, PC users have tried to depict equations using the basic facilities available in any word processor, which has invariably meant trying to cram all equations onto a single line. It can be done but it often requires lots of brackets and it doesn't look at all professional. The following is an example of an equation formatted this way: $1/(2\pi\sqrt{(LC)})$. OK, perhaps you could try to format it on a pair of lines but unless you use a fixed width font alignment it would be difficult, and it would be very easy to destroy the formatting in subsequent editing. On many of today's word processors there's a much better way of creating equations yet many users seem to be unaware of it. Here we look at the equation editor in Word 97. In fact, this is an MS Office applet that means it can also be used in other applications - Excel and Power Point, for example.

An Example

To set the ball rolling, I'll describe, in a step by step manner, how to create the equation I presented earlier.

Open a new Word document and from the Insert menu select Object... > Create New > Microsoft Equation 3.0. Conceivably your system might have a different version of the equation editor but they're all essentially the same. The equation toolbar will appear and you'll also find that a shaded box will appear at the cursor position with a dashed box inside it as shown here.

The shaded box encloses the entire equation and will expand as necessary as you create the equation. The dashed boxes (you might end up with more than one as the equation builds up) are place holders into which you can type of add equation templates. You'll find that the cursor is already inside the place holder so click on the Fractions and Radicals icon on the equation editor toolbar (second from the left on the bottom row) and the following menu will drop down:

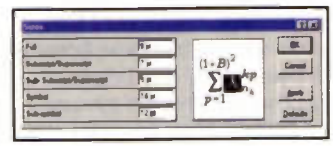
Click on the top left hand icon which is for a fraction with the numerator immediately above the denominator. The single place holder will be replaced with a pair of place holders and a horizontal fraction line between them. The cursor will already be in the top place holder so type "1". Now click in the bottom place holder and enter "2π" (the π is in the lower case Greek letters menu which will appear if you click on the appropriate icon on the equation editor toolbar). Now pull down the Fractions and Radicals menu again but this time click on square root. The equation will look like this:

The cursor is in the placeholder under the square root sign so type in "LC". Finally click anywhere outside the shaded box which encloses the equation. The equation editor toolbar will disappear, and you'll find the following properly formatted equation in your document. You'll also notice that, whatever font you were using for the text in your document, Times New Roman will have been selected for the equation, and that letters will be italicised, except for letters which form a function name such as sin or cos. All of this corresponds to the normal conventions for formatting mathematical equations.

$$\frac{1}{2\pi\sqrt{LC}}$$

Customisation

If you've worked through this example, with a bit of practice, you should be able to create just about any equation imaginable. All you have to remember is that you can type any text into a place holder and you can also put any equation template (which will often have its own place holders) inside a place holder. What won't be as obvious, though, is how to customise the equation editor to produce equations, as you want them to appear.



So far we've accepted the default settings and these will be OK in many cases. However, let's assume that we're creating a document with large lettering for use as an overhead projection foil. Perhaps we're using 36 point for the text but you'll find that, unless you've changed the settings, any equations you produce will use a much smaller point size. You can stretch the equation once you've produced it but this is a rather hit and miss affair. A much better solution is to tell the equation editor what sizes of text to use for the various parts of an equation. So, from the Size menu (notice how the menu bar changes when you're editing equations) select Define... and the following dialogue box will appear.

Now you can define sizes for full-sized text, sub-/super-scripts, sub- sub-/super-scripts, symbols and sub-symbols. And if you don't know what these mean, just click on the name and the corresponding text will be highlighted on the sample equation.

The other area of customisation we should look at concerns the automatic formatting of different elements of the equation. We've already seen that variable names are normally in Roman Italics and that function names are in Roman non-italic. And although the equation editor knows that sin, cos and tan are functions, it wouldn't know about user defined functions. So, if you had defined a function called myfun the equation editor would see it as five separate variable names multiplied together and would, therefore, format them in Roman Italics. But you can change this. After you've typed in the function name, select it and then select Function from the Style menu.

It's also possible to change the fonts and formatting (i.e. italics and bold) which are used for variables, functions, numbers and so forth. Although Times New Roman is pretty much the de facto standard among mathematicians, you may just choose to use something different if you were using a different font for the main text in a document. To do this, select the Define... option from the Style menu. Although I wouldn't really advise using a really bizarre font for equations - after all legibility is paramount here - the following example hints at what can be done, if you really insist.

$$\sum_{x=0}^{\infty} \theta^x = \frac{1}{1-\theta}$$

Finally, a couple of tips to close. First, you'll find that you can't enter spaces within the equation editor. To space out your equation correctly use the various fixed-width spaces which are available under Spaces and Ellipses (top row, second from left). And finally, you'll find that some of the templates have what appear to be shaded out placeholders (look under sub- and super-scripts, for example). These allow you to add something (in this case a sub- or superscript) to something you've already typed.

RESEARCH NEWS

by Dr Chris Lavers

Breast Cancer Screening Aid Cleared for Diagnostic Use

The war against breast cancer has just received a powerful new weapon in the battlefield with the arrival of a new advanced sensor developed by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. Research News has previously reported on a number of world-first developments in the fight against cancer including: the UK Lung Cancer Centre and Erlangen University in Germany (March 1999) and a medical detector developed by Philips Research Laboratories in Eindhoven, the Netherlands (June 1998).

The new device, called the BioScan System™ , was developed by OmniCorder Technologies, Inc., Stony Brook, New York and has just been allowed to market their device commercially by the US Food and Drug Administration in December 1999.

Recent studies have shown that human cancer cells produce detectable levels of nitric oxide. The nitric oxide causes changes in the blood flow of surrounding tissue which in turn cause consequent temperature changes in the surrounding tissue which may be detected by the diagnostic and monitoring sensor. The BioScan System™ is sensitive to temperature changes of less than 0.015°C and has an imaging capability of over 200 frames per second. The patient experiences no discomfort throughout the monitoring process and an additional benefit of the new system is the absence of any ionising radiation required to create the body image, as the sensor is entirely passive in its operation.

"Clearance for use of this non-invasive diagnostic tool is an important milestone for us," says OmniCorder president Mark Fauci, who noted that the device has also been cleared to be marketed for other applications. Dr Sarath Ghunapala, principal engineer of JPL's Device Research and Applications Section, invented the sensor, called the Quantum Well Infrared Photodetector (QWIP). The digital sensor detects the infrared energy emitted from the body, thus 'seeing' the minute differences associated with blood flow changes. Earlier versions of QWIP had other applications, such as locating hot spots during fires and observing volcanoes. It is quite an exciting development, as QWIP's were first discussed in Electronics and Beyond back in June 1998 (whilst covering Thermal Imagers). QWIPs are based upon GaAs semiconductor technology, engineered for a peak spectral response between 3-19μm with 0.4 to 0.5μm bandwidth. The first systems included 128 by 128 pixel arrays. Infra red photodetectors made from these materials are now providing a new generation of IR cameras and night-vision devices with superior performance and presently unmatched quality.

GaAs/InGaAs materials are fabricated into large 2-dimensional arrays sensitive to both the Middle Infra Red band (3-5μm) and Far Infra Red band (8-13μm) which are 'windows' for the atmospheric transmission of heat energy. QWIP systems were originally suggested with obvious military observation applications in mind, particularly satellite based platforms, but the transition into medical applications has followed a now long established tradition.

"It is a great pleasure to see something I invented being used for public benefit,' says Dr Sarath Gunapala, 'especially in medicine and even more so in the early detection of cancer." The BioScan System™ allows the physician to obtain immediate diagnostic information on the patient and chart the progress of the patient's treatment.

Light Illuminating Darkness in the 21st Century

The role of optics already reaches across almost every field of science and technology, from the modern high-speed wired fibre-optic communications networks that span the globe, to high-power laser robotic systems used in the automated fabrication of car bodies and within non-invasive key-hole surgery.

The guiding of light by Total Internal Reflection (TIR) has been noted for many centuries with theoretical treatises on the phenomenon noted by scholars such as the Arab Al Hazen in the 7th-8th Century and by Snell in Renaissance Europe. However the history of fibre optics is a much more recent event. The first recorded use of a fibre optic bundle to transmit an image was by a Munich University medical student, Heinrich Lamm, quick to see the possibility in medical applications. Partly through the impurities within early fibres, and high intrinsic fibre losses little progress was made until cladding the fibre with a lower refractive index glass was introduced. This step significantly cut down fibre loss. Within a decade the first recognisable fibre-optic endoscope was demonstrated by Larry Curtiss, another undergraduate, this time a physics student at Michigan State University. However fibre losses were still painfully high, almost 1000dB/ km! The next decade would see a steady and sometimes dramatic reduction in fibre losses to the current level well below 1dB/km.

In 1994 it was estimated that the capacity of telecommunications networks would double each year to cope with expected growth in the then new medium known as the Internet for data traffic, voice communications and multimedia. In reality actual capacity growth has nearly tripled every year, often outpacing the ability of the Internet's expansion to keep pace with demands placed upon it. One route taken in an attempt to stay ahead of the game has been the search to develop Dense Wavelength Division Multiplexing (DWDM) systems. Wavelength Division Multiplexing allows considerably more information to be carried down each fibre. An optical filter divides the incoming single into discrete wavelength bands, which serve as separate information channels. These bands can then be combined or multiplexed to transmit several information channels down a single fibre.

Essential to this concept are the optical filters used to separate the signal into separate wavelength bands, which can be as narrow as 1nm, requiring very exact fabrication methods for stable optical coatings.

In the last year, researchers at the Optoelectronics Research Centre (ORC) in Southampton, lead by Dr Anatoly Grudinin, and Dr Michael Zervas have introduced a series of novel components and devices onto the global telecommunications market. The group has developed a WDM transmitter, amplifier and high-power, fibre laser system. With the current expansion rates of optical systems already mentioned, the apparently unfillable 30 Tera Hertz available optical fibre bandwidth is now expected to be inadequate beyond 2005. Running out of fibre bandwidth does not signal the end of the optical fibre revolution but the beginning of an era of sophisticated bandwidth control and allocation. This has happened in previous transmission media such as AM and FM. Compact and reliable high power transmitters and amplifiers suitable for dense WDM systems are in demand with

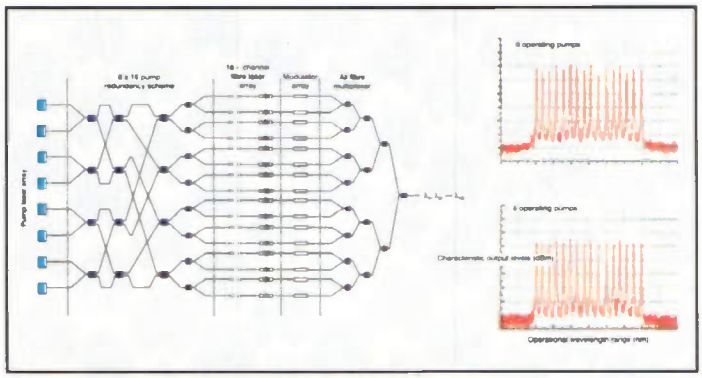


Figure 1. Schematic of WDM Device. Courtesy ORC Southampton University, UK.

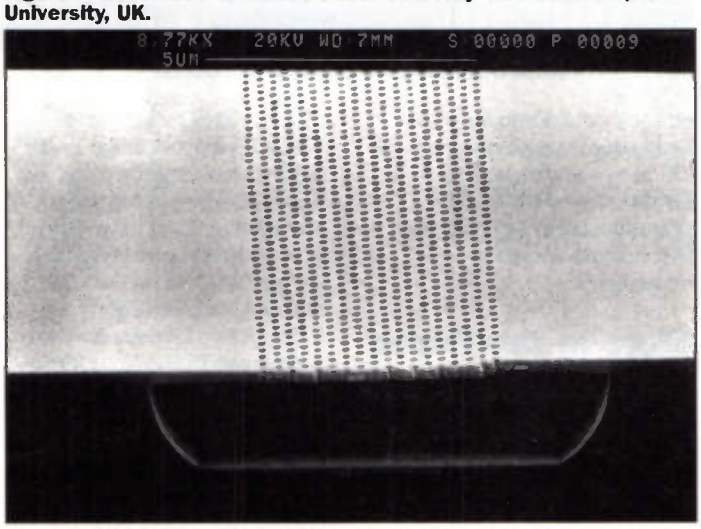


Figure 2. Photonic Band Gap structure in silicon nitride. Courtesy Dr Martin Charlton.

current systems based on semiconductor- Distributed Feed Back (DFB) laser technology. This consists of the direct one-to-one connection of a laser to a WDM channel. The Southampton system works on a distributed arrangement of lasers. The output power from the ORC developed fibre lasers is 25mW and the devices are as small as 5cm in length, ideal for compact packaging. The recent launch of the independent ORC spin-off company Southampton Photonics Ltd (SPL) demonstrated a fibre laser 8 x 8 channel having 100GHz bandwidth, and a 8 x 16 channel 50GHz all-fibre laser prototype WDM transmitter module with integrated laser pump redundancy. The pump redundancy protects against catastrophic failure if one or more laser diodes fail, as all pump channels are connected and distributed to the output through the entire scheme. When operating the prototype modules, the failure of 1 out of 8 pump lasers was only 2dB in output power. All the WDM channels remained in operation despite the drop in input to only 7 out of 8 original pump-diodes (see Figure 1), giving rise to a more graceful degradation of the communications architecture.

We have also seen the development of Photonic crystals in the last five years, and some really interesting new materials, with intricate 3-D structures that allow light to be manipulated in unusual ways, thanks to multiple Bragg diffraction. The structure has the scale of the order of the wavelength of light, and diffracts light in a similar way to X-ray scattering from crystal lattices. In the near future, such photonic crystals or Photonic Band Gap (PBG) materials will be used to guide light beams around tiny optical chips or to produce powerful light emitters. If the crystal structure has a big variation in refractive index, a 'photonic' bandgap occurs. Under these conditions Bragg diffraction prevents a precisely controlled range of wavelengths from propagating in any direction inside the crystal. As a consequence, if the crystal is a lasing material spontaneous emission of an excited atom inside the crystal is completely inhibited. We reported in October 1998 on Dr Martin Charlton's work at the Department of Electrical and Computer Science also at Southampton University, had developed PBG materials within waveguides themselves, see Figure 2 (a honeycomb of air holes etched through the cladding and core of a silicon nitride waveguide). The waveguide is undercut by an airgap forming a bridge! The pore diameters vary between 135nm in the silicon nitride core to 250nm in a lower silicon dioxide layer. The waveguide consists of 1.8μm thick silicon dioxide (n=1.46), and a 250nm silicon nitride waveguide layer (n=2.02). In Figure 3 a green 545nm wavelength is seen to transmit successfully through the silicon nitride waveguide.

The next obvious step was to include PBG structures into optical fibres for potential applications such as WDM as mentioned earlier. Another group at Bath University led by Dr Jonathan Knight has successfully produced a silica fibre containing a matrix of holes which again contains the periodic structure necessary to generate PBG structures for precise wavelength control and filtering (see Figure 4).

From the start, applications have been an important driving force for photonic crystals since the first theoretical work led by Eli Yablonovitch at Bell Communications Research in 1987. A group at the University of Ghent in Holland has fabricated PBG Light Emitting Diodes that are able to convert electricity to light with a staggering 22% efficiency. Line defects in a photonic bandgap material have been used to route light around sharp bends, on the scale of a wavelength with little or no loss, and the same effect has been demonstrated in the microwave (cm) region of the spectrum at Sandia National Laboratories in the United States. A recent development at the University of Toronto has demonstrated a photonic crystal with a tunable bandgap. Researchers produced an array of silicon within an artificial opal. Wavelengths between 1.38-1.62μm would not propagate in the crystal.

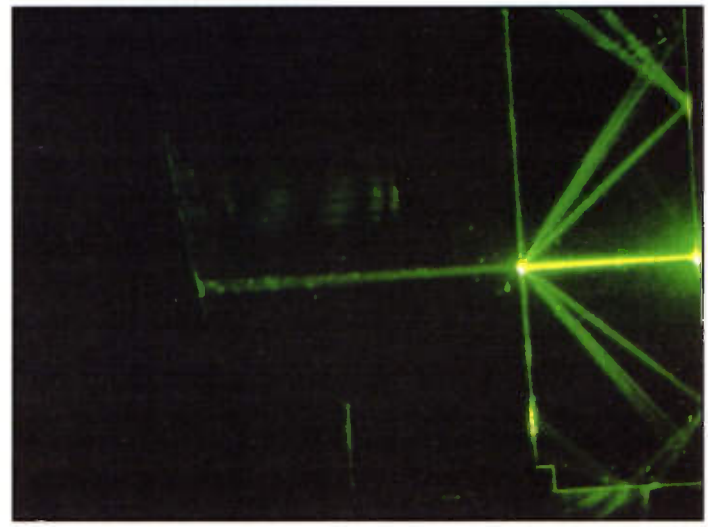


Figure 3. Transmission of green light through a Photonic Band Gap material. Courtesy Dr Martin Charlton.

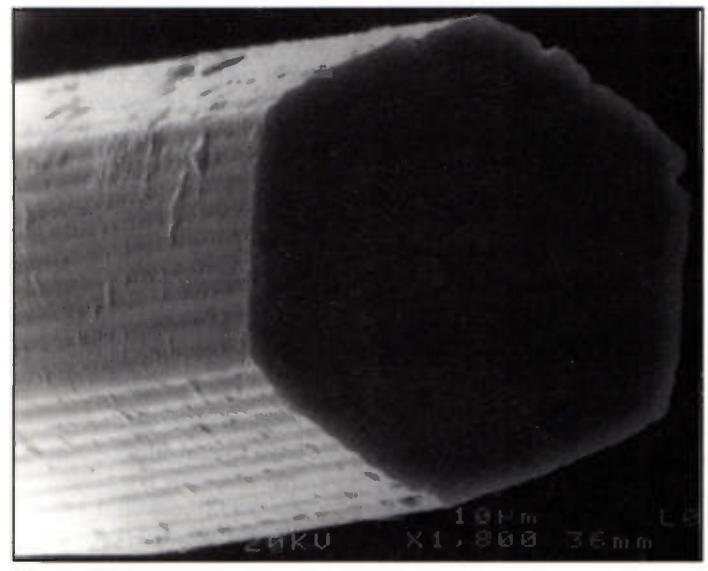


Figure 4. Silica fibre including air holes. Courtesy Dr J Knight Bath University.

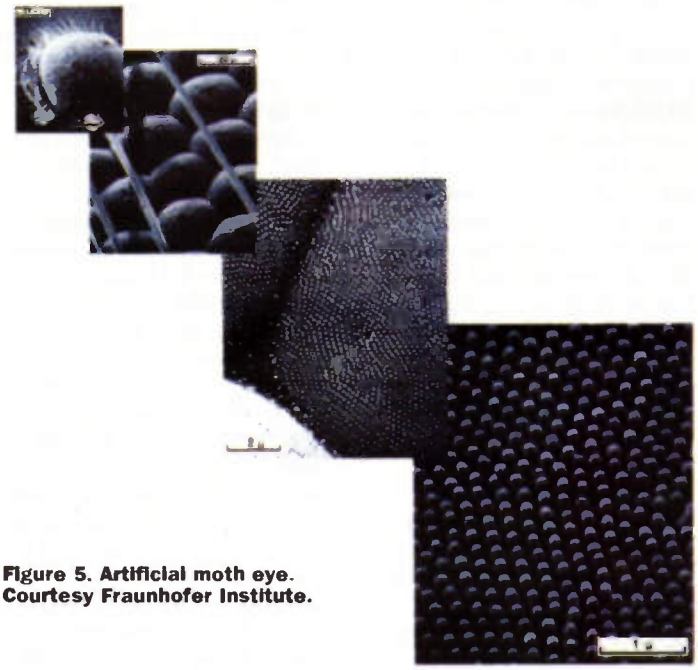


Figure 5. Artificial moth eye. Courtesy Fraunhofer Institute.

However, coating the internal opal surfaces with BEHA, a low index, nematic liquid crystal, allows an electric field to change the propagation behaviour. If low-cost production and high-performance can be achieved a significant step forward will have been achieved for controllable 21st Century optical technology.

The Fraunhofer Institute in Freiburg, Germany, has this month announced their development of an artificial moth eye structure (see Figure 5) which resembles a real moth-eye cornea (see Figure 6), with application to anti-reflective surfaces in overhead projectors and beam projection systems, as well as achieving some interesting surface properties. The structures are so fine that the human eye cannot see them. The specifically tailored micro-structures, called moth-eye structures, ensure that more light is transmitted through a Fresnel lens. The micro-structure lenses are produced by superimposing two laser beams on a photo-sensitive resist, rotating the photoresist plate by 90° and exposing a second time. It is developed and tiny

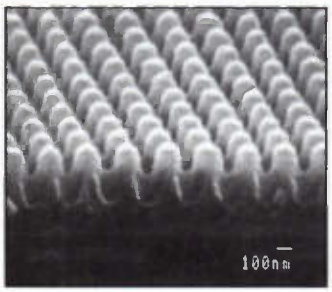


Figure 6. Real moth eye. Courtesy Fraunhofer Institute.

3-D moth-eye structures are found to exist. These structures are then replicated by embossing as a stamp covering up to a 40cm by 40cm area, producing anti-reflective surfaces on large areas quickly and economically. Incidentally the serendipitous nature of research benefiting other completely unexpected areas has shown that these so called 'functional' surfaces can also repel dirt, another effect found in nature. The botanist Professor Wilhelm Barthlott from Bonn discovered this secret in the lotus flower (see Figure 7) and Freiburg scientists are now transferring the self-cleaning effect to polymer surfaces. The dirt-repelling property is based on two factors, a micro-structure and a water-repelling (hydrophobic) surface. The micro-structure reduces the contact area for dirt particles so that dirt only lies loosely on the self-cleaning surface and is easily removed by rapidly rolling water droplets, as found in rain! Dr Andreas Gombert explained to me that his group of 14 including students had been working on these areas intensively since 1994. Andreas felt that the most challenging aspect was to create such fine structures over large areas and believed these moth-eye structures will be used in polymer lasers and light distribution surfaces for daylighting applications. The smallest microstructure they have made so far is a grating with a period of 200nm. Dr Gombert explained that moth-eye structures can be up to 10 times cheaper than current interference coatings and are

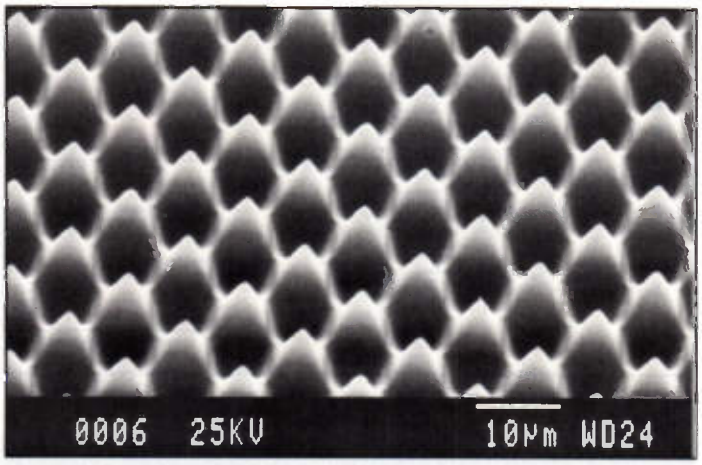


Figure 7. Lotus petals. Courtesy Fraunhofer Institute.

better than existing industrial scale plastic optical components. The next significant step forward is to develop 3-D photonics band gap materials that operate at optical frequencies.

Fibre in the Home

The ultimate goal of fibre technologists is to bring fibre for all its applications into the homes of consumers. The first fibre to home experiments took place in Japan back in the late 1970's. Fibres may bring in not only simultaneous two-way phone conversations, data, interactive TV, and Internet facilities, but may guide super efficient optical lighting with high-power LED's around the home. In fact the use of light emitting gallium nitride LEDs may oust bulbs as the usual illumination sources.

Phillps Research in Holland has developed PolyLEDs for high-contrast and high-brightness displays. Philips LEDs use polymers in a PolyLED device, which has a thin-film semiconducting polymer sandwiched between two electrodes. A relatively small voltage applied over the semiconducting layer results in recombination of charge carriers and causes light to be emitted. Tailoring the material properties of the polymer can produce light in full colour. PolyLED devices can be made easily over a large-area and are light-weight, requiring only a low-voltage. They have a low-power consumption, are both flat and thin, and yet do not have any viewing-angle dependency. Devices have now passed the 15,000-hour lifetime landmark for small segmented and matrix displays. Compared to other display techniques PolyLED displays should allow Philips to capture a considerable part of the US $B2.5 market for small and medium-sized displays, used in telephone handsets, calculators, watches and car dashboards. Tailoring the semiconducting polymer materials makes light of all colours possible (see Figure 8). PolyLEDs can be used individually and in active and passive matrix displays. More greyscales can be realised in PolyLEDs than in existing LCD displays because PolyLEDs are current driven whereas LCD's are voltage-driven. It will be interesting to see whether this significant technology development will steal the market from the competition.

Light Making Sense

Optical fibres of the future could be used in quite novel and unexpected ways. Light

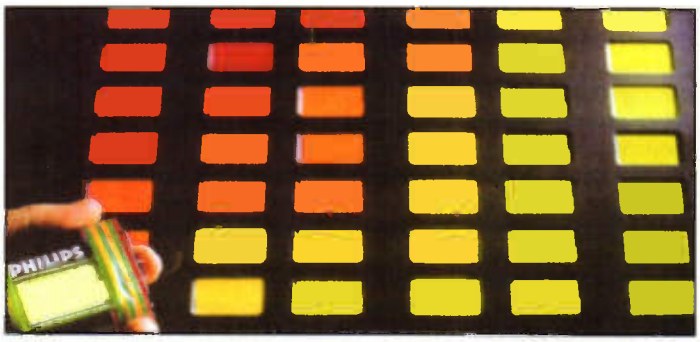


Figure 8. PolyLEDs Tailoring the semiconducting polymer materials makes light of all colours possible. Courtesy Philips Research.

guiding 'fabrics' made from interweaved glass fibres are creating new 'self-sensing' composite materials that can be used to monitor changes in temperature, stress or moisture in buildings. A team at Cranfield University uses glass fibres with a core diameter less than 10μm that may be woven into fabric or embedded into a building to measure stress changes in set concrete. Perhaps optical fibres embedded within clothes fabric will offer greater scope for future fabric design.

Many groups world-wide are concentrating on developing optical fibre environmental sensors, such as Dr Rekha Philip-Chandy's group at John Moores University in Liverpool. His group has developed several devices including an optical fibre pH sensor, fluorimeter, and a flow sensor using an optical fibre strain gauge. Rekha's strain gauge system has an optical fibre sensing head with a bendable fibre. The fibre has been designed with grooves inserted into a multimode plastic fibre. As the fibre bends the variation in angle of the grooves causes an intensity variation in the transmitted light. These changes are related to fluid flow. The flow sensor has been tested in a wind tunnel in airflow to generate both the magnitude and direction of the air velocity. The flow sensor has a repeatability of 0.3% and a measured wind velocity up to 30m/s with a resolution of 1.34m/s and a directional resolution of 5.9°. Optical fibre flow sensors are considerably more compact than existing devices and due to their small inertia can measure gusts and rapid changes in speed, requiring little maintenance in the field due to their lack of moving parts.

Compact Optical Lasers

The microminiaturisation of Lasers, unlike the first Ruby Laser demonstrated by Maiman, has been made possible by the development of Laser Diodes. Since the first GaAs laser diode developed by General Electric Research Labs in 1962 semiconductor lasers have moved into many lucrative consumer areas such as printing, optical recording, free-space communications and medical applications. These devices offer minimal power consumption and room

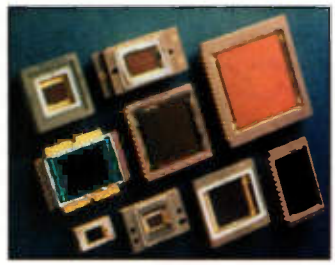


Figure 9. Full-frame image sensor. Courtesy Kodak.

temperature output power levels over 1W in pulsed operation, with Continuous Wave (CW) operation soon set to follow.

In the UK a new laser engineering centre was recently opened in Birkenhead based upon the expertise of the University of Liverpool's laser group. The Lairdside Laser Engineering Centre includes Nd:YAG, carbon dioxide laser systems and will join the rush to develop applications based lasers of the future.

Astucia, a company in Nottinghamshire has developed an active optical cat's-eye sensor which can be embedded into the road surface and can detect the subtle differences between ice and rain or foggy conditions. Studs are fitted with solar-powered LEDs which can be seen up to 900m away, significantly further than traditional cat's-eye reflectors which have a maximum range of less than 100m. Apparently, Astucia studs require only a couple of hours of daylight during the winter period to power them successfully at night. Astucia's studs have been tested in the UK and France, and clearly have a promising future. Lifor Limited has taken a similar idea and has developed a fibre-optic emergency escape lighting system based upon side-emitting fibres which can illuminate up to 130m, for use on oil-rigs where precious seconds could be the difference between life and death. A 532nm green diode-pumped solid-state laser allows the fibre to optimise the sensitivity of the human eye, so that an oilrig crewman in a smoking corridor could still find their way out by looking down towards his feet. The company plans to begin production in May 2000.

Optical Sensors have been going through a revolution in the last couple of years. Kodak digital science in Rochester, New York, is at the forefront of the exciting developments in digital imaging. Kodak has developed a series of full-frame image sensors (see Figure 9) featuring a dark current of less than 10pA/cm² at in room temperature operation, pixel sizes from 6.8 to 24μm, antiblooming protection circuitry and up to 16.8 million pixels! Common applications include scientific, industrial, commercial and medical image sensing. The Kodak interline image sensors for video applications is available in colour and monchrome with VGA and mega-pixel resolution. These are capable of up to 90 full resolution frames per second in a pixel count of 648 (H) by 484 (V) in 9μm (H) by 9μm (V) on a half inch photosensitive area (see Figure 10). So successful has Kodak's optical sensing technology become that Kodak have now released a Platinum Silicide (PtSi) Infra Red device sensitive in the 3-5μm range with a resolution of 320 by 240 pixels (see Figure 11). The sensor is a Middle Infra Red (MIR), medium resolution infrared detector having a high sensitivity Charge Coupled Device (CCD) and can be used for viewing high temperature scenes with pixels somewhat bigger than their visible wavelength counterpart: 27.5μm (H) by 27.5μm (V). In future years the trend will be towards multi-million pixel sensors in both the visible and the infra red, as well as other possible energy bands such as the UV with greater sensitivity and enhanced signal processing control. It is hardly surprising that with such small, but powerful imaging systems we are beginning to see the first true artificial imaging systems that could feasibly be used to restore at least some partial sight to certain groups of blind people in the coming decade.

The opportunity optics offers us in the 21st Century is limited only by our expectations. I can hardly do justice to the number of areas in which optics will have a key, if not pivotal role. In the future optics will open the doorway to space observations

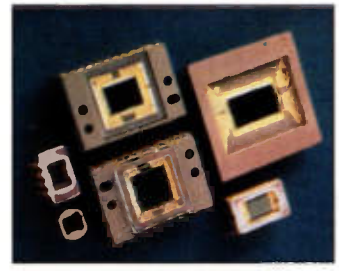


Figure 10. Interline image sensor. Courtesy Kodak.

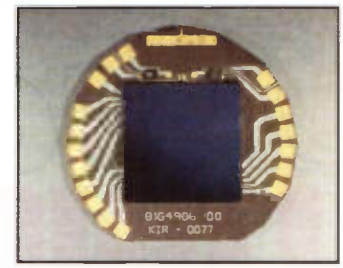


Figure 11. Infrared image sensor. Courtesy Kodak.

from both higher resolution Hubble style space telescopes, and to vastly improved terrestrial multiple or segmented mirror systems, such as a recently proposed 100m wide system. With such large telescopes, human observers could actually see Earth-sized planets orbiting around neighbouring stars.

Optics will provide ultrafast lasers and SuperDense Wavelength Division Multiplexing (SDWDM) schemes, unheralded medical diagnostics and treatment tools (such as the Optical Coherence Radar featured last year). Plus aids for detecting environmental hazards, laser radar (LIDAR) for safer air transportation (particularly with hard to see pylons and volcanic ash in mind) and both 3-D ground-based and satellite-based atmospheric monitoring systems.

Without doubt the 21st Century will be one of great technological leaps forward for mankind and immense individual benefit.

Further information:

Moth-eye structures at the Fraunhofer Institute. Dr Karin Schneider, Press and Public Relations,
e-mail
karin.schneider@ise.fhg.de
Fax +49 (0) 7 61/45 88-3 42.
Marianne Vincken, Philips Research Public Relations Dept, Prof. Holstlaan 4, 5656AA Eindhoven, The Netherlands.
e-mail
prpass@natlab.research.philips.com
Optoelectronics Research Centre, University of Southampton, Southampton S017 1BJ
www.orc.soton.ac.uk
Keith Wetzel, Marketing Manager, Microelectronics Technology Division, Eastman Kodak Company, Building 81, Floor 5, Rochester, NY, USA, 1465-2010 ccd@kodak.com

The Very LONG WAVES

PART 2

In part 2, George Pickworth looks at earth loops and the Sanguine System

Technology is an evolutionary process that began with humankind itself, but in this study of very long waves we take our starting point at around 1840, a few years after it was discovered that the earth is a conductor of electricity. From this basic discovery a pre-Hertzian signalling system evolved, and bears a striking resemblance to the extremely long wave Sanguine system developed by the Americans after the Second World War for signalling to nuclear submarines. See Figure 13.

Earth Currents

When it was realised that the earth could be used as a substitute for one wire of telegraph line, it was reasoned that it might be feasible to dispense with the remaining wire and employ the earth as the sole medium. However, the problem was to isolate outgoing and return currents.

Around 1835 Maiche of France and Laughter of the USA experimented with separating outgoing and return currents by using the upper layers of the earth's strata as the conductor for outgoing currents and a deeper strata as the conductor for return currents. One energised electrode was therefore inserted in the earth to a depth of about a metre whilst its complementary electrode was sunk to greater depth and connected to the surface by a bitumen insulated wire. See Figure 14.

It was believed that vertical leakage of current would not be significant so a galvanometer connected across a distant similar pair of electrodes would provide a pathway between the upper and lower strata thereby allowing the current to complete a circuit through a galvanometer. Not surprisingly the system was a failure.

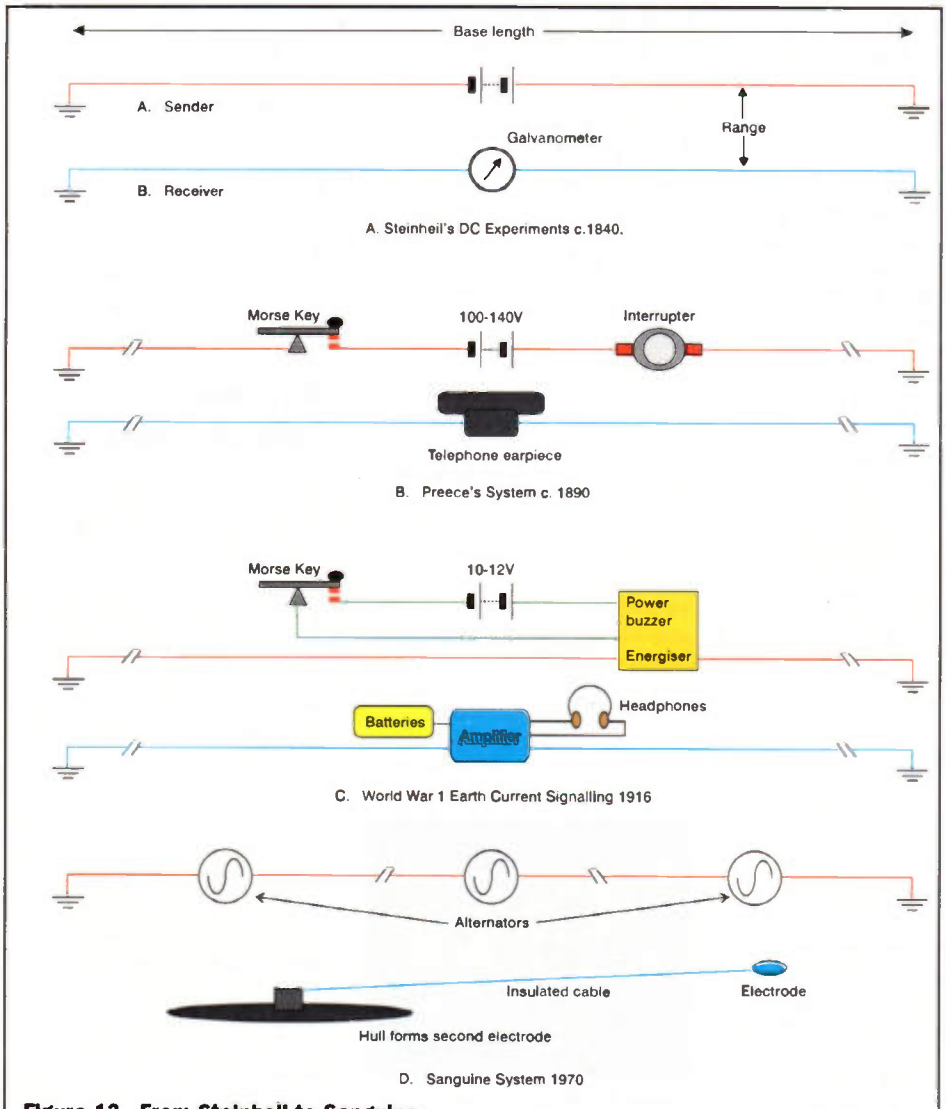


Figure 13. From Steinheil to Sanguine.

Steinheils System

Around 1840, Prof. C A Steinheil began experimenting with both earth electrodes inserted to the depth of about a metre and energised with DC. See Figure 13A. He then found that a galvanometer connected across a pair of distant probes, or secondary electrodes, indicated a current when they were aligned at a certain angle with the energised or primary electrodes.

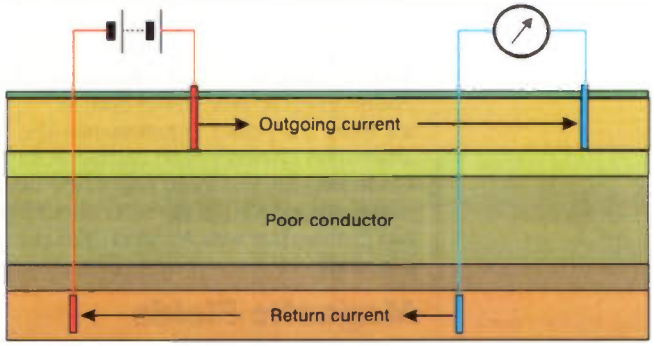
The probes made it apparent to Steinheil that instead of the current taking the short direct route between the pair of energised electrodes it was spreading over the earth's surface. To illustrate the spread of the current I have used the term current flow lines, but like magnetic lines of flux, they are of course imaginary. Steinheil found current flow lines near the surface extended in a pattern similar to the magnetic field of a bar magnet. See Figure 15. However, the flow lines actually occupy a volume similar to a flattened hemisphere. Nonetheless, he believed that because current flow lines spread over the earth's surface they had the potential for 'wireless' telegraph system.

Base Line

The distance separating the electrodes of each pair (sender and receiver pairs) became known as the base length whilst the electrodes and connecting wire was known simply as the 'base' So these terms are used in this study - see Figure 13A.
Now, because the only energising power available to Steinheil was from primary cells, it is not surprising that the range at which the probes and galvanometer could detect flow lines was little more than that of the base length of the energised electrodes. In other words the base length/range ratio was about 1:1.25. So, with technology available at that time Steinheil's system did not have a remote chance of competing with ordinary telegraph lines.

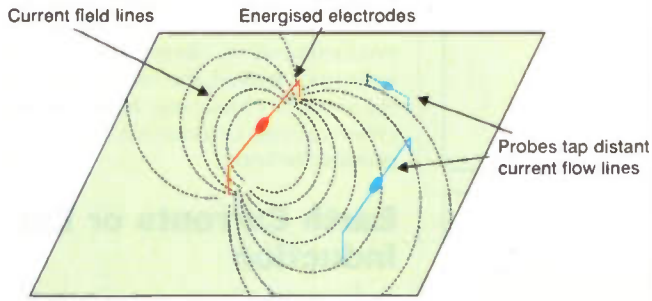
Rivers

Insulation of wires was primitive and unreliable so underwater cables were out of the question. But there was a need to extend telegraph services over rivers too wide to be spanned by overhead wires. Landlines employed bare wires attached to porcelain insulators supported on poles.



Wires connecting with deep electrodes were insulated in bitumen

Figure 14. Malche & Laughters concept of the stratum isolating outgoing and return currents.



Plan view of current flow lines extending from an energised base. The flow lines actually occupy a volume, i.e. a flattened hemisphere. Compare with magnetic field Figure 19.

Figure 15. Earth current flow lines - Steinheils Experiment.

In Europe it was usually possible to make the river crossing upstream where width was not too great for a suspended wire but this was not feasible in parts of North America and particularly India. Moreover, need is the mother of invention.

It was known that the distance that flow lines extended in water as much less than with land but this could be overcome by making base lengths longer than the width of the river. Indeed, the technique was shown to be practicable around 1840 by Professor Morse in the USA - see Figure 16.

However Morse did not follow up his work; this was left E. & H. Highton who in 1852 successfully adopted the system to the Indian telegraph service. Further development by W.F. Melhuis and others brought the system to a high level of perfection and enabled the telegraph system to extend over much of the sub continent. Furthermore, the use of relays enabled the system to be integrated with the landlines.

Another obvious application for a 'wireless' system was communication with lighthouses on offshore islands and in 1892 Willoughby Smith developed a system employing current flow lines to establish reliable communication between the mainland and the lighthouses on the Needles and Fastnet Rock. (See 'Electronics & Beyond,' December 1997, issue 120).

However, for military and strategic reasons a 'wireless' system was considered as an attractive alternative to highly vulnerable landlines. Indeed, the German radio station at Nauen was established for national security reasons. But for a system to be a viable alternative to landlines and later to submarine cables, its range had to be appreciable and this proved elusive to early pioneers working with DC systems and galvanometers. A breakthrough came in 1876 with Bell's telephone earpiece.

Telephone Earpiece

Sir William Preece realised that the telephone earpiece was able to produce audible sounds from very weak interrupted DC. In fact the telephone earpiece became an extremely useful scientific instrument that was widely used to complement the galvanometer that would of course only respond to DC or very low frequency AC. With an arrangement essentially the same as Steinheil's, Preece employed a interrupter to chop the energising DC into pulses with a repetition rate that produced a continuous audible noise in the earpiece connected to the secondary electrodes; typically 400 breaks/sec. The result was that Preece was able to detect signals over a much greater range than had been possible with Steinheil's DC galvanometer system - see Figure 13B.

In 1892 Preece established a communications link over 5.25km between Lavernock Point and Flatholm, a small island in the Severn Estuary - see Figure 17. At Lavernock Point, the base wire was 1.200m long and elevated by telegraph poles whilst at Flatholm the wire was 600m long but insulated with gutta-percha and laid on the ground. The ratio of base length to range was therefore 1:4.3 and a significant increase from 1:1.25 with Steinheil's DC system.

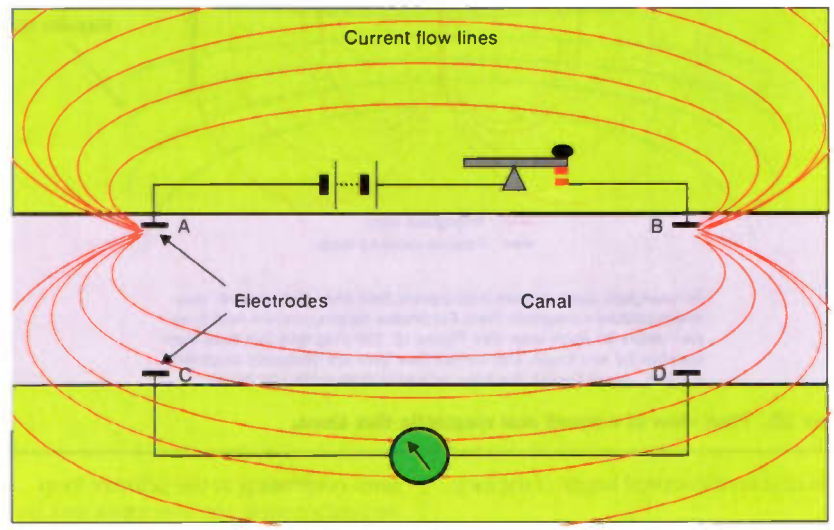
At first the greater range was attributed to the high sensitivity of the earpiece but Preece suspected that a most likely reason was electromagnetic induction.

Earth Loop

Notwithstanding that flow lines occupy a volume they in effect produce a hypothetical filamentous rectangular loop on a horizontal axis. The hypothetical loop carries the sum of the current carried by the flow lines and therefore produces a magnetic field. The length of horizontal length of the loop is set by the base length whilst its vertical height is determined by depth in the earth at which the return current flows. See Figures 18 & 19.

Return current flow is deepest on moist conductive soil and shallowest in soils overlying poorly conductive stratum such as limestone or gravel; these cause the current to extend laterally at the expense of depth. Moreover, rivers and underground streams can serve as conduits that concentrate return currents along a path of least resistance.

However, in addition to the effect of the underlying stratum, return current depth is effected by its frequency. Current flow is deepest with DC and decreases as frequency increases This is known as skin depth and applies to all conductors. As a very rough guide, current with a frequency of 1.0kHz may be confined to within 100m of the surface whereas currents with frequencies in the order of 50Hz may extend downwards to a depth of 2.0km. The above factors determine the shape of the volume of earth containing the flow lines



Current flow lines extend much less in water than on land, so the lengths of bases AB and CD are about three times the width of the river. Compare with Steinheil's system Figure 15.

Figure 16. Morse's system for signalling across a canal.

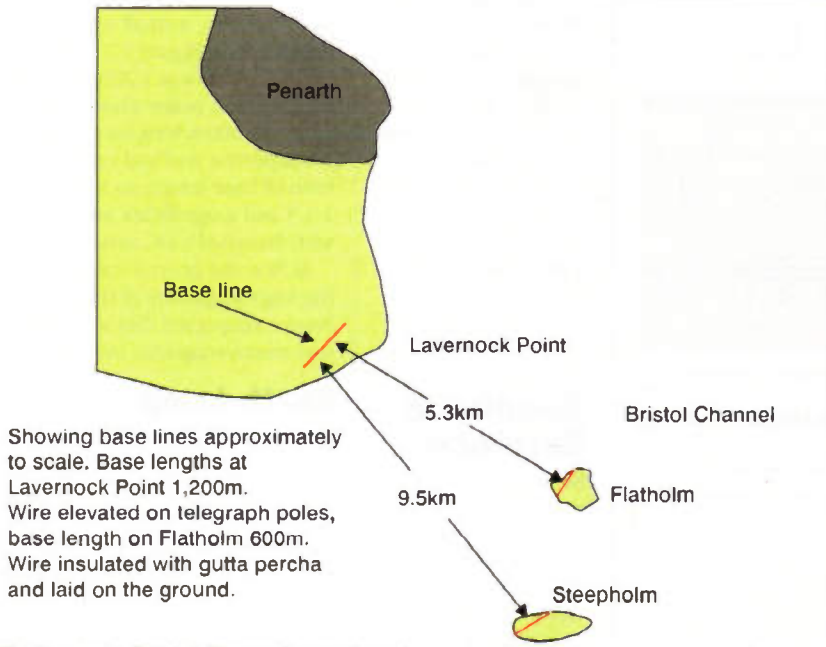
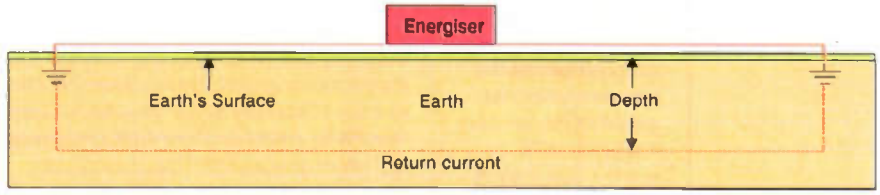


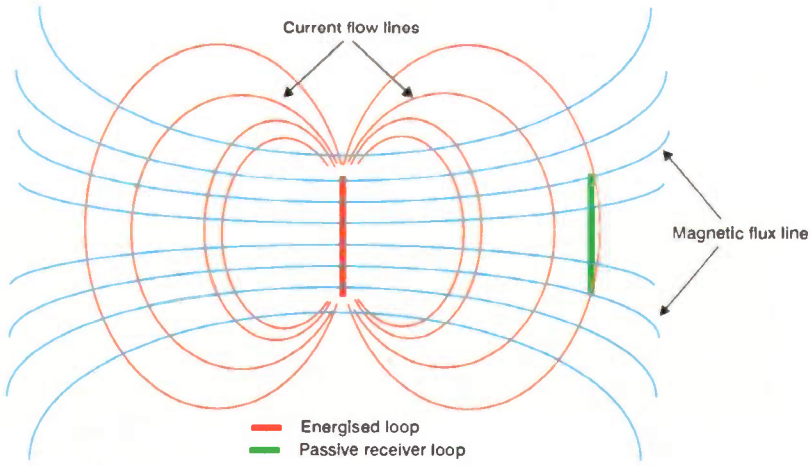
Figure 17. Preece's Bristol Channel experiments.



Earth currents occupy a volume but in effect create a rectangular filamentous loop on a horizontal axis. The loop produces a magnetic filed. Horizontal length of loop = base line.

Vertical length of loop $=\sqrt{1/2} \times \delta$ where δ is the electrical skin depth for the region

Figure 18. Diagram showing hypothetical earth loop created by return currents.



An energised base creates both current field lines and an earth loop that produces a magnetic filed. Electrodes tapping current field lines also create an earth loop. See Figure 18. The magnetic flux lines then couples the two loops. The current flow lines are obviously confined to earth. The magnetic flux lines extend to both earth and the air.

Figure 19. Plan view of current and magnetic flux lines.

and of course on the vertical height of the loop.

Mutual

When a distant pair of electrodes are aligned to tap a current flow line, as with Steinheil's system, they create a secondary earth loop. Then some of the magnetic flux lines originating in the primary loop mutually couple the two loops and an emf develops in the secondary loop each time the energising current is interrupted. See Figure 19.

During Preece's Bristol Channel experiments (see Figure 17) the energising voltage was 140VDC interrupted by means of a modified commutator to produce a musical tone (400Hz)) in the earpiece. Preece also experimented with a 192Hz alternator but found that interrupted DC system gave the best results both in audibility and power requirements. The interrupter caused a rapid change in the flux linking the two loops and so the value of the emf induced in the secondary loop was greater than with AC where the change is gradual.

Magnetic Fields

Unlike current flow lines, which can only exist in an electrically conductive medium, magnetic fields extend through strata with poor conductivity and most significantly through the air. It was therefore logical for the pioneers to assume that whilst short range signalling may well be via earth currents, signalling at greater ranges was predominantly via electromagnetic induction. Indeed, the current induced in the secondary 'base' may have arrived by either currents or induction, but most probably by both.

Earth Currents or Em Induction

To determine whether signalling was by currents or induction, Preece employed a tugboat plying between Lavernock Point and Flatholm (See figure 17) to trail a cable, insulated with gutta-percha and terminating in an electrode. The hull of the tugboat served as the complementary electrode. It was in effect an underwater 'base' and with this Preece claimed to have determined the point where signalling via earth currents gave way to induction.

It is interesting to note that G. W. Pickards 1910 concept of a submarine speech communication system employed underwater 'bases'. The surface vessel employed a 'base' similar to that used by Preece during his Bristol Channel experiments whilst the submarine employed 'mirror image' of Preece's 'base'. Communication was essentially via current flow lines - see Figure 20, and also Figures 13D, 23 & 24.

Large Continuous Wire Loops

The Bristol Channel experiments showed that current flow lines do not extend as far in water as in soil. Preece's philosophy was therefore that signalling via magnetic fields would give the greatest range especially over water. So, during 1894 he conducted numerous experiments with very large continuous wire loops created from ordinary telephone lines running along the road system but insulated from earth. During his River Severn experiments large diameter loops were created on either side of the river. Similar loops were employed during signalling trials across Loch Ness and from Kintyre over the Kilbrannan Sound to the Isle of Arran. However, during the Kilbrannan trials the continuous wire loops were complemented with earth loops, see Figure 21.

It was found that when the wire loop was

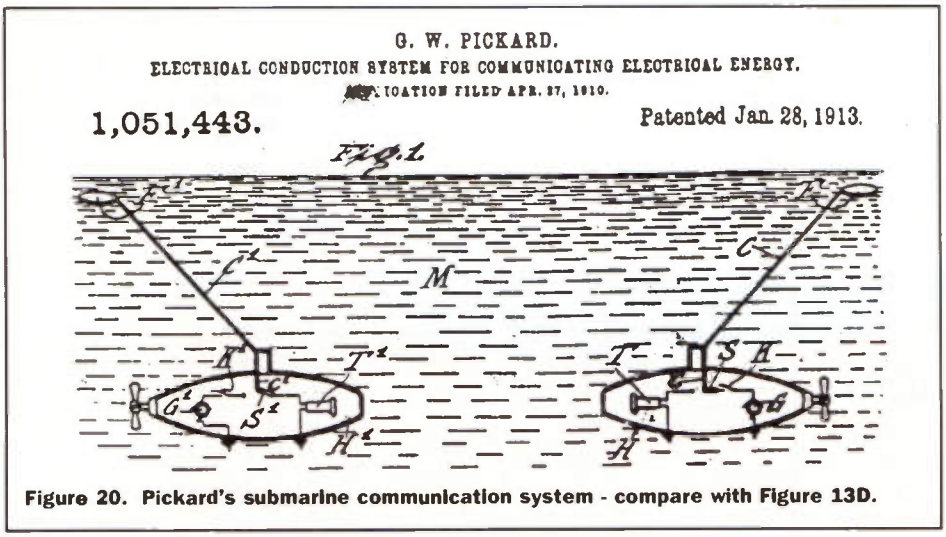

G. W. PICKARD.
ELECTRICAL CONDUCTION SYSTEM FOR COMMUNICATING ELECTRICAL ENERGY.
APPLICATION FILED APR. 27, 1910.
1,051,443. Patented Jan. 28, 1913.
Fig. 1.

Figure 20. Pickard's submarine communication system - compare with Figure 13D.

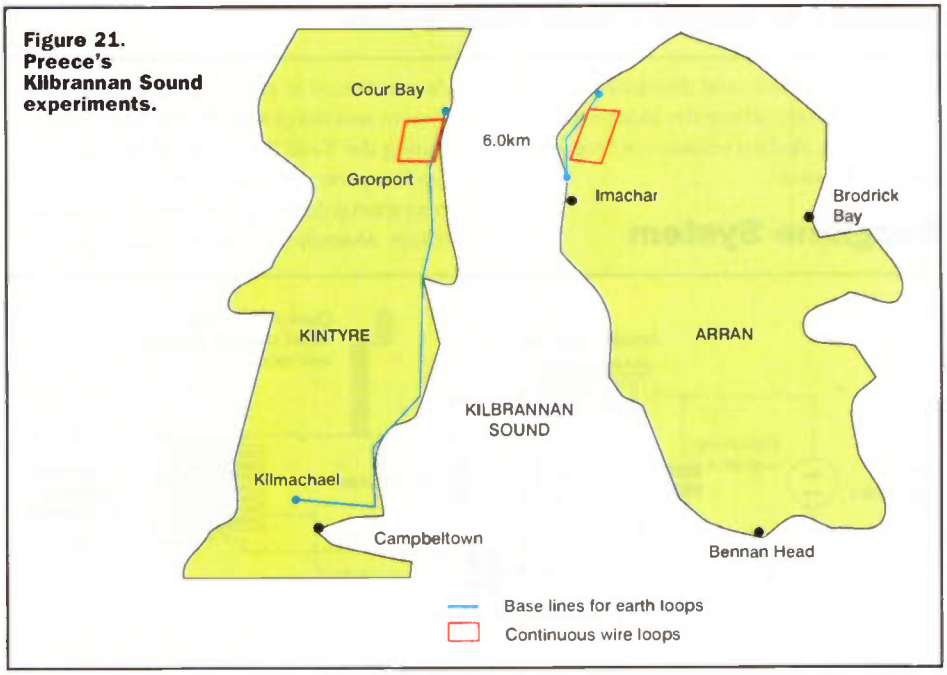


Figure 21. Preece's Kilbrannan Sound experiments.

energised with interrupted DC it induced a current across the distant earth loop. By the same token when the earth loop was energised a current was induced across the continuous wire loop. These experiments demonstrated that an earth loop could generate and respond to magnetic fields.

During the Lock Ness experiments, Preece found that earth loops gave better results continuously than wire loops and attributed this to the current flow lines complementing inductive coupling. Being insulated from the ground, the continuous wire loops precluded earth current flow lines.

No Practical Use

Preece concluded that inductive coupling via large diameter, single-turn, continuous-wire loops had no practical application. Indeed, for signalling to lighthouses on off-shore islands where the system may have had a use, limited space precluded such large diameter loops.

So in 1892, C. A. Stevenson proposed the use of multi-turn 100m diameter coils wound around a circle of telegraph poles for signalling to the lighthouse on the island of Muckle Flugga, Shetlands. Although the system was tested on the mainland and range was found sufficient for the 0.8km sea crossing, a coil was never installed on the island - see Figure 22. Indeed. Stevenson's system had nothing to offer over Willoughby-Smith's highly successful system employed with the Needles and Fastnet lighthouses.

Telephony

During one of the Loch Ness experiments (See Figure 23), Preece replaced the interrupter with an ordinary telephone microphone. Preece then found that with an earth loop having a 6.5km base length, telephonic signals were possible across the Lock. The average distance separating the two 'bases' was 2.0km. Base length was therefore more than three times greater than the width of the Lock. Note that the electrodes were immersed in the Lock.

In 1899 similar equipment to above was used to establish a communication link between the Skerries and Cemlyn, Anglesey over a distance of 4.5km. Another link was established between the Irish coast and Rathlin Island, a distance of 6.5km. Base lengths are unknown.

Remarkably, a similar system for signalling over land by voice, known as Erdsprechgerat (Earth Speech Apparatus), was used by the Germans during WW2 - see Figure 24.

The First World War

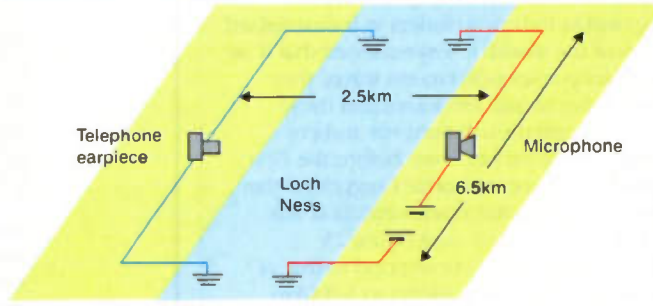
Experiments with inductive systems were largely abandoned as the range of Hertzian wave systems steadily increased and as we have seen, by 1906 the very long wave superstations had already made transoceanic 'wireless' telegraphy a reality. But, Preece's earth loop inductive system was well adapted for signalling from forward positions during the First World War when shellfire destroyed field telephone lines; The system was resurrected as Earth Current Signalling - see Figure 25.

World War 1 earth current receivers had the advantage in that triode valve amplifiers were employed - see Figure 26. The amplifiers dramatically increased sensitivity and enabled a working range of several km to be attained with 100m 'bases'. An impedance matching transformer coupled the 'base' to the first valve of a three valve transformer-coupled amplifier.

The energisers, known as power buzzers (see Figure 27) were essentially induction coils with an integrated vibrator type interrupter. Frequency could be varied in steps from 300 to 800Hz by attaching small weights to the vibrating armature. The Germans also used 'bicycle powered' alternators operating on a frequency in the order of 500Hz.

Power input to the power buzzer's primary winding was typically 20W and with 100m 'base' a range was typically up to 3.0km and 5.0km over soil overlying chalk. The base length to range ratio was therefore typically 1:30 and a maximum of 1:50. The dramatic increase in range over Preece's system was attributed to the use of receiver amplifiers and particularly the high voltage spikes produced by the buzzer's induction coil.

However, care had to be taken to ensure that the earth electrodes were not too large otherwise load resistance would be too low



Note that electrodes are in the lock. Compare with Morse's system Figure 16. Current flow lines probably complemented em induction. Compare with Erdsprechgerat Figure 24.

Figure 23. Preece's wireless telephony experiments across Lock Ness.

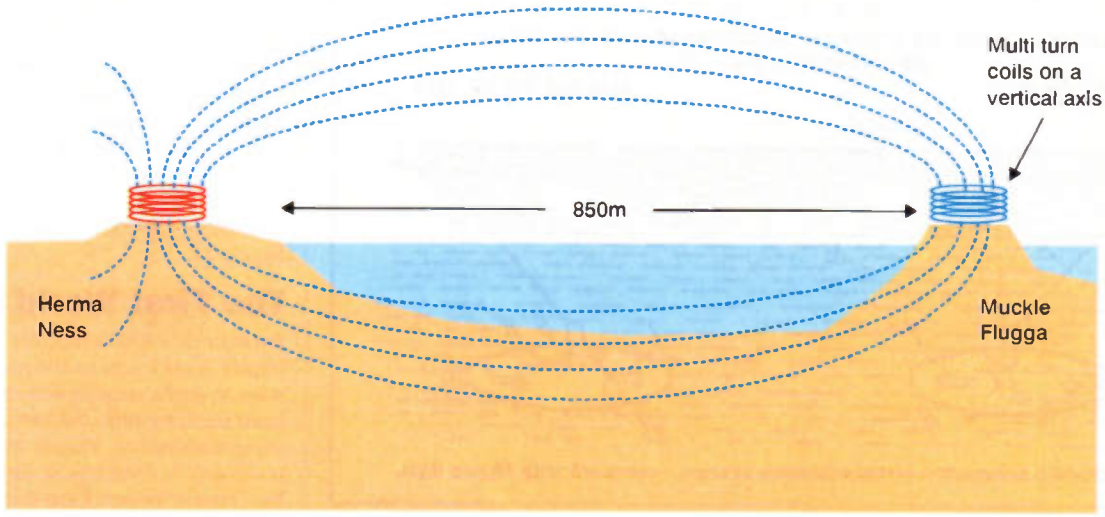


Figure 22. Stevenson's proposed system for signalling to the lighthouse on Muckle Flugga, Shetlands.

and the power buzzer be overloaded. Typically, 300Ω was obtained, much of which was contact resistance between the electrodes and earth. This presented a good impedance match with the sender, and was readily attained with old bayonets used as earth electrodes.

In 1916, Rupert Stanley calculated that with 20W a 5.0km range would be impossible by simply tapping current flow lines and substantiated Preece's assertion that signalling at a distance was principally by em induction.

Whistlers

During his various experiments, Preece had heard strange sounds that he was unable to identify but we now know as whistlers and 'dawn chorus', i.e. like birds singing in the morning! They have a spectrum extending from a few hundred to a few thousand Hz. Apparently, their origin is electrical storms on the far side of the earth and they propagate as em waves via the earth ionosphere waveguide.

Preece was not the first to hear whistlers and dawn chorus, they had been heard by telephone operators since the early days of the telephone, and later by operators of WW1 earth current signalling equipment. Nonetheless the whistlers demonstrated that an earth loop responds to very low frequency em waves. In fact, I use an earth loop for monitoring VLF signals but em pollution from power lines has made it impossible to hear whistlers in industrialised parts of the world. It was reasoned that if an earth loop responded to em waves they would also radiate em waves and these complemented earth currents and em induction. Moreover, even before the First World War some authorities suggested that Preece's telephonic communication was very long em waves - see Figure 23. Wavelengths would correspond to that of speech, i.e. 100km (3.0kHz) to 3,000km (100Hz). As with whistlers, the earpiece converted the induced audio frequency current into audible sound irrespective of how it arrived.

Indeed, Maxwell's equations show both Preece's earth loop system and WW1 earth current systems would have radiated some very long em waves and this leads us to the Sanguine system where the radiators are essentially scaled up versions of Preece's and WW1 'bases.'

Sanguine System

As mentioned in part 1, the Sanguine system was developed by the Americans during the 'Cold War' to send signals to nuclear powered submarines, at their operational depth, via extremely long em waves. Alternators were well suited to

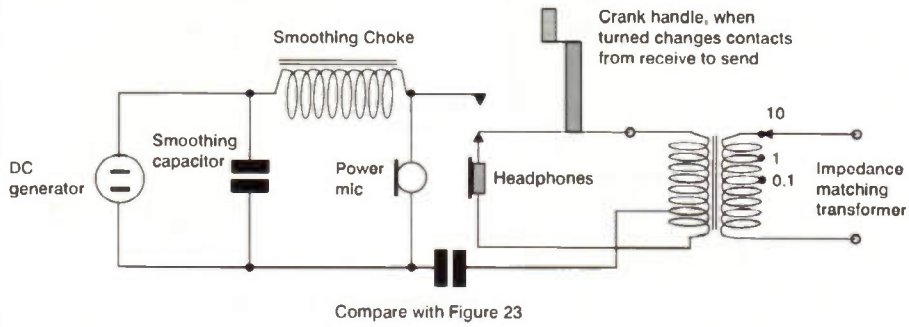
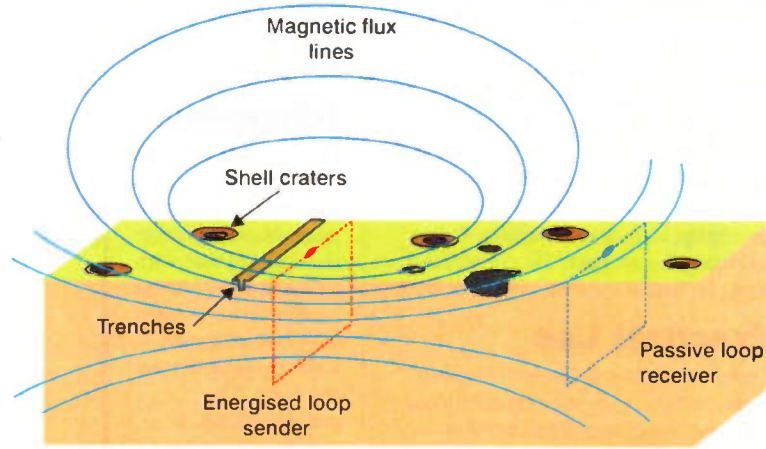


Figure 24. Erdsprechgerat 1916 - compare with Figure 23.



Used during WW1 for signaling from forward position when shellfire destroyed landlines. Range up to 5km. Receivers used valve amplifiers see Figure 26. Current field lines shown in effect form a single turn loop on a horizontal axis that creates a magnetic field - see Figure 19. Some flux lines pass through the passive or receiver loop. The sender was typically a vibrator interrupter/induction coil. Frequency was in the order of 800Hz - see Figure 27.

Figure 25. First World War earth current signalling - em induction - showing the magnetic field produced by the sender loop.

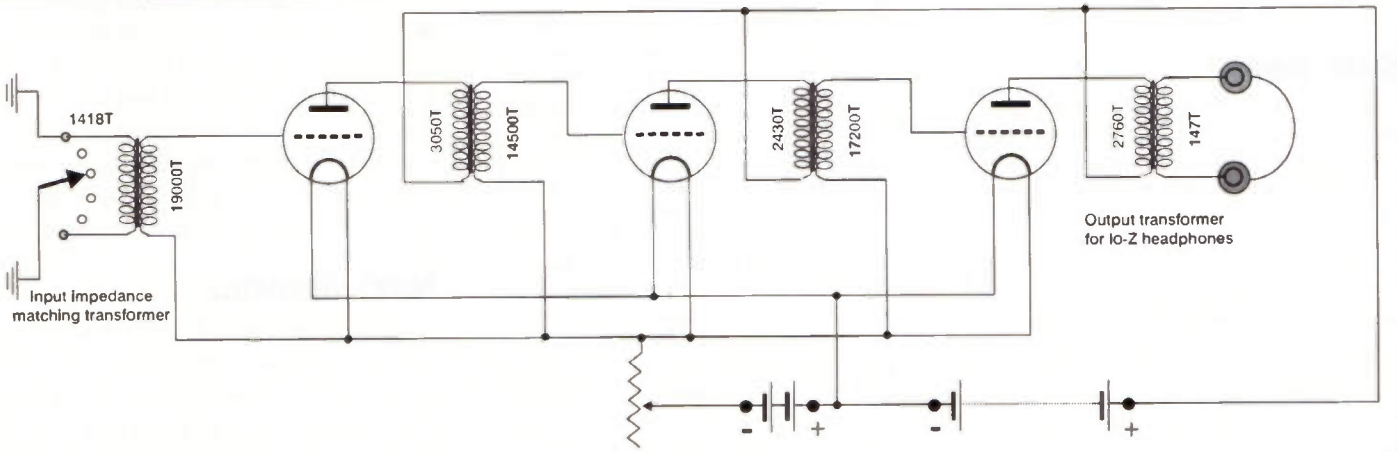


Figure 26. Earth current signalling amplifier.

providing energising current for the radiators.

Conventional very long wave antennas were useless as radiators of extremely long waves but it was realised that it is possible to increase radiation from an ordinary linear wire by simply increasing its length. So during early American experiments, power lines several hundred kilometres long were employed as temporary radiators.

Gas pipelines up to 1,000km were also adopted as radiators - see Figure 28. The steel pipes were already coated with insulating material to isolate the pipe from earth and galvanic currents so no further electrical insulation was required for its use as a radiator.

The pipelines chosen were ones that passed over gravel soil with a fairly high resistance, but with both ends terminating in soil with low resistance - this arrangement was the norm with Beveridge travelling wave antennas. Indeed, the pipeline was considered as the radiator and the earth electrodes simply served as a terminating resistor.

To ensure current flow remained reasonably constant along its length whilst energy was radiated, alternators, powered by gas taken from the pipeline, were installed along at intervals along the pipeline. See Figure 28A.

Radiating Loop

It was soon realised that a pipeline, or a power line 1,000km long is only a fraction of a wavelength long at 40Hz (7,500km) so it could hardly be considered as a travelling wave antenna. So it was considered as radiating earth loop (see Figure 29). Indeed, as already mentioned, the radiating loops are basically scaled up versions of Preece's and WW1 earth current signalling 'bases' - see Figure 13.

Radiation is therefore from the loop as a whole and not simply from its wire or gas line section, and was manifest as radiation resistance. For reception, the submarines trailed a wire 500m or longer that terminated with an electrode, whilst the submarine's hull forms the other electrode. Whilst highly sophisticated, the submarine 'antenna' is essentially a scaled up version of an underwater 'base' - proposed with Pickard's system - and towed by the tugboat

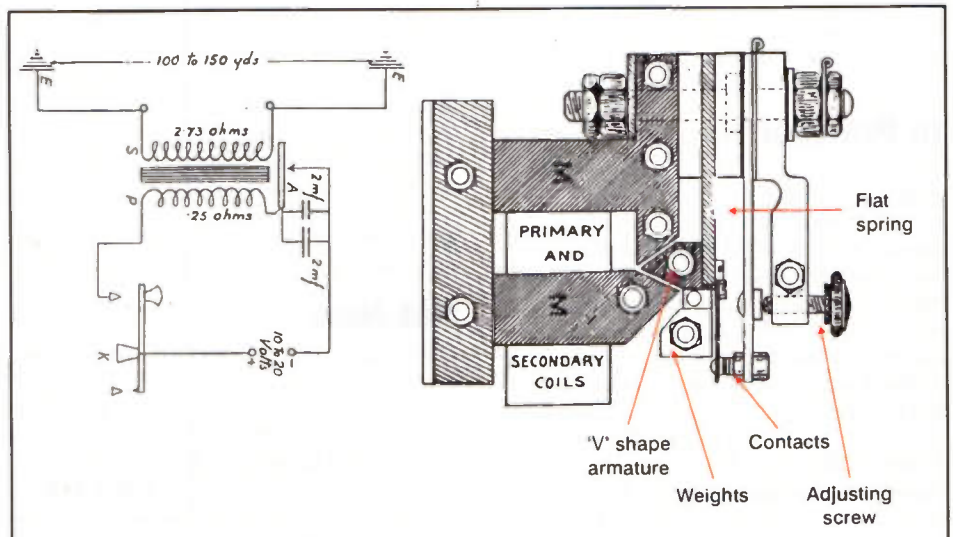


Figure 27. The power buzzer.

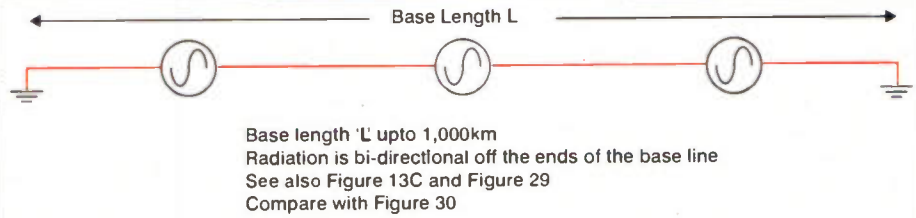


Figure 28a. A) Power line or gas pipe line base, B) Equivalence of four shorter bases - see also Figure 29.

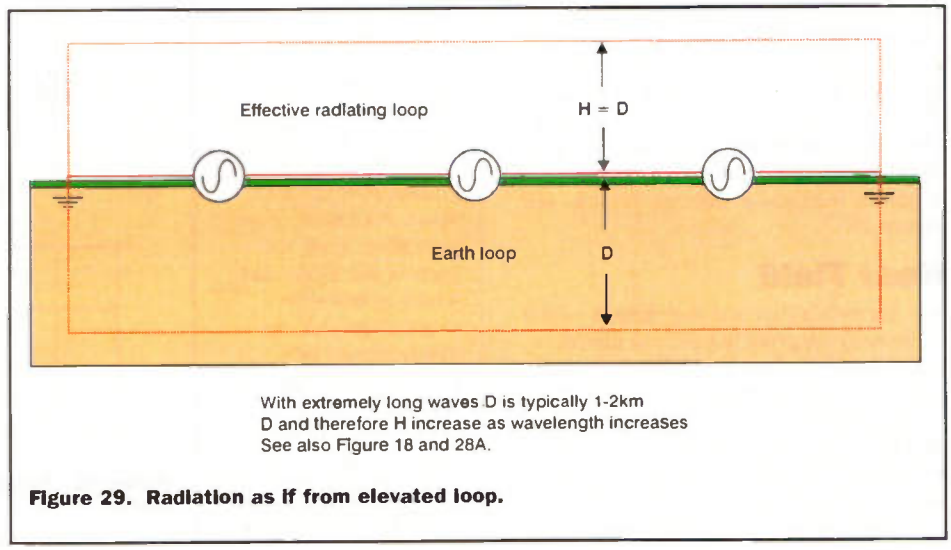


Figure 29. Radiation as if from elevated loop.

during Preece's Bristol Channel experiments - see Figure 20.

Skin Depth

As already mentioned, the depth at which the return current flows depends on soil type, underlying strata and signal frequency, and it is referred to as skin depth. Published data shows that with frequencies in the range 30 to 100Hz, skin depth is typically 1.0 to 2.0km.

A loop with a circumference only a fraction of a wavelength long has poor radiation efficiency, and this declines even further if wavelength is increased. However, a further decline in radiation efficiency is compensated in some measure by the lower frequency return currents travelling at a greater depth, and this increases the effective vertical height of the loop and therefore its circumference. Moreover, the vertical length of the loop has the effect to raising the loop to an equivalent height above the earth's surface - see Figure 29.

In Parallel

The problem with employing a power or pipeline as a 'base' (see Figure 28A) is that there are only certain places where space permits lengths of 1,000km. However, it was found that when a number of shorter 'bases' were located in parallel the effect was as if they were connected in series. For example, by locating four 'bases' each 160km long in parallel their effective length is increased to 640km - see Figure 28B. Moreover, by locating a second set of 'bases' at 90° to the first set, and introducing a phase difference in the current energising the two sets, it is possible to steer radiation over a fairly wide angle - see Figure 30.

Published data shows that a typical Sanguine grid type radiator system - designed for operation on 45Hz and consisting of 4 x 4 'bases' each 160km long - gave a calculated range of 10,000km. Base length/range ratio is therefore 1:15.6. Compare with 1:50 attained with WW1 earth current systems. Power input is given as 26.4MW but is provided by a number of alternators spaced along each 'base' line. Skin depth was given as 2.0km. Earth resistance is given as 44Ω, and a radiation resistance of only 0.012Ω. Percentage efficiency is therefore only 0.026, which is very low when compared to conventional antennas at higher frequencies.

The phase of the return current differs from that in the wire by about 45° and this constitutes to the reactive component of the loop. Nonetheless, much of the input energy goes into producing a strong magnetic field and in heating the soil - see Figure 19.

Near Field

It is significant that one wavelength - 45Hz (7,500km) - approaches the calculated operational range of 10,000km for a Sanguine system. However, as the system employs a number of widely distributed radiating loops, the inference is that the majority of submarines operate within the near field of a loop.

In the near field, reception involves currents, em induction and em waves, but with em waves becoming more significant as the distance from the sender loop increases. So, assuming that Preece's and WW1 earth current systems also radiated some em waves, the above would also apply. Unfortunately, their receivers lacked the sensitivity to respond to signals arriving predominantly as em waves as would have been the case at greater distances.

I find it difficult to believe that a base length/range ratio of 1:50 attained by WW1 earth current systems was simply by em induction and possibly some currents. At 5.0km only a few magnetic flux lines would extend far enough to link the two loops - this is equivalent to flux lines of a bar magnet 100mm long extending to 5.0m. Theoretically they extend to infinity but detection at 5.0m requires very sensitive equipment.

So, this summer I plan to conduct a series of experiments in an attempt to determine the role of em waves with both Preece's and WW1 earth current systems.

Not New

Before the turn of the last century it was proposed to install a 'base' constructed like an ordinary telegraph landline, up to a 1,000km long on either side of the Atlantic Ocean. See also Figure 28A. As we have seen, the base line/range ratio of Preece's Lavernock Point to Flatholm link was 1:4.3 but the Flatholm base length was only half that at Lavernock Point. So it was reasoned that with both 'bases' being 1,000km long, a range of at least 4,300km would be attainable - sufficient to span the Atlantic Ocean.

One base line would run down the eastern side of North America whilst the other would run down the western side of Europe via France, Portugal and Spain. Radiation, as we have seen, is off the ends of the loops and whilst at first sight it might seem that the 'bases' would be parallel they would really have been oriented in line but slightly offset, and at an angle of about 45°.

With 1,000km 'base' energised at say 1.0kHz (300km waves) transatlantic signalling would almost certainly have been possible, provided of course that sufficient energising power was available. But not by currents or em induction, but predominantly by extremely long em waves - and with that interesting thought I conclude part 2 of this study!

Next Month..

In part 3 we look at Tesla's system which Tesla described as being diametrically opposed to Marconi's system. It was Tesla who foreshadowed the discovery of the ionosphere.

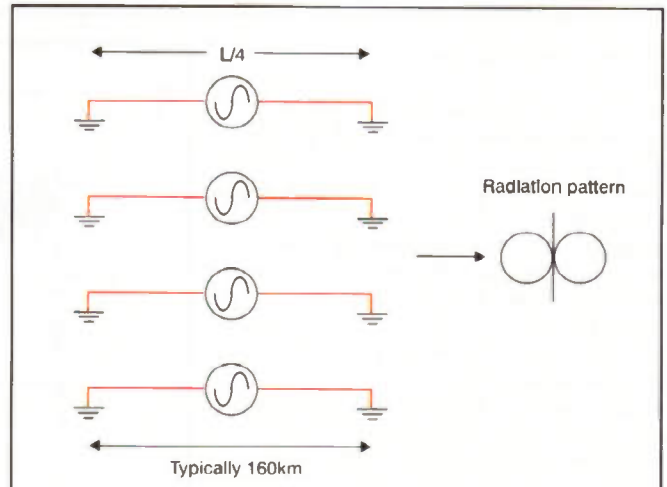


Figure 28b.

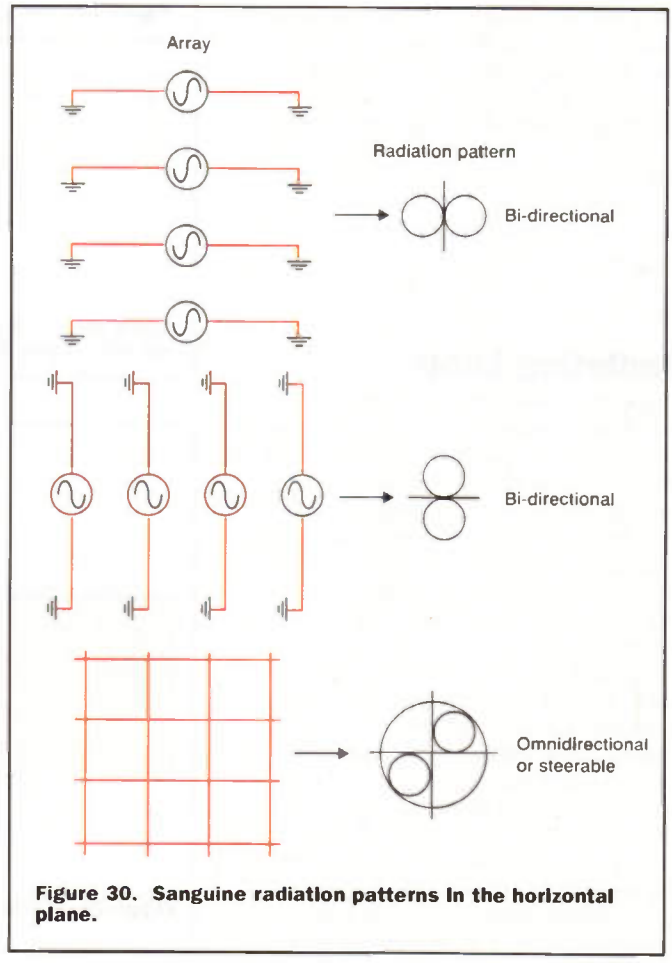
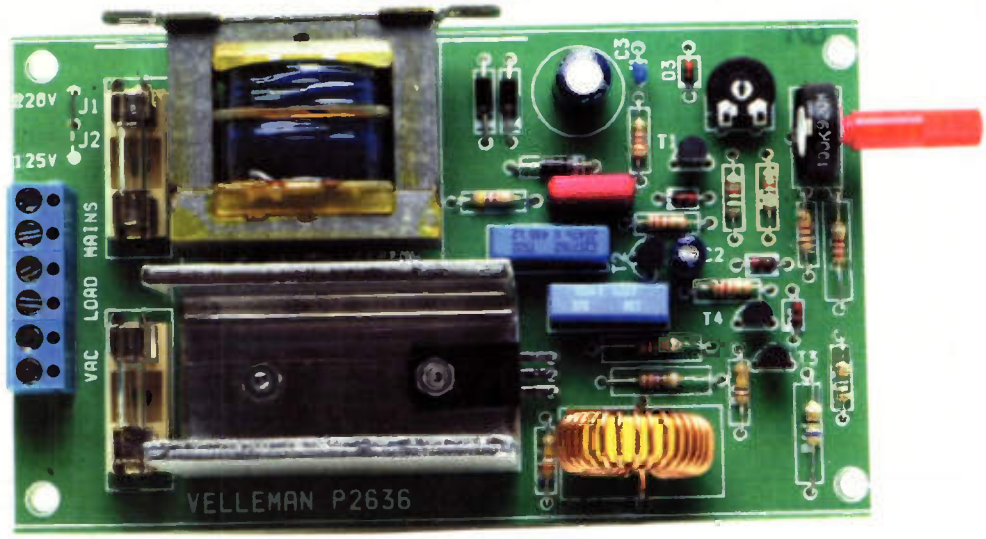


Figure 30. Sanguine radiation patterns in the horizontal plane.

PROJECT



Velleman UNIVERSAL AC MOTOR CONTROL

John Mosely constructs this sophisticated motor controller

This kit is primarily designed to control the speed of drills, but can be used with any other carbon brush ac motor equipment. A separate power supply is used to power the 'control circuitry' and this provides several benefits. Normal controls only provide control from 0% to 50% and offer very little torque, if any, at low speeds. The point of triac conduction is adjusted twice every cycle, so at low speed conduction is very short so providing little torque - see Figure 1b. In this design a 'pulsed DC' voltage is applied to the motor at low speeds - see Figure 1c - which maintains a high torque a low speeds. For control above 50%, the torque is adequate and Figure 1d is the normal operating mode.

Providing the phase of the supplies are the same, then the mains supply for low voltage power supply can be a different source to the load supply. Additionally, the controller can be used with resistive loads such as lamps and heaters etc. The circuit diagram is shown in Figure 2.

A 6V-0-6V transformer provides the mains control circuit. T1 produces a 50Hz square wave that is passed to T2 via a RC differentiating network. On every positive edge of the square wave, T2 conducts and discharges C2. C2 is charged via the resistive network RV1, 2 and R6, 7, and it is these values that will determine the point of firing of the triac. T3, 4 are a Schmitt

FEATURES

- No loss of torque at low speed
- Specifically designed for carbon brush motors
- Includes low voltage power supply
- 5.5A Max load
- 5 to 95% control range
- RF anti-interference circuit

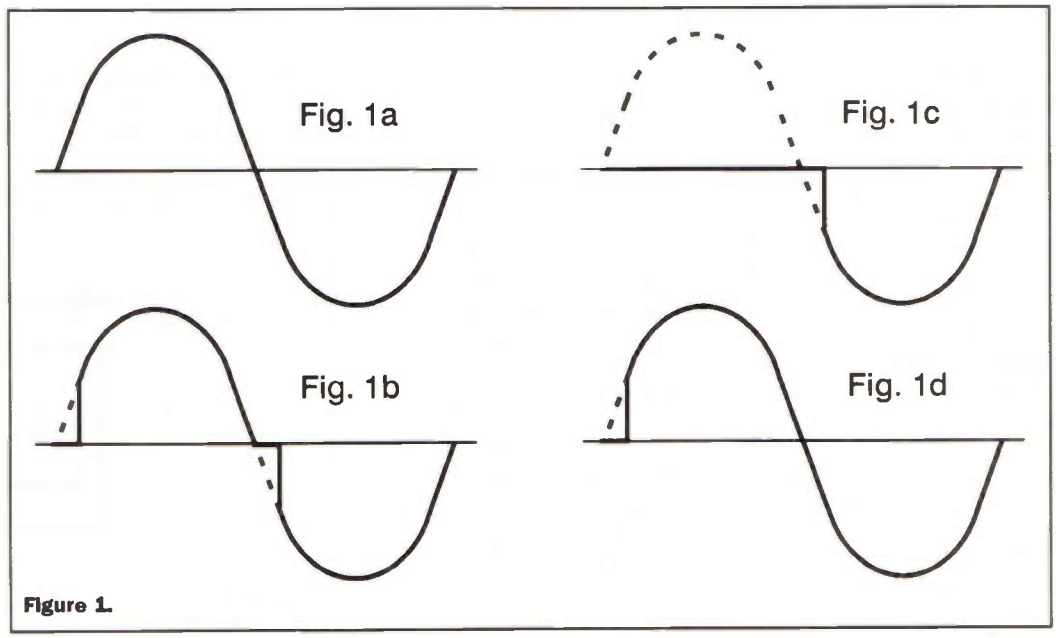


Figure 1.

trigger that switches the triac when the base of T4 is at 3.5V. T4 conducts until the beginning of the next cycle. L1 and C7 suppress any RF interference that maybe present. The RC network R13, C5 protect the triac from inductive voltage peaks and prevent it from being fired without and control voltage.

Construction

The supplied transformer has a 230V/120V windIng/tap and this needs to be set on the PCB by soldering in a jumper. Position J1 is used for 230V operation. Now all the resistors and diodes can be mounted - take care to mount the diodes the correct way round.

PROJECT PARTS LIST

RESISTORS:

R1	4k7
R2	3k3
R3	680Ω
R4, 5	22k
R6	1k5
R7	47k (50Hz operation)
R8	100k
R9	100Ω
R10	120Ω
R11	68Ω
R12	1k
R13	27Ω
R14	390k
RV1	100k Trimmer Vert This could be a linear pot if required
RV2	100k Trimmer Vert or Horz

CAPACITORS

C1	470µF Elect
C2	1µF Elect
C3	100nF
C4	47nF
C5	100nF/400V
C6	47nF/400V

SEMICONDUCTORS

D1, 2, 7	1N4007
D3 - 6	1N4148
T1, 2, 3	BC547 or similar
T4	BC517
TR1	BT137

MISCELLANEOUS

Tran1	6V-0-6V Min Mains Transformer
L1	300µH
F1	250mA Fuse
F2	5A Fuse
	Fuseholders
	Heatsink for Triac
	6-Way Mains Screw Connector
	Suitable Housing and 13A Outlet

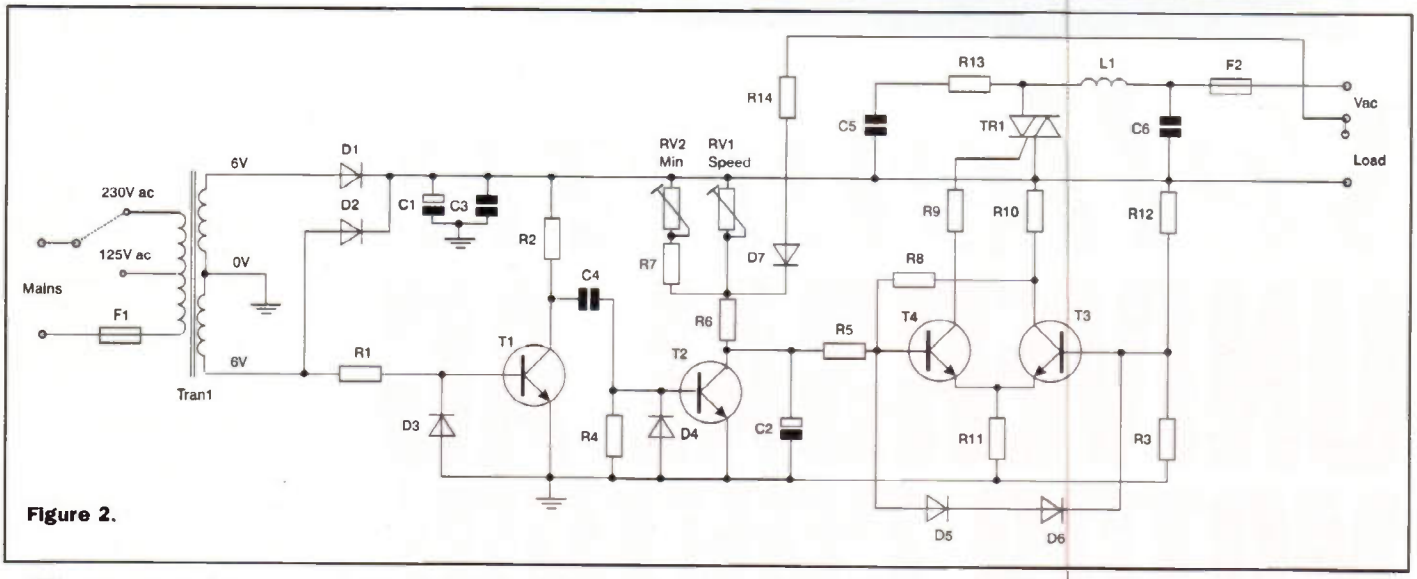


Figure 2.

RV1, speed control, is supplied with a small plastic spindle that is gently pushed into the resistor slot. This will have to be aligned with a wall of the selected case. This will naturally dictate the position of the PCB within the housing.

The transistors can now be soldered in place - note that T4 is a BC517 or equivalent. Now the capacitors can be inserted. In the original Velleman instructions and circuit diagram there is no C4! (this possibly could have been an alternate value for 125V ac working). The fuseholders and fuses can now be soldered in place, followed by the mains transformer. L1 is now inserted, and it is important to check that the wire ends are already tinned, if not scrap back the insulation sufficiently, to allow the inductor to be soldered in the board.

The triac is mounted to the heatsink and the legs are carefully bent to pass through the solder holes. Make sure the legs do not touch the heatsink. Now mount the 6-way mains connector. Finally, check all the joints and track for solder bridges and dry joints.

Testing

At all times take extra care as the board is at mains voltage. It is imperative that the controller is mounted in a suitable box with correct earthing. Connect the load and mains supplied as shown in Figure 3. Note, since the load and control voltage supplies are effectively separated, it is possible to connect the controller to low voltage loads (outdoor applications?).

RV1 is turned anticlockwise, and RV2 is turned completely clockwise. With a suitable motor load, adjust RV2 for the lowest possible motor speed. It is important that the motor always starts even with RV1 in the minimum position, otherwise large currents can flow through the motor brushes causing possible damage. If there is poor motor torque, disconnect from the mains and swap the connections to VAC.

In-Use

I have said in the past that I am genuinely impressed with the standard of the Velleman Kits, and this motor controller is no exception. If you follow the instructions, and check your work carefully, then you will almost certainly end up with a working kit - and one that works extremely well. This kit did just that, and when used with a standard electric drill, I was most impressed.

Do select your housing with care, and ensure that your mains outlet is suitably earthed and adequately protected.

Order Code VE90X, Price £19.99 Inc VAT.

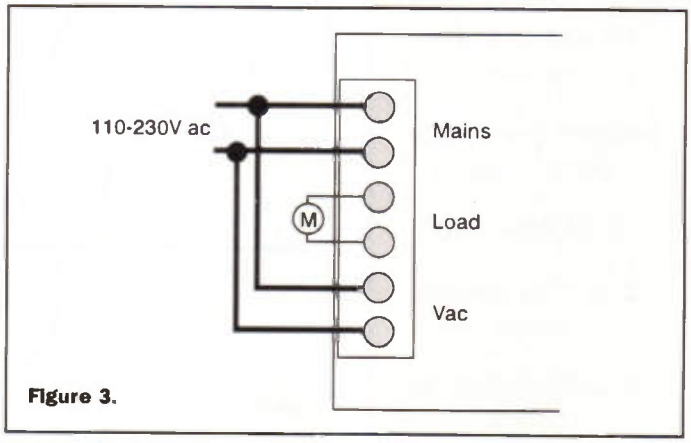


Figure 3.

High-speed Internet

While nobody doubts the significance of the spate of free dial-up Internet access from ntl, BT, AltaVista and the like, they have one common failing - they all rely on modem dial-up which is limited by the modem/telephone line speed. This currently maxes out at 56K, which in real terms means, if you manage to get a download speed of more than 3Kbps then you should be happy.

What many Internet users are clambering for, on the other hand, is higher speed access to the Internet. There are two main methods, both of which are in infancy in the UK: cable modems and ADSL (asynchronous digital subscriber line). Cable modems use the cable telephone networks' fibre optic links to achieve high data transfer rates. ADSL is a technique which uses existing copper wires between premises and a local exchange (known as the local loop) to transmit digital signals far in excess of the local loop's ability to transmit digital signals with ordinary modems. Both methods are able to deliver 2Mbps data rates, although both will probably restrict the available rate (at least initially) to around 500Kbps - around ten times the speed that a 56K modem can ever expect to achieve.

BT is currently building into its telephone network ADSL links, and expects to have half of the UK covered (in terms of population) by the summer of 2001. While existing local loops can be used, the exchanges themselves have to be upgraded to allow ADSL use, and it's this fact that means total coverage of the UK won't occur for years yet. Effectively, if you don't live in one of the large cities BT currently has plans to upgrade, don't expect ADSL in the immediate future. It's currently trialing ADSL in a few selected areas, and is expecting to install around half a million ADSL links to customers over the next 12 months or so. Cable modems meanwhile are already available in certain areas of the country and the rollout is going ahead across the rest of the cable telephone franchises over this year.

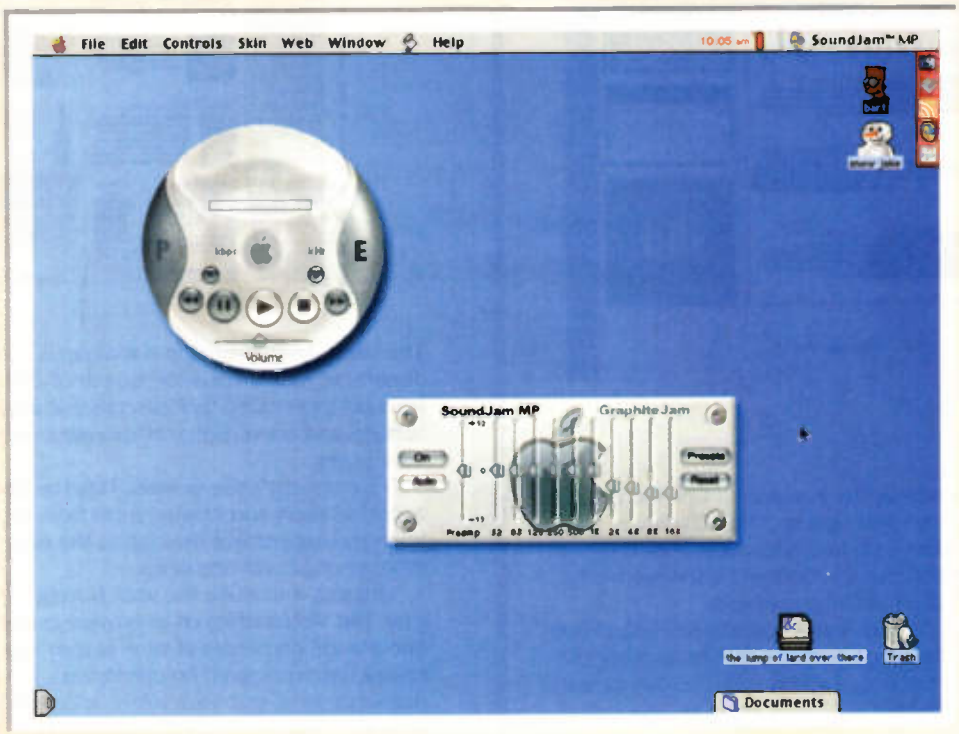
Of course, the cost of all this upgrading is to be borne by the customer. Prices for ADSL are expected to be around £50 per month. Cable modems cost £40 per month. The beauty of both ADSL and cable modems is that the service is what's known as always-on. From the moment you log on with your computer to the moment you log off, you are effectively on the Internet. It doesn't matter how long you surf, the price is all-inclusive - nevertheless, you have to do a lot of surfing for either of these high-speed methods to be economical.

Jammy Dodger

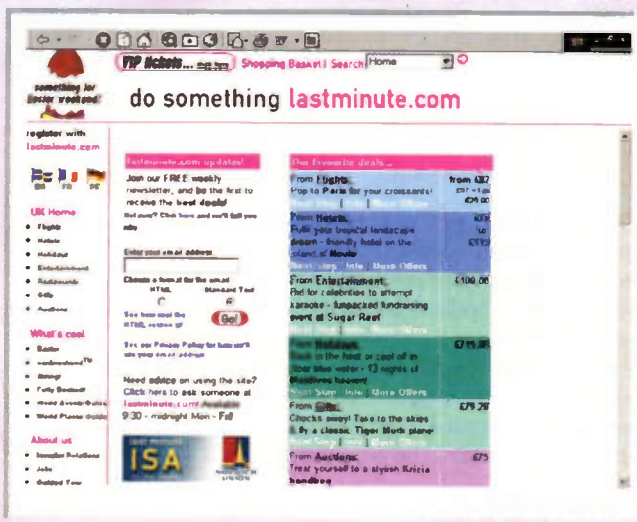
Mac users can rejoice in the new versions of SoundJam MP which have recently been released. SoundJam MP is the all-powerful software that creates, files, and organises MP3 format files for use either on the Mac, or to download to any one of three portable MP3 players: Diamond's Rio 500, the I-Jam, or the Nomad II. Existing users of SoundJam can update to SoundJam MP Plus for free, but there's also a new version - SoundJam MP Free - which can be used just to play MP3 format files. Initially, SoundJam MP Free lets you have 14 days (or 30 encodings) usage of SoundJam Plus's impressive range of features, too, so is the ideal way to experience the program.

New features in SoundJam MP Plus include the ability to record and convert to MP3 audio input directly, which is ideal for users wanting to create MP3 files from, say, a vinyl LP collection, and improved encoder quality (which was already pretty good). In fact, as SoundJam was already the most versatile MP3 utility around for the Mac, the alternatives to SoundJam merely slip further behind the leader.

The SoundJam Website, at: **<www.soundjam.com>** holds the SoundJam MP Plus updater, and SoundJam MP Free as downloads.



Lastminute.com is a UK Top Three Site



Lastminute.com at <www.lastminute.com> is the second most frequently visited e-commerce site, according to the latest statistics from NetValue at <www.netvalue.com>, a European source for effective Internet usage measurement.

First place is maintained by Amazon.co.uk at <www.amazon.co.uk>, with Amazon.com at <www.amazon.com> in third place. The data is derived from NetValue's Internet Observatory in the UK, France and Germany for February 2000.

Latest statistics also reveal that MSN is still the most frequently visited of all Internet sites in the UK - including e-commerce and non-e-commerce.

Key findings from the study include:

- 71.1% of UK home users visited an e-commerce site during February 2000 compared with 60.1% of home users in Germany and 65% in France Online music and book stores are still the most frequently visited genre of e-commerce sites.
- 25.6% of UK home users visited one in February; 19.6% visited a bank insurance site; 17.3% visited a shopping mall and 21% went to a travel site.
- Germans seem to prefer more serious Internet sites, with Deutsche Bank, personal insurance and a rail information site featuring in the top 6, whilst the French and British are still mostly using the Web to pursue leisure interests namely travel, music and books.

Internet usage of the panelists is measured by NetMeter software. It resides on the panel member's PC and tracks all Internet services.

1. Amazon.co.uk
2. Lastminute.com
3. Amazon.com
4. Jungle.com
5. Bonzi.com
6. Ugo.com
7. Expedia.co.uk
8. Barclays.co.uk
9. Bol.com
10. Apple.com

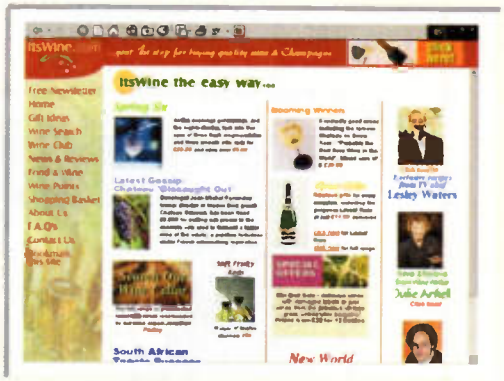
UK's ten most frequently visited sites February 2000 (Source: NetValue)

Boarding House Net Access for Cheltenham Ladies

More than two hundred and fifty boarders at Cheltenham Ladies' College have been provided by NBase-Xyplex at <www.nbase-xyplex.com> with Internet access from their own rooms, in a project which saw the College's entire network upgraded to a switched 10/100 Mbps network.

Previously, the school's sixth-form boarders had access only to standalone PCs in their rooms, allowing them to work on word-processing tasks but not to access other resources within the school or on the Internet.

Web Wine Shop Provides Expert Advice



The latest development in convenience shopping for the discerning wine lover is the launch of a new Internet based wine business called ItsWine.com that aims to bring all the benefits and convenience of shopping on the Internet to the wine buyer.

The company's site at <www.itswine.com> is designed to appeal to every sort of wine lover from the novice wanting to learn and experiment through to the expert searching out the more unusual and rare items.

"Our aim is to make the wine buying experience fun and easy. The Web enables us to provide customers with as much information on bottles of wine as they require - right down to tasting notes prepared by our experts, Jonathan Pedley, master of wine, and wine writer, Julie Arkell that are on the Web site," said Edward Mills, founder of ItsWine.com.

Save Over £200 on the Cost of a Second Line

AltaVista, and NTL are the latest to join the mad scramble of companies launching free access to Internet services. This has really stoked up interest for those wanting to get connected to the Internet at home.

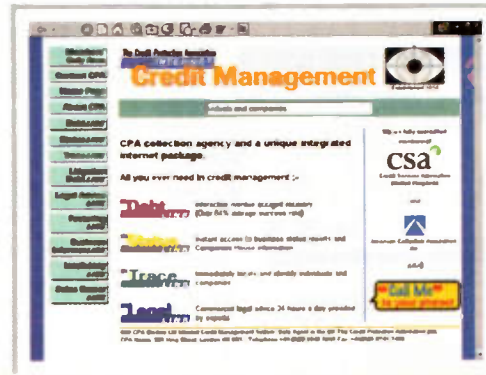
However, unlimited access is very well, but this can tie-up the phone line - meaning that you cannot make or receive any calls during that time. Many will want to avoid this problem by installing a second phone line which can cost about £200 per year.

But a UK Internet start up has a solution. Online Call Manager is a free software application that means you don't have to get a second line.

The software which can be downloaded from the Online Call Manager Web site at **<www.ocmuk.com>** takes the form of a little pop up box that appears on the screen when a call comes through. It tells the user who is calling and they are given the choice to divert to mobile, fixed line or voicemail or take the call over the Internet using Voice over Internet Protocol (VoIP).

Users are charged only for the diversion of incoming calls. Rates are 10p per minute and typical users can expect to pay less than £2.50 per month.

No More Cheque in the Post with Getaresult.co.uk



The Credit Protection Association, an established provider of credit management services, has announced details of a new online initiative designed to address the issue of late payment which accounts for a quarter of the UK's 40,000 annual business failures.

<www.getaresult.co.uk> allows businesses to submit details of outstanding invoices electronically, commencing a three letter cycle to the debtor from the Credit Protection Association. This proven, professional system has an 80% success rate in resolving late payment problems.

According to BACS, the automated payments clearing house, UK small businesses have a combined overdraft of nearly £4 billion.

Late payment is an issue that is particularly prevalent in the UK, where more than one in three businesses suffer from late payment problems according to new research from the Credit Management Research Centre.

With this new online service, businesses have the freedom to address late payment at any hour they choose seven days a week from any location, and went live at the end of March.

The service costs around £25 to chase each debt. CPA is currently running a special launch offer, allowing businesses to submit three outstanding debts simultaneously for the price of one.

Web Site Launched for Aspiring UK Internet Start-ups

Andrew Ogilvie, a veteran Scottish net entrepreneur, has launched Net Venture World, a Web site offering help and advice for aspiring Internet entrepreneurs.

<www.netventureworld.co.uk> offers straightforward, practical advice on the complexities of starting up an e-business. The intricacies of Internet marketing, attracting investment and the technicalities of setting up a site are tackled with a no jargon approach.

Net entrepreneurs will be able to share their experiences in a new email discussion list. The new site aims to tap the growing interest in the possibilities of Internet business. Publicity given to over-night Internet millionaires has made the man in the street consider how to get involved in an Internet start-up.

"For anyone new to the Internet industry a lot of the jargon and business issues are quite intimidating, people really don't know where to start," said Ogilvie.

Net Venture World is particularly keen to encourage enthusiastic novices and small businesses that bring innovation to the UK Internet scene.

"There is a huge buzz in UK start-ups right now, but not much support for the novice entrepreneur. Not everyone has millions in startup funding and we need to encourage the smaller players. Out of small things and great ideas, big things can definitely grow, given the right support," said Ogilvie.

Ogilvie, aged 31, founded eurotrip.com at **<www.eurotrip.com>**, a leading Web site for European back-packing and student travel, in late 1994. From early beginnings as a home-page with a handful of personal travel recommendations it grew into a market leader.

In December 1999 a US company, who retained Ogilvie to work on the site's marketing strategy, acquired eurotrip.com.

"My advice to anyone thinking about jumping into the Internet business is just do it and make the most of the Internet's opportunities," said Ogilvie.

Portal in a Box

Actinic PortalBuilder, launched in March, contains everything needed to build, host and manage a comprehensive online shopping mall, including design templates, remote management capabilities, banner advertising, comprehensive searching and more. For further details check Actinic's Web site at <www.actinic.co.uk>

Messenger Plus Optimises Email Attachments

eFax.com at <www.efax.com> has launched a free software product called Messender Plus that adds a new dimension to email document delivery over the Internet. Messenger Plus makes documents more portable than ever - over thirty common formats, like fax, PDF, AutoCad, and PowerPoint can be easily sent to any email recipient for instant viewing and printing in the highest possible resolution.

Messenger Plus software allows users to send large colour and black-and-white documents, created with nearly any common application. Using eFax.com's proprietary compression technology, Messenger Plus sends fax and email documents in a format up to 2-3 times smaller than their original size.

Additionally, Messenger Plus enables users to send text-annotated faxes and voice-annotated emails from their computers and then hyperlink these annotations to other documents or even Web sites.

Other features include personal signature stamps, highlighting tools, and the ability to combine, re-order or delete pages from existing fax or email documents using a thumbnail view function.

Getting a Web Site into the Top 10

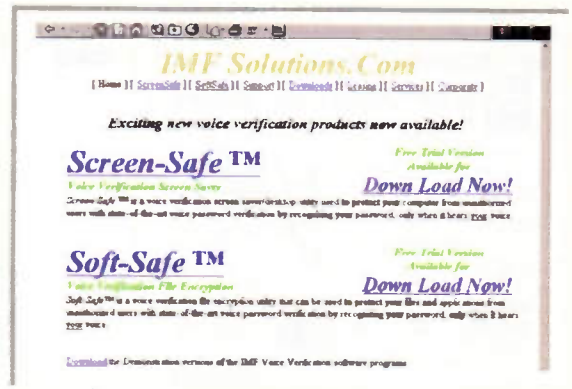
PSINet UK has joined forces with Top-10 Promotions to announce PSINet Top-10, a new service that guarantees Web sites a top ten ranking with the major search engines on the Internet.

Ian Henderson, deputy-managing director of PSINet UK said, "Typically, businesses build an Internet presence and then sit back and wait for people to visit their site. Although it costs nothing to register with a search engine, unless the site is advertising a product or service that has virtually no competition, registration alone will not yield a high ranking."

A top ten ranking with a major search engine such as Yahoo, Lycos or Alta Vista will generate targeted traffic to a Web site 24 hours a day. One of the main benefits of PSINet Top-10's services is the production of a free detailed visibility report.

Visitors to the Web site at <www.psinet.top-10.com> can submit a form to receive a free detailed visibility report. This report provides an easy to read table that shows the customers Web site's current ranking on all major search engines when searching for a given key word. The report is automatically generated and sent via email within one hour.

Dowmload Voice Verification Products Free



IMF Solutions, has launched two new state-of-the-art voice verification products, Screen-Safe and Soft-Safe, through its new Web site <www.imfsolutions.com> and several of the Internet's leading shareware distribution Web sites.

Screen-Safe is a full functionality voice identity protected screen saver program that is used to protect your computer from unauthorised users by recognising your password, only when it hears your voice. Demo versions of both applications can be downloaded from the IMF Web site for free.

Internet.com Acquires LinuxApps.com, Premier Linux Web Site

Internet.com at **<www.internet.com>** has acquired LinuxApps.com at **<www.linuxapps.com>** a premier download site for Linux developers and offers the widest range of downloadable Linux applications on the Web.

LinuxApps.com features an extensive library of Linux titles and up-to-the-minute listings of new applications and will be closely integrated with other Internet.com Linux-focused sites including: LinuxToday.com **<linuxtoday.com>**, LinuxPlanet **<www.linuxplanet.com>**, LinuxStart **<www.linuxstart.com>**, Linux Central **<www.linuxcentral.com>**, JustLinux **<www.justlinux.com>** and LinuxProgramming.com **<www.linuxprogramming.com>**.

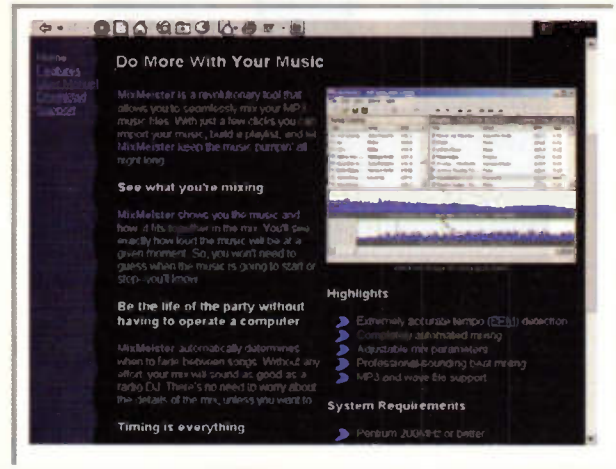
French Ministry Bans English E-mail

In an effort to limit the spread of English throughout the Internet, the French Ministry of Finance has banned common English language business words such as e-mail and start-up from official meetings.

Instead, civil servants are directed to use the phrases courrier electronique and jeune pousse - a young plant.

The announcement came as two French newspapers - Liberation and Le Monde - reported that French President Chirac had used the phrase les start-ups when he toured Republic Alley, a building in Paris that houses many young French Internet companies.

MixMeister Releases MixMeister for MP3 Mixes



MixMeister announced the public release of MixMeister 1.0, a software tool to seamlessly mix MP3 music files.

MixMeister is a Windows-based application that makes building a killer mix easy. With just a few clicks users can import music, organise the mix and produce professional-sounding results.

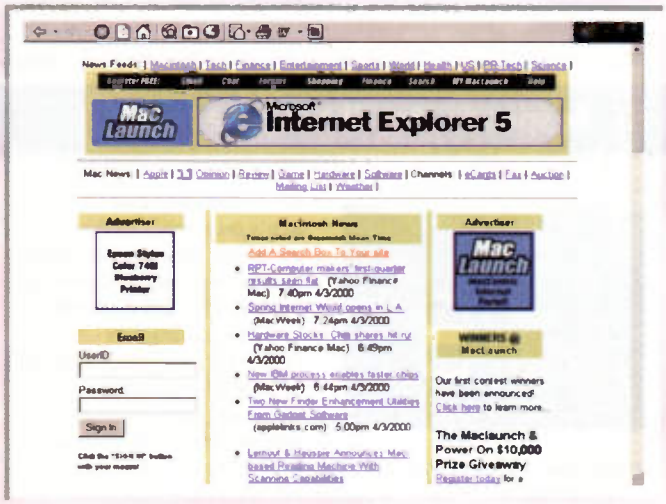
MixMeister delivers unprecedented ease-of-use through intelligent mixing algorithms. By creating a unique profile for each song, MixMeister adapts the mix just like a radio DJ.

Additionally, users can adjust the song's profile: configure it for beat mixing; and save the settings for future use. MixMeister automatically combines all these inputs to create a perfect mix, every time.

MixMeister provides a complete picture of the music through a graphical timeline. With MixMeister's visual roadmap of the entire mix, users can see exactly how all the songs fit together. The display includes the start, stop, fade, and music speed measured in beats per minute (BPM).

MixMeister 1.0 is available as a free evaluation version on the MixMeister Web site at **<www.mixmeister.com>**.

MacLaunch Acquires MacOPINION.com Web Site



MacLaunch at **<www.maclaunch.com>**, the Internet's first all-encompassing portal targeting Macintosh users, has acquired the MacOPINION at **<www.macopinion.com>** Web site.

Under the terms of the MacLaunch/MacOPINION agreement, MacLaunch will take possession of the MacOPINION Web site and will assume total responsibility for the operation of the site including the continued production of original Mac-centric content and all advertising sales.

The addition of the MacOPINION operation will boost the MacLaunch network of sites to approximately 1.4 million page views and 2.8 million ad impressions per month.

The MacOPINION site will continue to feature original content produced by some of the leading columnists in the Mac user community. Plus, it will also offer direct access to the wealth of services offered at MacLaunch, including Mac-centric news and software updates, free e-mail, chat rooms, news, sports, weather, stock tracking, online shopping and Web search tools.

MacLaunch is dedicated to providing a wide range of online information and communication services with a decidedly Mac-centric twist.

Prime Minister Opens Monster.com Call Center

In an effort to expand its European customer base, monster.com at <www.monster.com>, a global online careers site has opened a call centre in Glasgow, Scotland. The multi-lingual, business-to-business call centre will handle inbound and outbound functions and service the UK, France, the Netherlands and Belgium.

British Prime Minister Tony Blair MP attended the announcement of the call centre, which will bring more than 180 jobs to Glasgow over the next three years.

Staffed with 50 people operating in six languages, the call centre will be equipped to handle inbound and outbound functions. The inbound team will handle customer and job seeker inquiries across all of monster.com's European Web sites, including local content and language sites in the United Kingdom, the Netherlands, Belgium and France.

The outbound business-to-business team will focus its sales efforts on small- and medium-sized organisations throughout Europe.

Service911.com Acquires Downloadable Driver Site

Service911.com, a computer support Web site at <www.support911.com>, has acquired Windrivers.com at <www.windrivers.com>, a Windows Support/Driver Web site

The deal gives Service911.com's technical and computer savvy customers the ability to download drivers, the software that allows computers to communicate with peripherals, components, and other hardware, directly from the Internet.

Since being founded by Scott Hermanson in August of 1997, Windrivers.com has grown to more than 3 million unique visitors per month, while becoming the Web's most reliable source for drivers and updates. It specialises in drivers for Windows-based utilities including CD-ROM/CDRs, hard drives, modems, monitors, network cards, printers and scanners.

As part of Service911.com's industry-leading support content library, Windrivers.com's collection of downloads will grow from its current focus on Windows-related components to include those based on Linux, UNIX and Macintosh's Mac OS operating system.

Service911.com offers help for computers and people who use them. The acquisition of Windrivers.com boosts the site's support capabilities to include driver updates, related news, product reviews and links to driver-related information that are often difficult for advanced computer users to find.

Napster Rocking Music Industry

Napster's free software at <www.napster.com> allows users to swap MP3 files, making it a huge hit with music fans and college students. In fact, Napster has seen its user base grow by as much as 25% per day.

However, musicians and record companies are trying to shut Napster down. The Recording Industry Association of America has sued Napster for copyright violations and £70 million in damages. And universities are blocking students from using Napster because the program is jamming up campus networks.

But now some enterprising computer hackers have come up with a variation on Napster software that helps people search and swap any type of computer file - not just MP3 music files.

The variation, dubbed Wrapster, uses Napster's servers to exchange everything from games and movies to software and spreadsheets by tricking them into thinking the files are in the MP3 format.

BT Responds to Challengers

BT at <www.bt.com> is rising - in it's own way - to the challenge recently presented by NTL and AltaVista, which plan to offer UK customers unmetered Internet access.

In BT's new plan, users will be charged £15.25 a month for unmetered Internet access during evenings and weekends, with weekday charges of 1p per minute.

Residential and business customers who want round-the-clock unmetered access will pay roughly double that amount.

Dot Com Mania Hits the UK

A growing number of economists in the UK say the country could lead the way in Europe's efforts to create a US-style new economy. Prime Minister Tony Blair has pledged to streamline government regulations, create incentives and invest government funding to make the UK the best place in the world for e-commerce by 2002.

The government is talking about cutting its hefty 40% capital gains tax to 22%, in part to energise the IPO market. Since 1998, 50 British Internet companies have launched public offerings, and a flood of new listings is expected in the first six months of this year.

Microsoft Backs RealNames in Browser Catch-up

Microsoft is investing in RealNames and adopting that company's keyword system that allows a person to navigate the Web without having to enter formal addresses but merely keyword. For example, entering BBC would take you to the BBC Web site at <www.bbc.co.uk>.

The technology has already been incorporated in Microsoft's Internet Explorer browser, and will next be added to its MSN online service. America Online has used a keyword system for some time now, and the Netscape Navigator browser has somewhat similar capabilities.

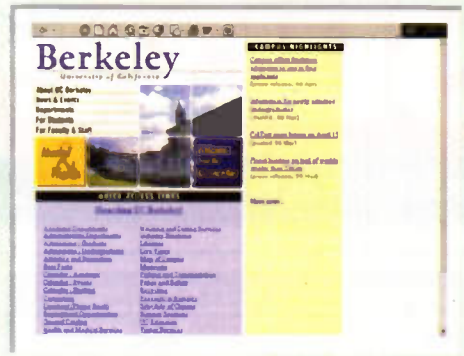
Oxford English Dictionary on Web

Oxford University Press has introduced an online version of the Oxford English Dictionary (OED). The online OED, available at <www.oed.com>, will be updated quarterly and is available for an annual subscription cost to individuals of £350 and to organisations or businesses of £500.

Oxford University Press also has made a second edition of its dictionary available on CD-ROM and is spending £35 million to create a fully revised third edition.

Upon its scheduled completion in 2010, the third edition will contain nearly 1.3 million words and phrases, including additional slang and foreign terms, and will be the first full revision of the original 1928 dictionary.

Unbreakable Hyperlinks



UC-Berkeley computer scientists are working to eliminate those frustrating dead-ends on the Web - broken hyperlinks.

The researchers analysed a number of Web pages, and found that the vast majority of linked pages could be uniquely identified based on a small set of words that no other document shares.

If those words were used to augment the standard URL, the page could found via a search engine even if the URL was no longer accurate. For further details, check: <www.berkeley.com>.

UK Hacker Stole Gates' Credit Card Details

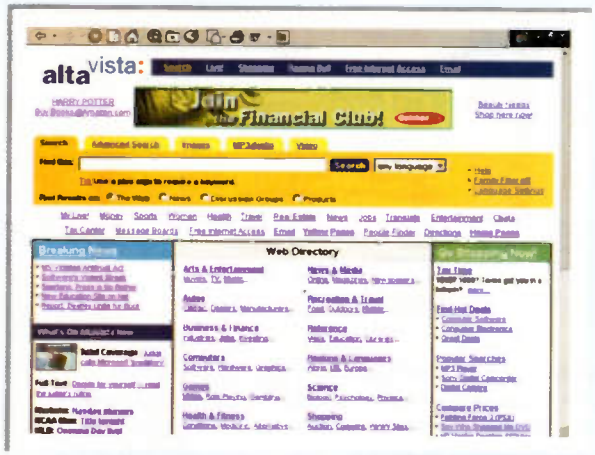
Eighteen-year-old Raphael Gray was arrested at the end of March in Wales on charges of Internet fraud following a joint investigation by the FBI and Welsh police.

Gray and an unnamed accomplice had allegedly hacked into nine e-commerce sites, stealing credit card information on 26,000 accounts in the US, Canada, Thailand, Japan and Britain.

Among the credit cards compromised was one belonging to Microsoft chairman Bill Gates.

Gray, who calls himself the saint of e-commerce, said, "I just wanted to prove how insecure these sites are - I have done the honest thing, but I have been ignored."

AltaVista Launches Truly Free Internet Service



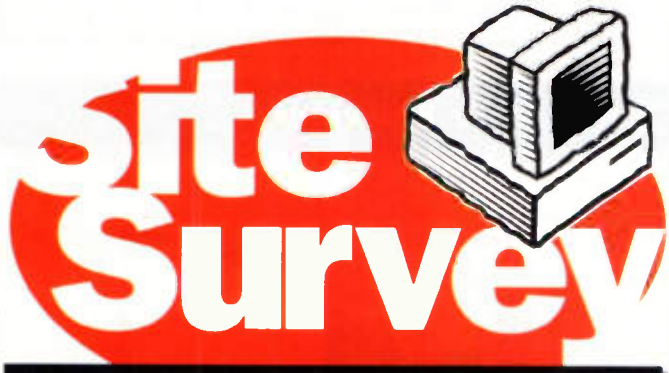
AltaVista at <www.altavista.co.uk> is set to offer customers a free monthly Internet access and free unmetered phone calls, all for one up front charge. The service will be launched within the next three months.

AltaVista is providing a simple structure to Internet charges, which will ensure that consumers do not face hidden extra costs once they commit to a service.

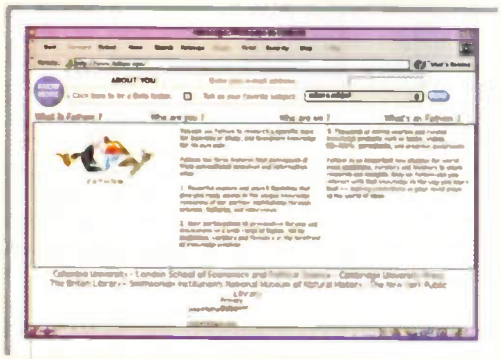
Through research conducted for AltaVista by Datamonitor, to go online for free with Btclick.com at <www.btclick.com> or Freeserve at <www.freeserve.com> will actually cost the consumer £126 per year in local call rates. With AOL the cost goes up to £198 per year.

It is these phone-call costs that according to Durlacher analysts, is preventing more people going online.

The AltaVista system is currently undergoing robust testing to ensure that it is completely stable. Following a number of questionable launches by competitors of other free services, AltaVista will manage the roll-out of its service, to ensure that the customer's satisfaction with the service remains paramount.



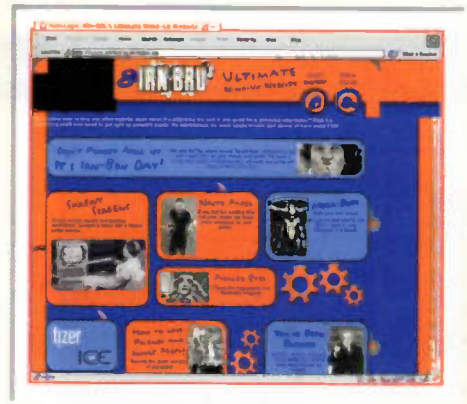
The months destinations



Destinations of the Month

One of the Internet's greatest features is the fact that it is a source of information. It is, after all, the world's biggest library, being as large as the world itself. One of its poorest features is that - as it is so huge - it can be quite difficult finding the information you might want. Hundreds of search engines, and some rather clever search tools have helped, but generally, it can be a little tricky locating the information you want if it's at all technical or specific in nature. Fathom is a brand-new site - in beta test stage at the time of writing - that aims to help academics and curators, though is available for anyone to use. Its idea is to centralise as much related information as possible making the research of information as easy as possible. If the beta's anything to go by, Fathom will be a simply brilliant resource. Check out Fathom, at: <http://www.fathom.com>.

The other side of the coin for Internet users is the fact that far from being a tremendously yawn-inducing old source of boredom, err... no, we mean intellectually stimulating resource, it can be an absolutely wonderful place to find amusement. So, if you're only looking to enjoy yourself on the Internet, and want to leave the world of geeks to the geeks, try Irn-Bru's comprehensive source of fun. Here you'll find tricks to play on your friends (possibly ex-friends when you play these tricks), jokes to make you giggle, pictures to boggle your eyes, and a general good time for all. The Irn-Bru Website is at: <http://www.irn-bru.co.uk/>.



There's much being said about people buying cars over the Internet to beat the UK car dealers' expensive stranglehold on the market, that we had a look to see how easy it is to buy a new car this way. Well, it is easy. All you have to do is point your browser to CarBusters.com, at: <http://www.carbusters.com/>, choose your make and model of car to find out how much you'll save, click a few buttons and wait for delivery. It really is that simple, and if I was a UK car dealer I'd be starting to get worried - in fact, extremely worried.

The 8031 SINGLE BOARD COMPUTER

PART 2

Richard Grodzik continues his description of a compact and versatile computer

Testing The System

Once the 8031 SBC has been populated and soldered and checked for shorts and opens, A series of small and simple programs will check the functionality of each peripheral. The first program example will check the integrity of the data bus and whether the EPROM emulator is functioning in the circuit.

The assembler directive #INCLUDE SFR51.EQU loads all the addresses of the 8031 into the .LST file so that individual portlines and SFR's are automatically assigned their unique address.

```
;PORT
#INCLUDE SFR51.EQU

.ORG 0h
HERE:
            mov P1,#0aah
            MOV P1,#055H

            SJMP HERE

.ORG 0800H
.END
```

The .ORG 0800H statement causes 2Kbytes of object code to be assembled, which is the capacity of the 27C16 EPROM. Running the A.BAT file will produce a PORT.OBJ file which is sent to an EPROM emulator connected to the 8031 SBC. Applying a logic probe to 8031 lines P1.0 through P1.7 will show that the data is continually changing from 55H to AAH. If this does not happen proceed no further, since there is every likelihood that a hardware connection fault exists which must be investigated and rectified. Disconnect the power line and using a simple continuity tester check the entire board against the circuit diagram.

If we examine the PORT.LST file, the register table will be shown as follows: The user program occurs at the end of the table and shows that it has correctly assembled.

The 8031 is equipped with a SFR (PCON) which suspends all processor activity, preserves the internal Block contents and tristates the control and data bus, effectively placing the 8031 is a dormant state in which negligible power is consumed. To 'snap' it awake, an active low is applied to an interrupt pin or the processor can be cold started by a reset. In the following example the 8031 is put into the idle state at program START. Once an external interrupt is issued on pin INT0, BYTE 11H is placed on port P1.

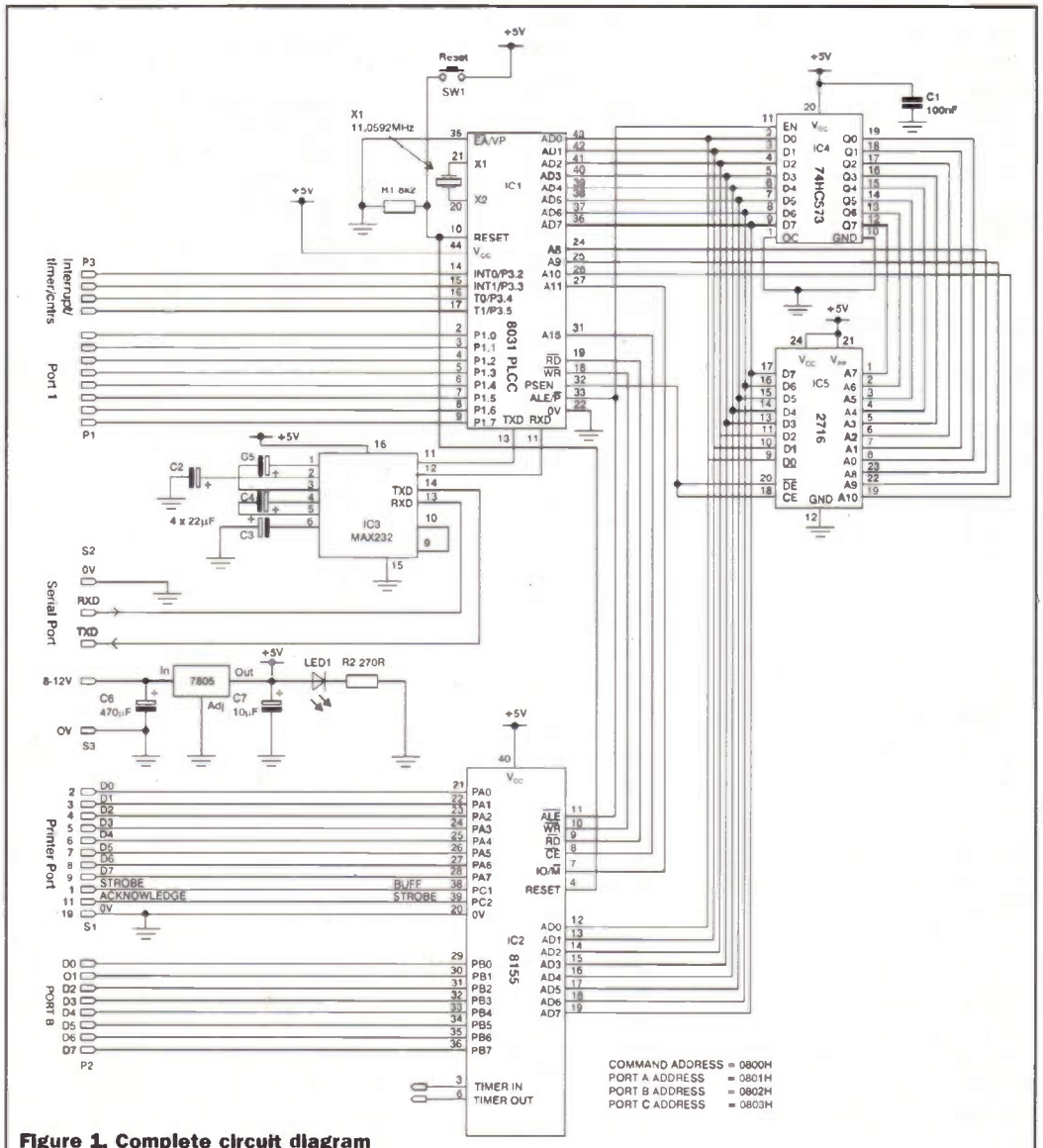


Figure 1. Complete circuit diagram

```
0001  0000                #include sfr51.equ
0001+ 0000
0002+ 0000                ; THIS IS THE SPECIAL FUNCTION
                            REGISTER
                          ; TABLE FOR USE WITH THE 8051
0003+ 0000
0014+ 0000
0015+ 0000                P1.EQU90H
0016+ 0000
0017+ 0000                P1.0.EQU90H
0018+ 0000                P1.1.EQU91H
0019+ 0000                P1.2.EQU92H
0020+ 0000                P1.3.EQU93H
0021+ 0000                P1.4.EQU94H
0022+ 0000                P1.5.EQU95H
0023+ 0000                P1.6.EQU96H
0024+ 0000                P1.7.EQU97H
0025+ 0000
0037+ 0000                P3.EQU0B0H
0038+ 0000
0039+ 0000                P3.0.EQU0B0H
0040+ 0000                P3.1.EQU0B1H
0041+ 0000                P3.2.EQU0B2H
0042+ 0000                P3.3.EQU0B3H
0043+ 0000                P3.4.EQU0B4H
0044+ 0000                P3.5.EQU0B5H
0045+ 0000                P3.6.EQU0B6H
0046+ 0000                P3.7.EQU0B7H
0047+ 0000
0048+ 0000                ; TCON BITS
0049+ 0000
0050+ 0000                TCON.EQU88H;REGISTER ADDRESS
0051+ 0000
0052+ 0000                IT0.EQU88H;BIT ADDRESS
0053+ 0000                IE0.EQU89H
0054+ 0000                IT1.EQU8AH
0055+ 0000                 IE1.EQU8BH
0056+ 0000                TR0.EQU8CH
0057+ 0000                TF0.EQU8DH
0058+ 0000                TR1.EQU8EH
0059+ 0000                TF0.EQU8FH
0060+ 0000
0061+ 0000                ; SCON
0062+ 0000
0063+ 0000                SCON.EQU98H;REGISTER ADDRESS
0064+ 0000
0065+ 0000                RI.EQU98H;BIT ADDRESS
0066+ 0000                TI.EQU 99H
0067+ 0000                RB8.EQU9AH
0068+ 0000                TB8.EQU9BH
0069+ 0000                REN.EQU9CH
0070+ 0000                SM2.EQU9DH
0071+ 0000                SM1.EQU9EH
0072+ 0000                SM0.EQU9FH
0073+ 0000
0074+ 0000                ; IE
0075+ 0000
0076+ 0000                IE.EQU0A8H;REGISTER ADDRESS
0077+ 0000
0078+ 0000                EX0.EQU0A8H;BIT ADDRESS
0079+ 0000                ET0.EQU0A9H
0080+ 0000                EX1.EQU0AAH
0081+ 0000                ET1.EQU0ABH
0082+ 0000                ES. EQU0ACH
0083+ 0000                IE.5.EQU0ADH
0084+ 0000                IE.5.EQU0AEH
0085+ 0000                EA.EQU0AFH
0086+ 0000
0087+ 0000                ; IP
0088+ 0000
0089+ 0000                IP .EQU 0B8H;REGISTER ADDRESS
0090+ 0000
0091+ 0000                PX0.EQU0B8H;BIT ADDRESS
0092+ 0000                PT0.EQU0B9H
0093+ 0000                PX1.EQU0BAH
0094+ 0000                PT1.EQU0BBH
0095+ 0000                PS.EQU0BCH
0096+ 0000                IP5.EQU0BDH
0097+ 0000                IP6.EQU0BEH
0098+ 0000                IP7.EQU0BFH
0099+ 0000
0100+ 0000                ; PSW
0101+ 0000
0102+ 0000                PSW.EQU0D0H;REGISTER ADDRESS
0103+ 0000
0104+ 0000                P.EQU0D0H;BIT ADDRESS
0105+ 0000                F1.EQU0D1H
0106+ 0000                OV.EQU0D2H
0107+ 0000                RS0.EQU0D3H
0108+ 0000                RS1.EQU0D4H
0109+ 0000                F0.EQU0D5H
0110+ 0000                AC.EQU0D6H
0111+ 0000                CY.EQU0D7H
0112+ 0000
0113+ 0000                ; ACC
0114+ 0000
0115+ 0000                A.EQU0E0H;REGISTER ADDRESS
0116+ 0000
0117+ 0000                A.0.EQU0E0H;BIT ADDRESS
0118+ 0000                A.1.EQU0E1H
0119+ 0000                A.2.EQU0E2H
0120+ 0000                A.3.EQU0E3H
0121+ 0000                A.4.EQU0E4H
0122+ 0000                A.5.EQU0E5H
0123+ 0000                A.6.EQU0E6H
0124+ 0000                A.7.EQU0E7H
0125+ 0000
0126+ 0000                ; B
0127+ 0000
0128+ 0000                B.EQU0F0H;REGISTER ADDRESS
0129+ 0000
0130+ 0000                B.0.EQU0F0H;BIT ADDRESS
0131+ 0000                B.1.EQU0F1H
0132+ 0000                B.2.EQU0F2H
0133+ 0000                B.3.EQU0F3H
0134+ 0000                B.4.EQU0F4H
0135+ 0000                B.5.EQU0F5H
0136+ 0000                B.6.EQU0F6H
0137+ 0000                B.7.EQUOF7H
0138+ 0000
0139+ 0000                ; OTHER SPECIAL FUNCTION
                          REGISTERS (NOT BIT ADDRESSABLE)
0140+ 0000                SBUF.EQU99H
0141+ 0000                TH1.EQU8DH
0142+ 0000                TH0.EQU8CH
0143+ 0000                TL1.EQU8BH
0144+ 0000                TL0.EQU8AH
0145+ 0000                TMOD.EQU89H
0146+ 0000                PCON.EQU87H
0147+ 0000                DPH.EQU83H
0148+ 0000                DPL.EQU82H
0149+ 0000                SP.EQU81H
0150+ 0000
0151+ 0000
0152+ 0000
0153+ 0000
0002  0000
0003  0000                .ORG 0h
0004  0000                HERE:
0005  0000 75 90 AA               mov P1,#0aah
0006  0003 75 90 55               MOV P1,#055H
0007  0006
0008  0006 80 F8             SJMP HERE
0009  0008
0010  0800                .ORG 0800H
0011  0800
0012  0800                .END
0013  0800
0014  0800
0015  0800
tasm: Number of errors = 0
```

```
;IDLE
#INCLUDE SFR51.EQU
;INT0 active low input

.ORG 0h ;RESET VECTOR
      LJMP START

.ORG 3  ;INT0 INTERRUPT VECTOR

      MOV PCON,#0H          ;NORMAL MODE
      LCALL PORT
      RETI

START:
      SETB EX0              ;(IE SFR)
      SETB EA               ;(IE SFR)
      MOV PCON,#1           ;IDLE MODE
                            ;TRI-STATE PSEN AND DATA BUS
WAIT: SJMP WAIT

PORT:
      MOV P1,#011H
      RET                   ;RETURN TO CALLING PROGRAM

.ORG 0800H
.END
```

Counters and Timers.

The 8031 is equipped with two 16-bit timer/counters. First we shall look at an example of a counting function. In the following example counter 1 is used to count external switch presses. A simple push to make switch is wired in series with the 0V line and the T1 terminal pin. Each switch press will increment the counter and the accumulated counts will be progressively displayed on port P1.

```
;COUNTER
#INCLUDE SFR51.EQU
;COUNTER PROGRAM
.ORG 0                  ;START ADDRESS OF ROM

.ORG 0400H              ;START OF USER PROGRAM

 CLR EA                 ;DISABLE ALL INTERRUPTS
 SETB P3.5              ;COUNTER PIN SET HIGH
 MOV TMOD,#050H         ;16 BIT COUNTER T1

 SETB TR1               ;TURN ON COUNTER ;(TCON SFR)
 MOV TL1,#0             ;CLEAR COUNTER-LOW BYTE
 MOV TH1,#0             ;CLEAR COUNTER-HIGH BYTE

LOOP:MOV A,TL1          ;MOVE COUNT VALUE(LOW BYTE)
                        ;INTO ACCUMULATOR
 MOV P1,A               ;AND SEND TO DISPLAY

WAIT:JB P3.5,WAIT       ;WAIT FOR LOW ON T1 PIN
                        ;TO INCREMENT COUNTER
 CLR TR1                ;DISABLE COUNTER
 SETB P3.5              ;TAKE COUNTER PIN HIGH
 LCALL DELAY            ;DEBOUNCE SWITCH
 SETB TR1               ;TURN ON COUNTER
 LJMP LOOP              ;AND REPEAT

DELAY:                  ;DEBOUNCING DELAY
 MOV R6,#010H           ;DEFINES DELAY PERIOD (10- 50 mS)
DEL1:DEC R6
 MOV R7,#0FFH
DEL2:DEC R7
 CJNE R7,#0,DEL2
 CJNE R6,#0,DEL1
 RET


.ORG 0800H
.END
```

Here the timer 0 is used to generate a square wave on pin T0.The frequency dependent on the values loaded into the high and low byte timer registers. Note that the timer increments towards FFFFH. When this point is reached an interrupt is issued.

```
;TIMER
#INCLUDE SFR51.EQU
.ORG 0H
   LJMP BEGIN
.ORG 0BH                ;TIMER 0 INTERRUPT
      CPL P3.4          ;TOGGLE T0 LINE
      MOV TH0,080H      ;LOAD TIMER 0 HIGH BYTE
                        REGISTER
      MOV TL0,0H        ;LOAD TIMER 0 LOW BYTE
                        REGISTER
      RETI

BEGIN:CLR EA            ;DISABLE INTERRUPTS
      MOV TMOD,
      #00001001b        ;GATE ON,16 BIT TIMER 0
      SETB TR0          ;TIMER 0 ON
      SETB ET0          ;ENABLE TIMER 0 INTERRUPT
      SETB EA           ;ENABLE GLOBAL (all)
                        INTERRUPTS

WAIT: SJMP WAIT         ;WAIT FOR TIMER 0 INTERRUPT

.org 0800h
.END
```

The Serial Communications Port

The 8031 contains an onboard USART which is formidable in that it is difficult for the novice to initialise. The example program 'TXD' shown below shows how serial transmission at 9600 baud is achieved. Connect the TXD line of the 8031 SBC to pin 2 of a D Type 9-way socket. Connect pin 5 to the 0V line and strap together pins 4,6 and 7,8 to disable hardware handshaking. A simple comms program such as Terminal in Windows is then configured for Terminal emulation at 9600,8,1,no parity. Download the TXD.OBJ file to the SBC and press the reset button. A stream of data will display the entire alphanumeric characters on the PC.

```
;TXD
#INCLUDE SFR51.EQU
.ORG 0h
      MOV A,#030h       ;ASCII CHARACTER '0'
CYCLE:
      ACALL TXD         ;TRANSMIT CHARACTER
      INC A             ;NEXT CHARACTER
      MOV P1,A          ;DISPLAY ON PORT P1 LINES
      ACALL DEL         ;DELAY BETWEEN EACH
                        CHARACTER
      LJMP CYCLE        ;REPEAT FOREVER



                        ;TXD SUBROUTINE

TXD:  MOV SCON,#050H    ;SERIAL MODE 1,RECEIVER
                        ENABLED
      MOV TMOD,#020H    ;TIMER 1  8-BIT AUTO RELOAD
      MOV TH1,#0FDH     ;TIMER RELOAD VALUE
                        ;FOR 9600 BAUD-11.0592

      CLR EA            ;DISABLE GLOBAL INTERRUPT
                        (IE SFR)
      MOV SBUF,A        ;LOAD SERIAL BUFFER WITH
                        DATA
      SETB TR1          ;TIMER 1 ON (TCON SFR)
LOOP: JNB TI,LOOP       ;IF FLAG TI IS SET, (SCON SFR)
                        ;BYTE HAS BEEN
                        TRANSMITTED
      CLR TR1           ;TIMER 1 OFF  (TCON SFR)
      CLR TI            ;CLEAR BYTE RECIEVED FLAG
                        (SCON SFR)
      RET               ;RETURN TO CALLING
                        PROGRAM

DEL:MOV R1,#$95
LOOP2:MOV R0,#$F
INLOOP:DJNZ R0,$
      DJNZ R1,LOOP2
      RET

.ORG 0800H
.END
```

Work through the source code shown on the immediate previous page with the aid of the SFR registers depicted in SFR_1 and SFR_2 diagrams examine how the SFR's have been programmed.

For high speed communications, it is a simple matter of programming the SCON (serial control register) as follows:

```
;HIGHSPEED
#INCLUDE SFR51.EQU
.ORG 0h
        MOV A,#055h     ;01010101 BINARY
CYCLE:
        ACALL TXD       ;TRANSMIT
        LJMP CYCLE      ;REPEAT FOREVER


                        ;TXD SUBROUTINE

TXD:    MOV SCON,#080H ;F/32 HIGH SPEED MODE

        CLR EA          ;DISABLE GLOBAL INTERRUPT (IE
                        SFR)
        MOV SBUF,A      ;LOAD SERIAL BUFFER WITH DATA
        SETB TR1        ;TIMER 1 ON (TCON SFR)
LOOP:   JNB TI,LOOP     ;IF FLAG TI IS SET, (SCON SFR)
                        ;BYTE HAS BEEN TRANSMITTED
        CLR TR1         ;TIMER 1 OFF  (TCON SFR)
        CLR TI          ;CLEAR BYTE RECIEVED FLAG
                        (SCON SFR)
        RET             ;RETURN TO CALLING PROGRAM


.ORG 0800H
.END
```

Here, the 8031 USART operates at high speed with each bit period of 6ms duration. Note that RS232 data format is not used and no start or stop bit is transmitted.

To receive data the 8031's serial buffer (SBUF) is again used, but this time the RI flag of the serial port control register (SCON) is polled to see if a byte has been received.

```
;RXD
#INCLUDE SFR51.EQU
.ORG 0h


RXD:    MOV SCON,#050H      ;SERIAL MODE 1,RECEIVER
                                        ENABLED
        MOV TMOD,#020H      ;TIMER 1  8-BIT AUTO RELOAD
        MOV TH1,#0FDH       ;TIMER RELOAD VALUE FOR
                            ;9600 BAUD-11.0592
        CLR EA              ;DISABLE GLOBAL INTERRUPT
again:  SETB TR1            ;TIMER 1 ON
LOOP:   JNB RI,LOOP         ;IF FLAG RI IS SET,
                            ;BYTE HAS BEEN RECEIVED
        MOV A,SBUF          ;TRANSFER SERIAL BUFFER
                            CONTENTS TO A
        CLR TR1             ;TIMER 1 OFF
        CLR RI              ;CLEAR BYTE RECIEVED FLAG
        MOV P1,A            ;DISPLAY RECEIVED BYTE
        LJMP again

.ORG 0800H

.END
```

The use of software polling is restrictive to the processor since all other activities have to be suspended while it waits for a serial byte to enter the serial port. A much more powerful way of receiving serial data is by means of an interrupt facility. Here a background programming can be executing: when a serial byte arrives, the program suspends and vectors to the serial interrupt vector at which the interrupt routine services the received data.

How it Works

The serial registers are configured for reception of data. The global interrupt and the serial interrupt is enabled. The background program (MAIN PROGRAM) begins execution and is interrupted when a byte is received in the serial buffer - an INTERRUPT is issued, and execution of the background program is suspended. The program counter is loaded with address 23H (The serial interrupt vector),and program execution recommences here. The received byte is loaded into the P1 register - the contents of which appear on port lines P1.0 - P1.7. The program returns to the background program where the received byte is re-displayed.

```
;RXD_INT
#INCLUDE SFR51.EQU

SERIAL  .EQU 023H           ;SERIAL INTERRUPT VECTOR

.ORG 0H
        LJMP START

.ORG SERIAL                 ;INTERRUPT SERVICE ROUTINE
                            GOES HERE

        CLR ES              ;DISABLE FURTHER INTERRUPTS
        CLR TR1             ;TIMER 1 OFF
        MOV P1,SBUF         ;DISPLAY RECEIVED BYTE
        SETB TR1            ;TIMER 1 ON
        SETB ES             ;ENABLE INTERRUPTS
        CLR RI              ;CLEAR RECEIVE BYTE FLAG
        RETI                ;RETURN TO BACKGROUND
                            PROGRAM


.ORG 0100H
START:

        MOV SCON,#050H      ;SERIAL MODE 1
        MOV TMOD,#020H      ;TIMER 1  8-BIT AUTO RELOAD
        MOV TH1,#0FDH       ;TIMER RELOAD VALUE FOR
                            ;9600 BAUD-11.0592
        SETB EA             ;ENABLE GLOBAL INTERRUPT
        SETB ES             ;ENABLE RECEIVE DATA INTERRUPT
        SETB TR1            ;TIMER 1 ON
==================================
                            ;BACKGROUND PROGRAM
                            ;
LOOP1:  MOV P1,SBUF         ;DISPLAY RECEIVED BYTE
        SJMP LOOP1          ;REPEAT

==================================
.org  0800H                 ;2 kbytes ROM (2716)
.END
```

Continued next month

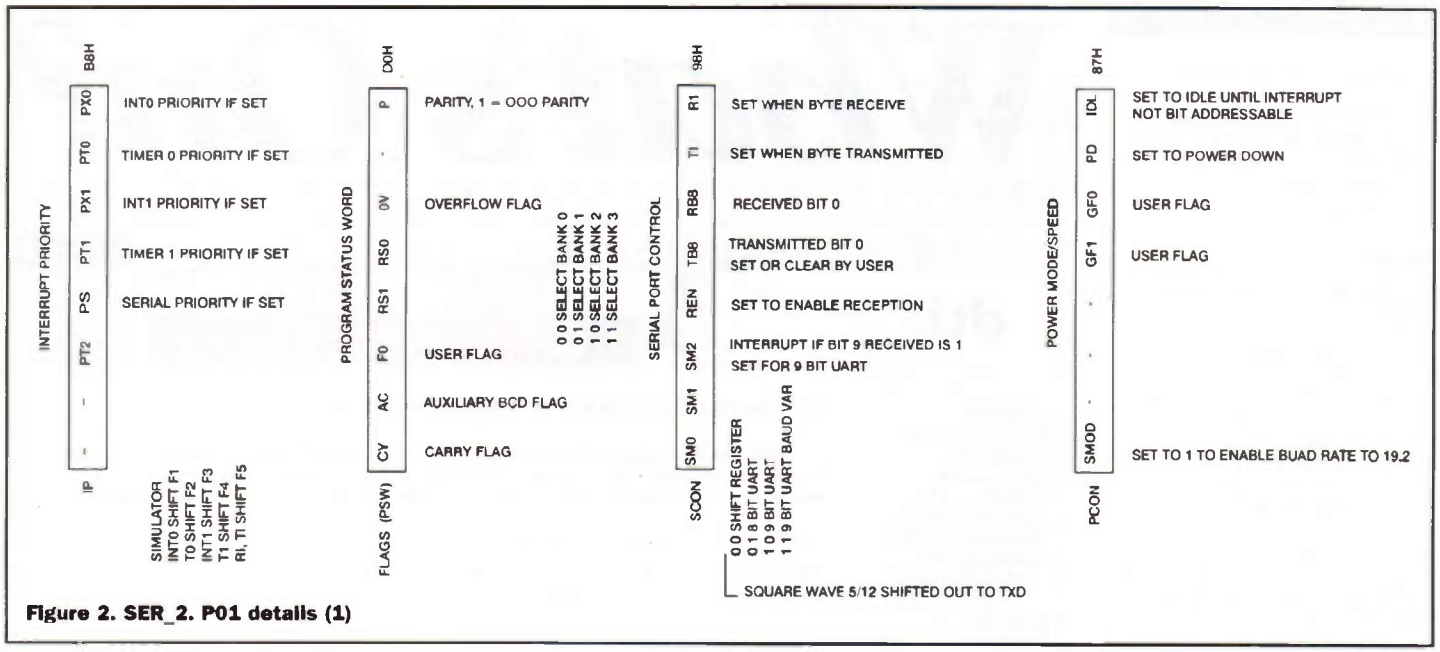


Figure 2. SER_2. P01 details (1)

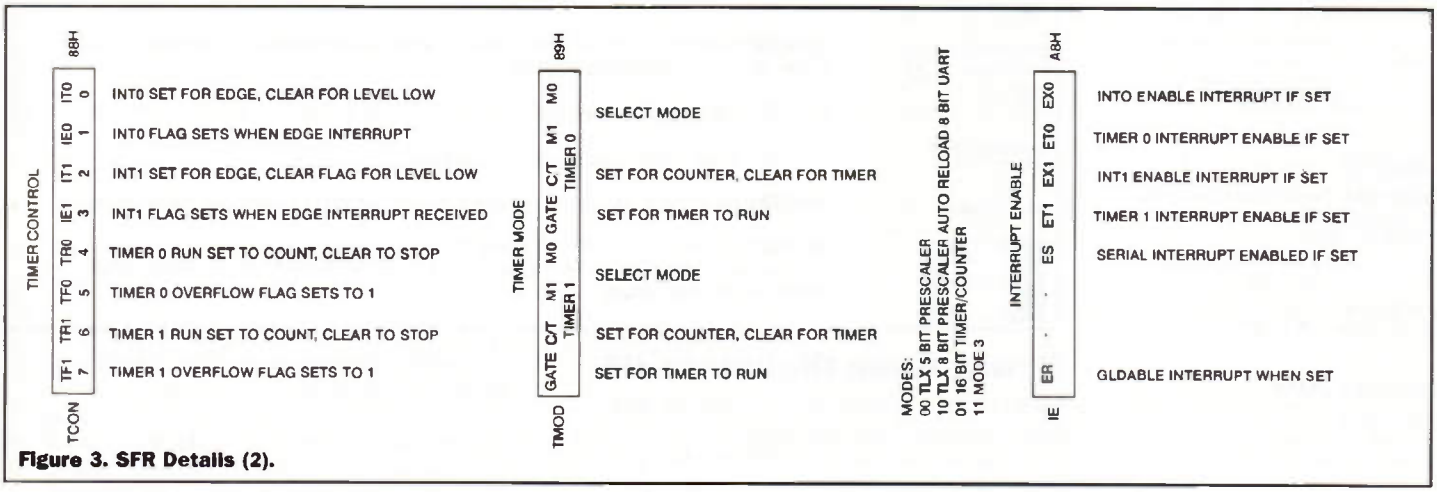


Figure 3. SFR Details (2).

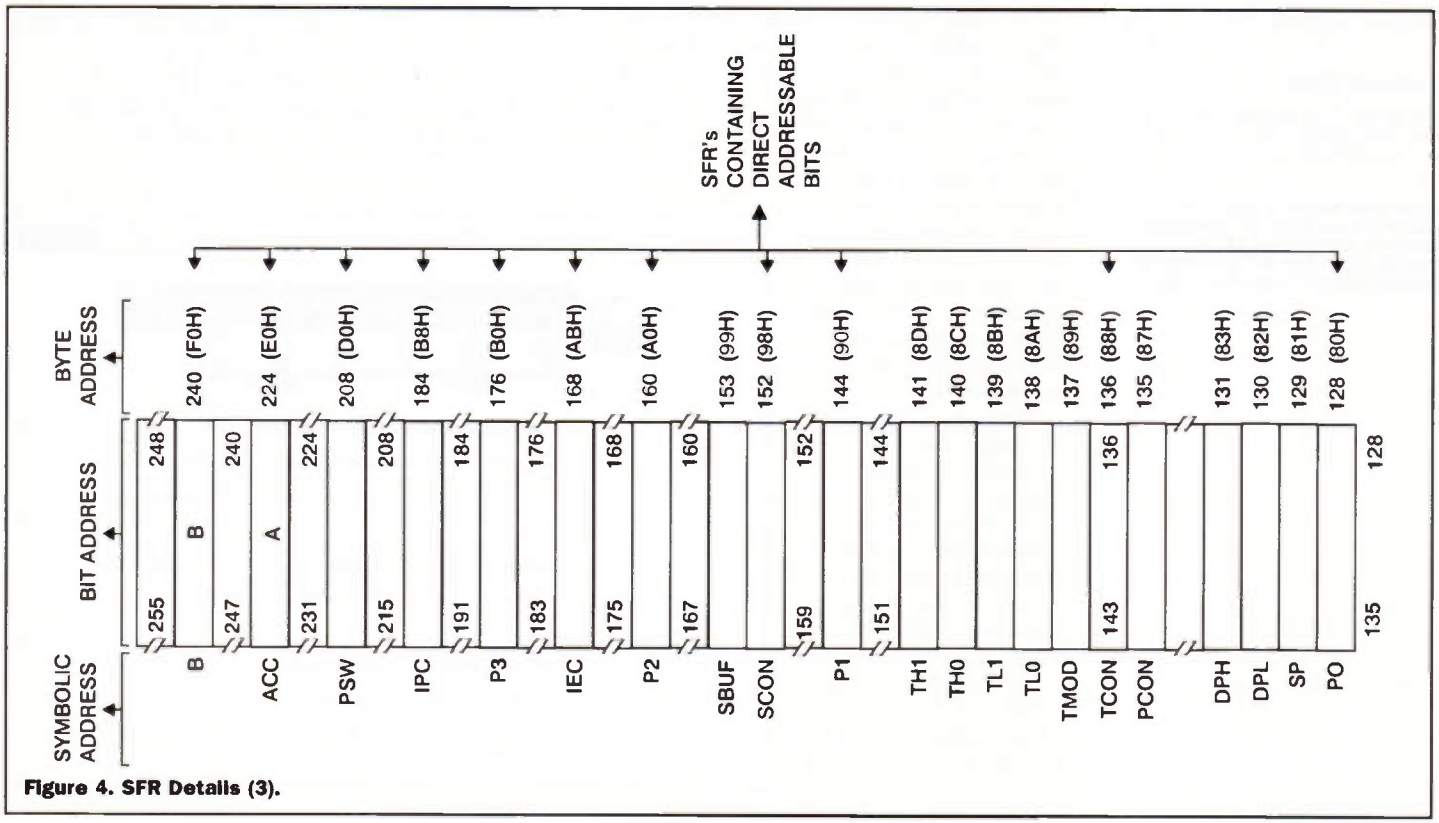


Figure 4. SFR Details (3).

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.

May 2000

7 to 12 May. World Telecommunications Congress/ISS 2000, IEE, Birmingham. Tel: 020 7344 5471.

8 May. Wireless Communications Workshop, Bracknell. Tel: 020 7861 6385.

8 to 11 May. IFSEC/Security Solutions, NEC, Birminham. Tel: 020 8742 2828.

9 May. PLD and FPGA, Sandown. Tel: 020 7861 6369.

9 to 10 May. Dealer Expo and Channel Expo, NEC Birmingham. Tel: 01923 676 867.

9 to 11 May. Networks Telecom, NEC, Birmingham. Tel: 020 8742 2828.

9 to 11 May. Mobilexpo, NEC, Birmingham. Tel: 020 8910 7910.

15 to 17 May. Mediacast 2000, Earls Court, London, Tel: 020 8910 7910

17 to 18 May. Batteries Conference and Exhibition, Solihull. Tel: 01372 367021.

23 to 25 May. Internet World, Earls Court, London. Tel: 020 8232 1600.

24 to 25 May. Embedded Systems Show, London. Tel: 020 7681 1000.

June 2000

16 to 18 June. Theme World - Theme Park & Attractions, Alexandra Palace, London. Tel: 0208 451 6385.

27 to 29 June. Networks Telecom 2000, NEC Birmingham. Tel: 0208 742 2828.

27 to 29 June. Computer Telephony Expo, NEC Birmingham. Tel: 0208 742 2828.

September 2000

21 to 24 Sept. Live - Consumer Electronics Show, Earls Court, London. Tel: 0208 742 2828.

October 2000

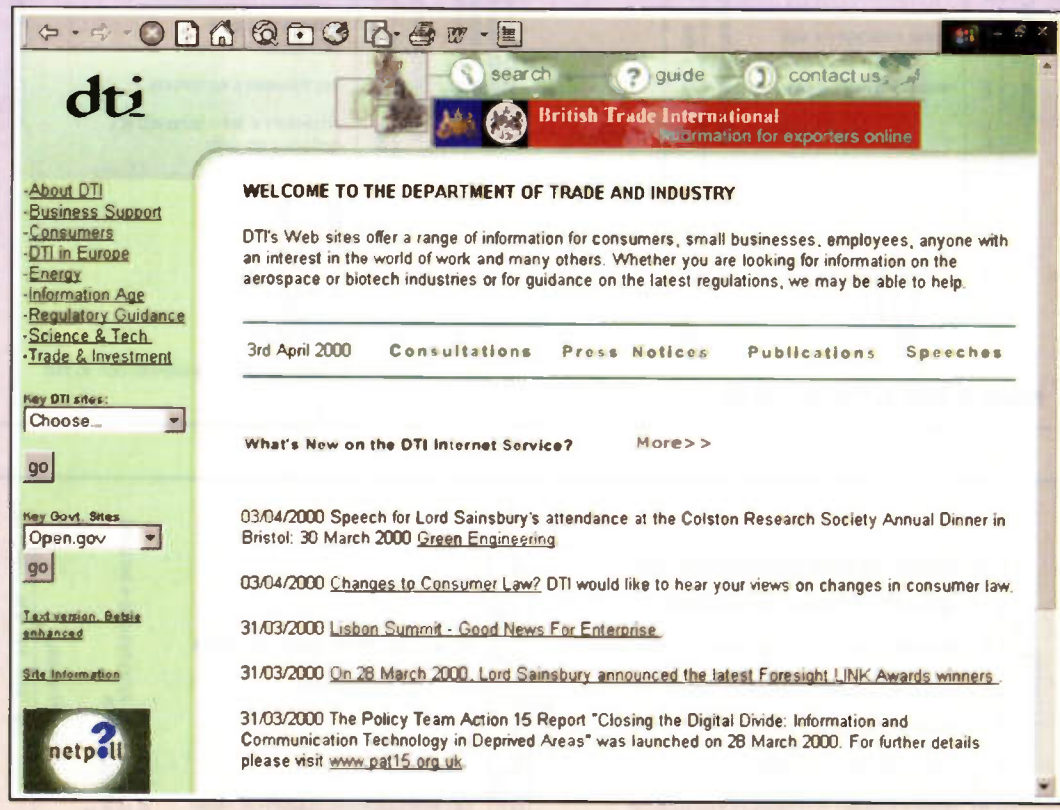
3 to 5 Oct. Coil Winding 2000, NEC Birmingham. Tel: 0207 417 7400.

November 2000

14 to 16 Nov. EID - Electronic Information Display 2000, Sandown Exhibition Centre Esher. Tel: 01822 614 671.

Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics and Beyond*, P.O. Box 777, Rayleigh, Essex SS6 8LU or e-mail to swaddington@cix.compulink.co.uk.

What's On?



Hewitt Goes Global via US

Patricia Hewitt, Minister for E-Commerce and Small Business,visited the US in March to exchange ideas on driving forward global e-commerce and responding to the challenges of the developing technologies.

"The impact of e-commerce and modern technologies on business is global. If the UK is to play a leading role in the knowledge driven economy, we have to be able to co-operate as well as compete," said Hewitt.

"The UK is a world leader in mobile telephony and digital television, and we have an estimated two year lead over the US in these areas. But the US has traditionally led the way in e-commerce and the use of the Internet. Therefore it is crucial that we work together and learn from each other," said Hewitt.

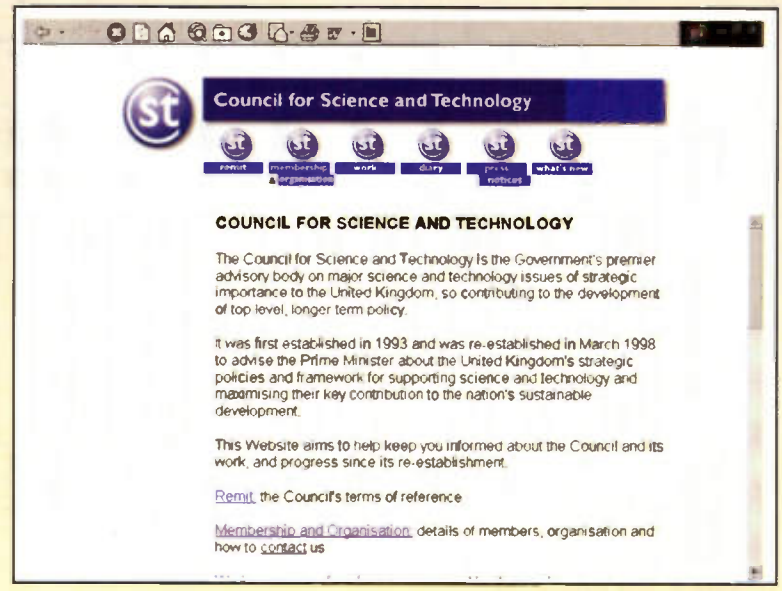
"If we are to maintain our lead in the e-revolution, we must continue to look forward and harness new and developing technologies. Things that think and e-science are the next big leap forward. The UK and the US must both be ready to embrace this exciting future," said Hewitt.

During the visit, Hewitt also met key players in the US's small business sector and the Small Business Administration (SBA).

"Small businesses are the lifeblood of the UK economy. Next month sees the launch of the Small Business Service (SBS) in the UK," said Hewitt.

"The first class support services the SBS will provide will play a major role in building an enterprise society in which all firms can thrive and fulfil their potential. I hope David and I can learn some important lessons when we meet our US counterparts in the SBA," added Hewitt.

For further details, check: <www.dti.gov.uk>. Contact: Department of Trade and Industry, Tel: (020) 7215 5000.



Science and Technology Council Points Way Forward

The Council for Science and Technology (CST) has made recommendations to government on how to improve science teaching in schools. The Council also published a review of the exploitation of science and technology by business.

The CST is the Prime Minister's top level advisory body on science and technology issues.

In its report Science Teachers, published in March, the CST made a number of recommendations including:

- improving the continuous professional development of qualified science teachers
- facilitating the identification and spread of good or best practice in science teaching
- and encouraging teachers to make the most of the resources and support provided by organisations in the private, voluntary and public sectors.

The report draws on the results of a survey of primary and secondary science teachers, commissioned by the Council and undertaken by the School of Education at King's College, London in July 1999. Over 900 head teachers and 1500 science teachers participated from 1300 primary and secondary schools in England.

The CST also published a report in March called Technology Matters, examining ways of strengthening the capacity of UK businesses to create wealth from science and technology.

This second report makes a detailed assessment of the UK's performance, and examines the main factors effecting the creation and growth of new technology based businesses: people, technology, finance and sponsorship by government in its widest sense.

Welcoming the CST reports, science minister Lord Sainsbury said, "We greatly value the work the CST has done: these two reports are timely and constructive contributions to current debate. We will be considering the Council's recommendations in our discussions on policies in these areas."

For further details, check:
<www.cst.gov.uk>.
Contact: CST, Tel: (020) 7271 2097.

Hewitt Launches 3G Mobile Auction

Patricia Hewitt, the small business and e-commerce minister has launched the world's first auction for third generation (3G) mobile spectrum licences.

The next generation of mobiles will offer much more than just a telephone. Users will be able to surf the Internet, rapidly download e-mails, music, high quality pictures and video on the move.

"By holding the first 3G spectrum auction in the world the UK is maintaining its lead in the global telecommunications and information markets. The outcome of this auction will shape the future of the UK mobile telecomm market," said Hewitt.

"That is why I am delighted that so many high quality companies, including nine potential new entrants, have seen the opportunities of 3G and are taking part in the auction. We have reserved the largest of the five licences for a new entrant only. This will ensure at least one new company will be offering a 3G service," added Hewitt.

As Electronics & Beyond went to press the Spectrum Auctions has reached around 110 and raised more than 16billion, more than 5 times tha amount originally expected to be raised by the auction. The group led by Virgin entrepreneur Richard Branson dropped out in the previous round, leaving TIW, Vodaphone, One2One, NTL Mobile and Orange in connection.

Internet users can monitor each round of bidding for the five licences. The results of each round showing the bidders and their bids will be published on the Radiocommunications Agency auction Web site at <www.spectrumauctions.gov.uk>.

"Greater competition will spur a faster roll out of innovative services, fresh approaches, and lower prices. UK consumers will be among the first in the world to reap the benefits of this exciting new technology," said Hewitt.

For further details, check:
<www.radio.gov.uk>.
Contact: Radiocommunications Agency, Tel: (020) 7211 0211.

Antique Computers REBORN

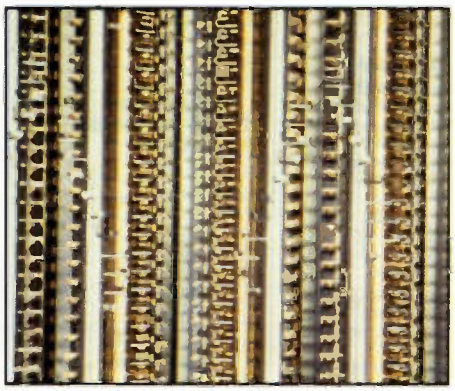
Mike Bedford investigates the work being done in recreating these groundbreaking computers

If you fancy living in an Elizabethan manor house and fitting it out with Jacobean furniture, finance is likely to be your only obstacle. Similarly, if your passion is classic motors, you'll find no shortage of 60s MGB Roadsters, 50s Morris Minors, 40s Ford Populars, or even 30s Austin 7s. Given a bit more persistence, and a bit more cash, you could own a 1929 Morris Cowley Tourer, a 1911 Ford Model T, or a 1907 Rolls-Royce Silver Ghost. Turning to the world of electronics, people have built up impressive collections of vintage valves, Morse keys, early radios, gramophones and televisions. And although they're unlikely to be in private hands, many of the record breakers and technological 'firsts' are still in existence. For example, the Mallard, the world's fastest steam locomotive, is housed in the National Railway Museum in York and the Apollo 11 Command Module which took Neil Armstrong to the Moon can be seen at the National Air and Space Museum in Washington DC.

If you have an interest in the history of computing, however, you'd have a much harder time building up a collection or seeing some of the pioneering computers. Admittedly a few people are now starting to realise that what remains perhaps ought to be preserved and that when today's PCs become obsolete, they shouldn't all be consigned to the skip. Museums are also starting to preserve and exhibit vintage computers. But, according to the enthusiasts, this is too little and too late - already much has been lost. And without a doubt nearly all the pioneering computers such as the University of Pennsylvania's ENIAC, the Manchester Baby, and Cambridge's EDSAC were broken up years ago. There are various reasons for this. First of all, the people who were involved with computers in the early days weren't, in the main, conservationally minded. It just wouldn't have occurred to the scientists who were involved in groundbreaking research of the late 40s that their creations would be of interest to historians in the future. Secondly, the lifetime of computers is much shorter than most other commodities. Due to a continual fall in prices and improving performance, computers tend to have a life of just a few years.

A car, on the other hand, can serve a useful purpose decades after it was manufactured. And there's another reason that is peculiar to computers. What happens when your PC starts to run out of steam? For many people the answer is to add more memory, to swap the disk for a larger one, or even to install a new motherboard and processor. Frequently, therefore, when a PC is eventually pensioned off, it's a mixture of components of various eras instead, for example, of the pristine 1995 PC which collectors of the future would want. And this is exactly the same reason that most of the pioneering computers are no longer with us. The Manchester Baby, for example, the world's first stored program computer, was completed in 1948. Needless to say research continued but, rather than start again from scratch, this new work involved adding to the original Manchester Baby. Within a short period of time, therefore, the original Baby was unrecognisable. Not only this but once its potential for further expansion came to an end, it would almost certainly have been taken apart so those components could be salvaged for new research.

There's a vibrant market in reproduction period furniture for those who hanker after the real thing but balk at the price tag of genuine antiques. Admittedly the situation with antique computers is rather different. It's not that the prices are too high - as we've seen, many of the early computers can't be obtained at any price. Nevertheless, perhaps there's a lesson here for computer historians. If you just can't get hold of an ENIAC or the Manchester Baby, perhaps you can build a replica. Since we're talking of equipment that was built comparatively recently - just over 50 years ago at the most - perhaps photographs and the original plans will still be around so that a replica could end up as a very convincing one. There's even a good chance that valves and other components from this era will still be available and this would allow an even greater degree of authenticity. This has been the hope and expectation of various teams of techo-historians. Capitalising on the eminence of the UK as a centre for computer research in the 40s and 50s, these enthusiasts are attempting to regain what has been lost. But their aim isn't just to produce copies that look like the originals - these replicas are to be working models too. Computer historians of the future will, therefore, be able to look at early computers, understand the circuitry of early computers, and even try their hand at programming these amazing machines. This article tells the story of the rebirth of a number of British antique computers.



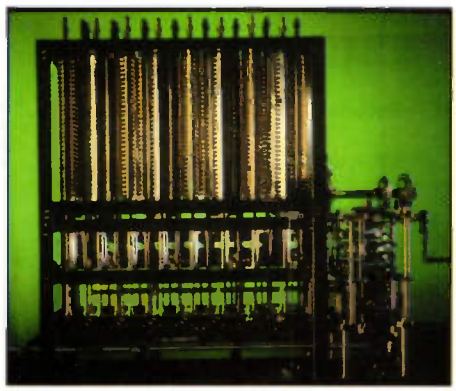


Photo 1. Views of the Babbage Engine. Courtesy of the Science Museum.

Babbage's Difference Engine

I guess it makes sense to cover this subject in chronological order. In the correct sequence for the original machines, that is, not the order in which they were rebuilt. As such, we can start with none other than Babbage's Difference Engine. And this rebuild project is really in quite a different category from all the others, which we'll look at. For although Babbage designed his Difference Engine and drew up detailed drawings for its manufacture, it was never actually built - not in Babbage's lifetime, at least. So when the London Science Museum decided to build Babbage's invention to commemorate the bicentenary of his birth in 1791, it wasn't just to gain a historical insight into a machine that had long fallen into disrepair. Instead, it was to find out whether it could ever have worked, had it been built back in 1849.

So what was the Babbage Difference Engine and why was it so important? We're talking of something which was designed in the mid 19th century and the very first

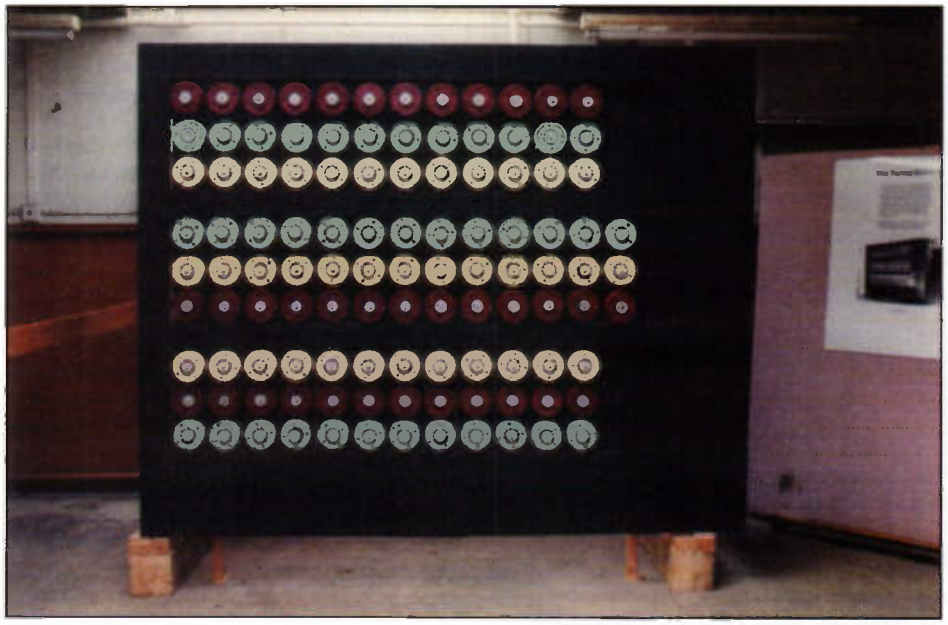


Photo 2. Partially re-built 'Bombe' with mock-up of front panel. Courtesy of Bletchley Park Trust.

electronic switch, the thermionic triode, didn't appear on the scene until the 1920s. Clearly this couldn't have been an electronic computer, therefore, in fact the Difference Engine was designed as a conglomeration of cogs, gears and levers. There's no rule which states that a computer must be electronic, though, so perhaps this isn't too out of place in our investigation of antique computers after all. If we try to define the word 'computer' we get into all sorts of problems as is evidenced by the number of groups who each claimed, in the late 40s, that they'd invented the world's first electronic computer. I don't intend to get bogged down in semantics, though, so just let's say that the Difference Engine was designed to perform computations and to do so automatically. In fact, it was designed to evaluate tables of polynomials up to the 7th order and to 31 decimal digits using the differences method. The main application was military - a common thread in the development of computers. The Difference Engine wasn't a general-purpose computer as today's PCs are, therefore, although interestingly Babbage went on to design just such a device. This second machine, the Analytical Engine, was also to have been made of purely mechanical parts but it was very similar in its concept to today's stored program computers. Like the Difference Engine, Babbage never built the Analytical Engine and the project would be such a huge undertaking that nobody has been inspired to do so since. So whether the Victorians could have greeted the computer age is open to conjecture. But we digress. What of the rebirth (or should that be the birth) of the Difference Engine?

The project to manufacture this machine according to Babbage's original plans took six years and cost in the region of £250,000. The Difference Engine has 4,000 parts, it measures 3.3m long by 2.1m high by 460mm deep and it weighs three tonnes. The first test, conducted towards the end of 1991 at the Science Museum, involved the generation of the seventh powers of all the numbers from one to one hundred. Actually this, $y = x^7$, is the simplest of all 7th order polynomials. Having initialised the dials, the handle was turned and for each rotation a number was generated and could be read by eye from the engraved wheels. After a hundred turns the number 100,000,000,000,000 was read off the dials and 99 previous results had been correct too. Of course, this had only exercised the Difference Engine's least significant 15 digits but to really put the machine through its paces and generate a 31-digit number, the handle would have had to have been cranked another 19,207 times. All in all, the project was a success and Babbage's reputation remained intact.

The Bombe

As we've seen, much of the pioneering work on computers was motivated by military applications. It was true of Babbage's Difference Engine, it was true of the University of Pennsylvania's ENIAC, and it was true of the Bombe and the Colossus which were built during the Second World War at Bletchley Park near Milton Keynes. Both these latter two computing devices were used for code breaking and both have been, or are in the process of being, rebuilt by enthusiasts. Much has been written about the German Enigma machine, which was used to encrypt military wartime messages prior to transmission by Morse Code. Much has also been written about Colossus, an early electro-mechanical computer that was used at Bletchley Park for code breaking. However, contrary to popular belief, it was an earlier computing device referred to as the Bombe which was used to crack Enigma - the Colossus came later and played a different role as we'll see later. The Bombe is often referred to as the Turing Bombe after Alan Turing, one of the fathers of computing who played an important role in its design. A rebuild of the Bombe is one of the latest projects being undertaken by the Computer Conservation Society and, when complete, the rebuilt Bombe will be demonstrated to the public at Bletchley Park.

As you'll know if you've ever dabbled in cryptography, a cipher (or a code as most people call ciphers even though this isn't strictly true) in which one particular letter always translates to the same encrypted letter isn't very secure. The Enigma encryption machine, on the other hand, was believed by the German military to be uncrackable. Every time a letter was encrypted, one or more of the machines three dials rotated so that the internal settings would be different for the next letter. Furthermore, the number of combinations was such that the machine would only return to the same state every 17,576 letters. Not only this but the machine would be initialised differently every day and there were no less than 150,000,000,000,000,000,000 possible initial settings. The German's confidence in the cipher's impenetrability was, therefore, understandable but history shows otherwise. Cracking an intercepted message, and thereafter all messages transmitted on the same day, involved making educated guesses at part of the message. The preamble at the start of a message could often be guessed, indeed, later in the war, British intelligence actually leaked false information so that the name of an allied ship, for example, would crop up in received messages. The first part of the cracking process was purely manual and involved deciding, from a knowledge of the Enigma machine, what parts of the intercepted message could correspond to the guessed text. Although the actual process was very much more involved than just knowing this one fact, it was known that an Enigma machine could never encrypt a letter to itself and this, clearly, eliminated some possibilities. Having come up with so called menus from this process, the Bombe came into play. The Bombe was a mechanical device with electrical sensing using high-speed relays that contained replicas of the Enigma's three wheels. It behaved as a search engine, trying out all possible settings of the three wheels looking for those combinations that could give rise to the menu. The fastest drums rotated at 120 rpm giving a dwell time of 10ms during which the entire relay sensing circuits had to operate.

John Harper, who is heading up the rebuild project, provided some insight into the scope of the work. "Letchworth (the home of British Tabulating Machines, the manufacturers of the original Bombes) built just over 200 Bombes in about 5 years. We are only building one. However, they had hundreds of people involved with around 30 people in the drawing office alone. BTM allocated vast mechanical manufacturing facilities to the Bombe covering acres of manufacturing space. They had night shifts running and worked very long hours. The sheer number of some of the parts we have to make is mind boggling. For example there are over 12,000 studs needed in the commutators and over 18,000 drum brushes. Something in the order of 50,000 cable terminations on nearly four miles of red wire have to be made. Around 17,000 screws of varying sizes hold the machine together. To put it another way about 650kg

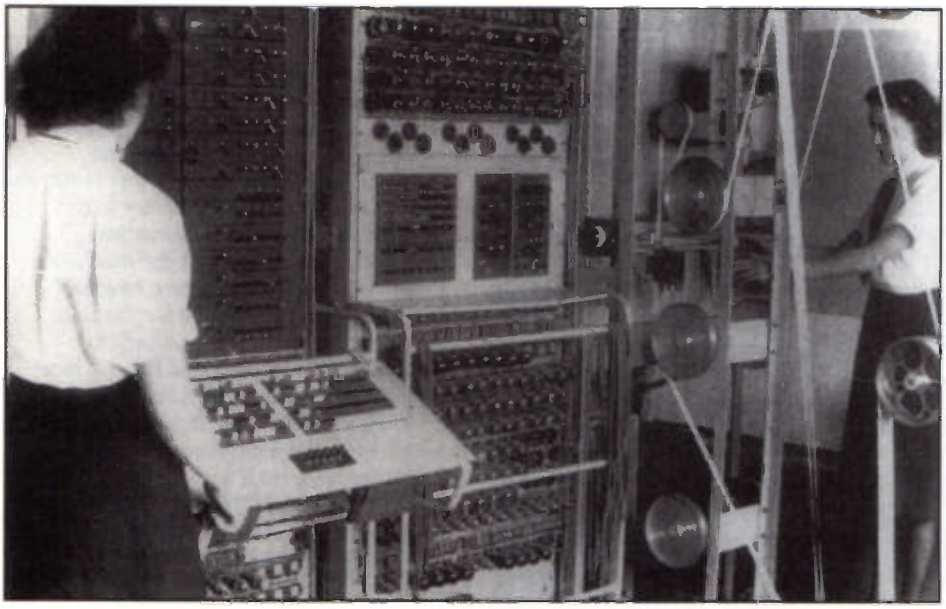


Photo 3. The Colossus Computer, the world's first electronic programmable computer, in use at Bletchley Park in December 1943. Courtesy of Bletchley Park Trust.

of parts has to be assembled in the existing frame with most of these items weighing only a few grams." In total contrast to the organisation that built the originals, John is being helped by a group of elderly engineers who originally designed, manufactured and maintained the Bombes. The rebuild is expected to cost £180,000.

The rebuild project started in 1996 and much of the time so far has been in research and in pulling together and redrafting the necessary drawings. This has been a phenomenal task. 4,000 or so of the component drawings produced by British Tabulating Machines and sent to GCHQ Cheltenham in 1946 were returned to Bletchley Park in 1995. These included virtually no assembly drawings although a number of parts schedules were provided. Furthermore, these proved to be full of errors and referred to the many variants of the Bombe, not necessarily to the one being re-built. Another problem was that the Bombe made use of some parts that were used in BTM's commercial equipment but since these were considered to be standard parts, schematics didn't appear in the Bombe documentation. Fortunately, though, the team discovered copies of Hollerith and IBM punched card equipment manuals held in the Science Museum Archive and actual equipment from the era has been obtained. This just hints at the problems associated with rebuilding a machine which was built 50 years ago and subsequently destroyed and on which details were, for many years, considered a military secret.

The redrafting is being carried out using a CAD system that offers a number of benefits. For a start it's possible to construct major parts of the machine on paper to check that each part will fit in the total assembly. This confirms that the correct part is being used and that it is accurate. Secondly, it allows computer-aided manufacturing techniques to be used at a great saving in time and finances. But the project hasn't all been research and drafting: some parts of the Bombe have already been manufactured and assembly has started. Much of the work so far has been mechanical and the parts assembled include castings, and metal mounting plates. A start has also been made on the wiring looms even though only three of the 80 that will be needed are complete. The final major element of the project is finding components such as jacks and relays, which will be required in the rebuild. Many components have been salvaged from old telephone exchanges and punch card equipment and even from people who had worked on the original Bombe and had hoarded components throughout the intervening 50 years.

The project is always in need of funds and supporters. If you feel able to help in any way please contact the Project Manager - John Harper on 01462 451970 or bombe@jharper.demon.co.uk. And if you have a garage full of 1940s relays and so forth, take a look at the Web site at http://www.jharper.demon.co.uk/bombe1.htm for details of some of the parts which are still being sought.

Colossus

Toward the end of the Second World War, it became strategically important to crack another code, this time one that was used in conjunction with radio teleprinter communication. Automation was called for but now, rather than the electromechanical technology of the Bombe, electronic circuitry was used for the first time. In fact, the computing device in question, the Colossus, has been referred to as the world's first electronic computer, an epithet that requires a word of explanation. Colossus was, at least in part, electronic as opposed to mechanical or electro-mechanical and yes it did perform calculations. However, unlike ENIAC which followed it on the other side of the Atlantic, Colossus wasn't a general purpose computing device - it was designed to perform a very specific task, albeit one which did require a degree of programmability. As we'll see later, even the ENIAC wasn't really the direct predecessor of today's computers but that's another story.

Interestingly, unlike the case with the Bombe, when a plan to rebirth Colossus was put together some years ago, the major

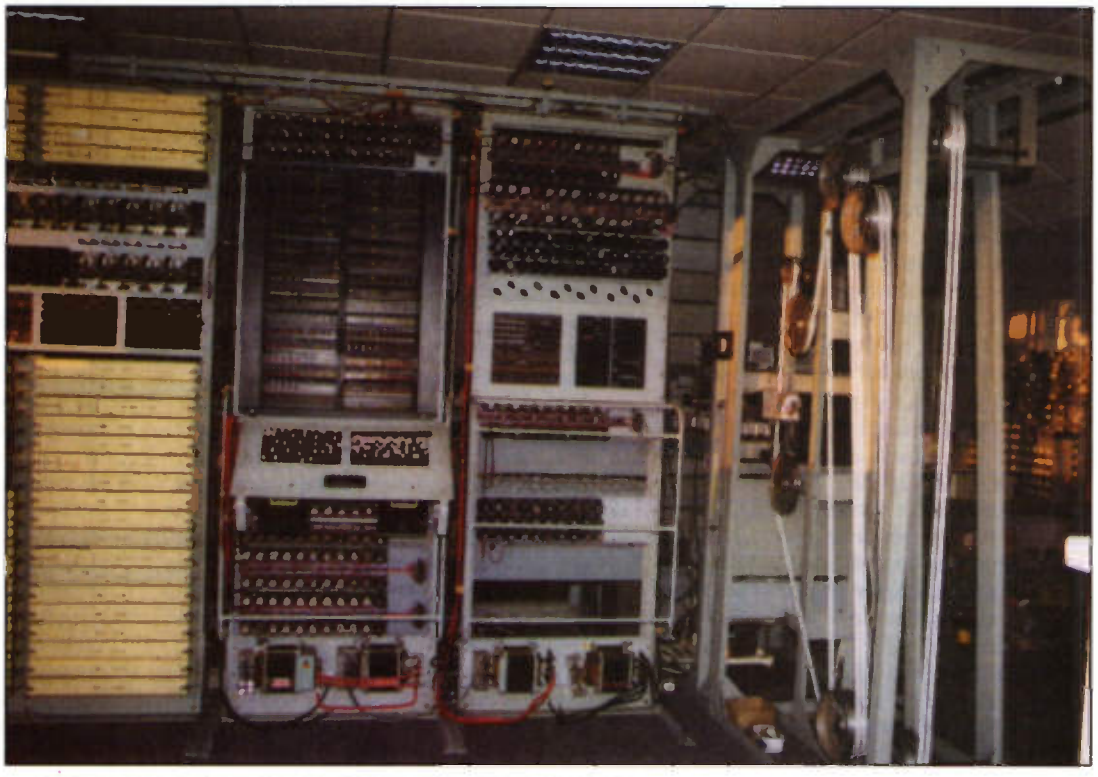


Photo 4. Rebuilt Colossus. Courtesy of Bletchley Park Trust.

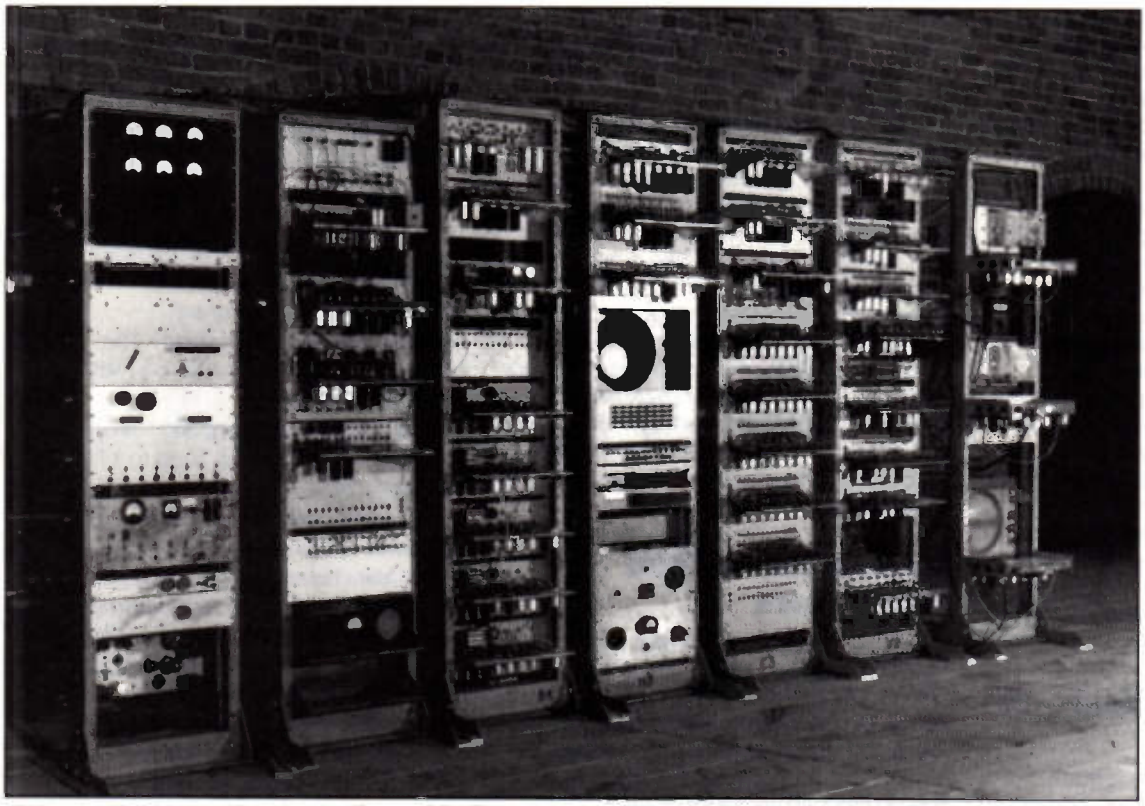


Photo 5. The 'Manchester Baby' - the world's first stored program computer - which is on display in the Futures Gallery at the Museum of Science and Industry in Manchester, who kindly provided the photograph.

hurdles were legal and political, not just technical. Despite the fact that Colossus was a wartime invention, the technology was sufficiently ahead of its time that a pair of the later MK 2s units was in use at GCHQ until 1960. Then, in accordance with the requirements of British intelligence, they were dismantled and the plans destroyed. In hindsight it might seem surprising that the technology was considered so sensitive 15 years after the end of the war but this only hints at the difficulties which were encountered even much later. Tony Sale of the Computer Conservation Society undertook the job of recreating Colossus. And at the start of the project, all the team had - due to GCHQ's zealousness in keeping Colossus a secret - were eight photographs and a few portions of circuit diagrams which had been held illegally by ex-Bletchley Park staff. Of course there was also the information in the heads of those people who had worked on Colossus. But when we bear in mind that many of these were, by the early 90s, in their eighties, it's clear that this wouldn't be an easy resource to tap. In 1992, when interest in rebuilding Colossus first emerged, all the information, even the reminiscences of the original Colossus veterans, was protected by the Official Secrets Act. Tony Sale persevered and was eventually given permission to build a Mark 1 Colossus, which had no memory. This permission specifically outlawed the building of the more sophisticated Mk2 machine and even the Mk1 would have to be a non-working model. Permission to actually put the rebuilt Colossus through its paces was withheld. In the event, the project team decided that they would, nevertheless, build a Colossus Mark 2, albeit in secret, in the hope that official restrictions would, eventually, be withdrawn. In fact this happened in March 1996 when the US government released formerly classified documents, including details of the code-breaking principles employed by Colossus. We don't really have space to look in detail at the considerable technical challenges which also had to be met but suffice it to say that the completed Colossus is now operational and on public display.

The Manchester Baby

Although by no means the most recent computer which has been rebuilt, our brief introduction will conclude with a look at the Manchester Small Scale Experimental Machine (SSEM), otherwise known as the Manchester Baby. Like the Bombe, the SSEM was an automated calculating machine, like Colossus it was electronic, like ENIAC it was programmable and hence general purpose, but unlike anything that had ever gone before it, the SSEM held its program of instructions in memory. The earlier ENIAC was programmable by use of switches and patch leads but the SSEM was the first computer to employ the technique of holding a program in its own internal memory. This, the first stored program computer, is the direct predecessor of today's PC even though the electronic circuitry was really quite different. Clearly 1948 was long before the advent of integrated circuits but even the transistor had been invented only six months earlier and was still, itself, in the research labs. So the SSEM had to be built out of valves - lots of them with all the reliability and power consumption problems that brought. Secondly, primarily because this was the era of valves, the memory used a technique that involved the storage of charge on the surface of a CRT screen. This was in contrast to the earlier ENIAC, which had used memory not dissimilar from that used in today's computers but based on valves. Needless to say, the use of this memory technology greatly increased the valve count.

Before we look at the SSEM rebuild project, let's have a look at the specification of the machine. Unlike all the earlier computing devices which we've looked at, the SSEM was sufficiently similar to today's computers that this information is meaningful to a PC user. The SSEM was a 32-bit computer with a random access main store of 32 words extendible up to 8,192 words. It executed instructions at 830 per second. By way of comparison, today's entry level PCs have around 256,000 times more memory and execute instructions 500,000 times faster. Professor F C Williams and Professor Tom Kilburn of the University of Manchester started work in 1946, and the SSEM ran its first program in June 1948 - the world would never be the same again.

Like many of the projects covered in this article, the Manchester SSEM rebuild was carried out by the Computer Conservation Society, this time under the leadership of Chris Burton. The aim was to make a perfect replica using genuine 1940s electronic components and wiring them up in the ugly manner which was representative of electronic construction of the time. The challenges here were somewhat different from those we've already seen. In this case, most of the original documentation - including photographs and schematics - were available and some of the people who designed the SSEM were still alive. And whereas it would be wrong to underestimate the task of pulling the documentation together - for example, it wasn't always obvious which circuit diagrams referred to which parts of the computer - the research phase of the project was less problematic than, for example, in the Bombe rebuild. One of the major difficulties with the SSEM was getting hold of 50 year old valves, resistors, capacitors, cathode ray tubes and so forth. And unlike the case of the mechanical parts used in the Bombe, if the necessary valves could not be found, manufacturing replicas would prove almost impossible. What you'll find surprising if you've never dabbled with valves, is that many of the components used in the SSEM were manufactured for many years after 1948 so the team weren't necessarily looking for 50-year-old valves. And also there are warehouses full of brand new valves, many of which were discontinued years ago and have been stockpiled ever since. It's quite conceivable that some of this so-called 'new old stock' used in the

rebuild came from the same batches from which valves in the original were taken. Ironically, obtaining some of the passive components was more problematic. Obsolete resistors and capacitors tend not to be hoarded in the same way so these components had to be salvaged from old equipment and from junk boxes. But to make the problem worse, capacitors tend to degrade with age. Because of these difficulties many of the passive components in the re-built computer are modern, but the status of each and every component has been documented and the aim is to replace these with genuine components as the opportunity arises. The SSEM was rebuilt at the University of Manchester and has since been relocated to the Museum of Science and Industry in Manchester. Here, at 11.15 on the 21st June 1998, the exact 50th anniversary of the original successful run, the Baby's first program was started by Professor Tom Kilburn and Geoff Tootill, who were part of the original team.

And Another 50 Years of Rebuilds

So the Manchester Baby represented a major milestone in the history of computing and the rebuild marked the 50th anniversary of computing as we know it. But computers have continued to be lost in the 50 years since the Manchester SSEM ran its first program and so projects to rebirth or restore them continue. To close, and to give you a feel what has been done and what's in progress, I'll briefly mention some of the other projects undertaken by the Computer Conservation Society. Some of these products would be better described as restorations rather than rebuilds but this in no way diminishes their worth to future generations. Furthermore, even a restoration can involve putting together and recomissioning a computer that was dismantled years ago. Current projects are involved with the re-building, restoration, acquisition and maintenance of the Ferranti Pegasus, the Elliot 401, the Elliot 803, S100 based microcomputers, and DEC PDP minicomputers. There are also groups who are working on software emulations of early computers to enable people to try their hand at programming them on a PC.

Seeing Re-birthed Computers

All of the rebuilt historic computers described in this article are on public display. The Bombe is still a long way from completion and work continues on the Colossus even though it's now working, but you can see them all nevertheless. If you do fancy taking a look at these computers, here's some information on the museums where you can see them.

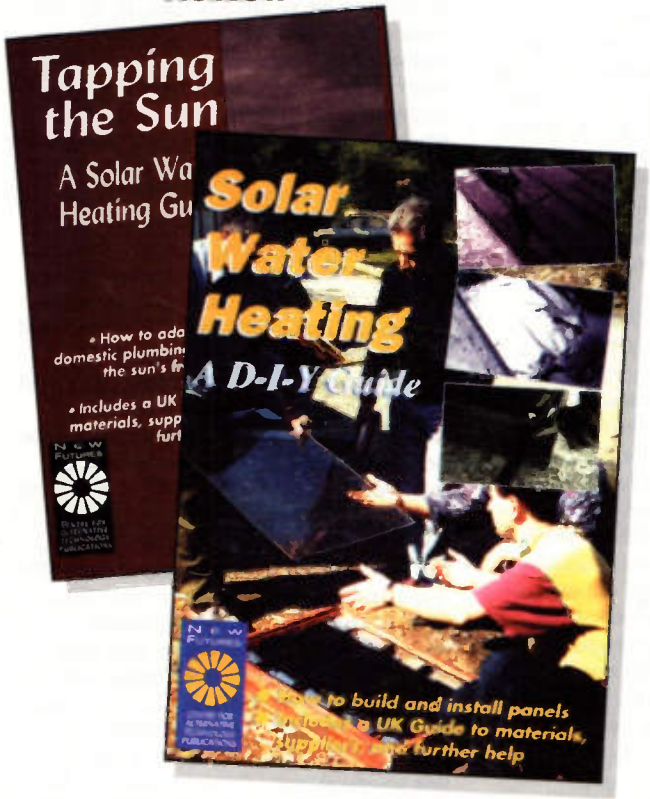
The Babbage Difference Engine is on display at the London Science Museum, Exhibition Road, South Kensington, London SW7 2DD, Tel: 020 7942 4455/4454, <www.sciencemuseum.org.uk.> The Museum is open seven days a week, from 10.00 to 18.00. The Museum is closed from 24 December to the 26 December and also 31 December to the 1st January. Admission is as follows: adults - £6.95, over 60s and students - £3.50, under 16s - free. Admission is free to all after 4.30pm.

The Colossus and the Bombe can be seen at Bletchley Park, which is being transformed into a museum of cryptography, computing and communication. The museum - The Mansion, Bletchley, Milton Keynes, MK3 6EB, Tel: 01908 640404, <www.bletchleypark.org.uk> - is open alternate weekends from 10.30 to 17.00. Admission is £4.50 for adults, £3.50 for children and concessions, and free for children under 8.

The Manchester Baby is now housed at the Museum of Science and Industry in Manchester, Castlefield, Manchester M3 4FP, Tel: 0161 832 1830 (24 hour information line), <www.msim.org.uk.> The museum is open 10.00 to 17.00 every day except 24th, 25th and 26th December. Admission is £6,50 for adults, £3.50 for adult concessions, £2.00 for 5-18s (inclusive), and free for under 5s. These prices include entrance to the Science of Sport exhibition, which is on until 4th June 2000. 18s and under not wanting to visit this exhibition will be granted free admission to the rest of the museum.

Quick BOOK Review

Solar Water Heating - A DIY Guide



Ever fancied saving money on your heating bills? If you are a practical person, one easy way is to build some solar heating panels from scrap copper pipes or old radiators This book is a very practical and easy-to-read book on how to set about making solar heating panels. The introduction covers general principles about the way to generate solar hot water. It contains step by step instructions for making your own solar collector. There is a chapter on constructing an electronic temperature controller. This senses the temperature difference between the solar water panel and the water in the hot water tank. Any increase in the preset temperature difference will contro a pump. There's a resource guide on where to obtain products.

If you are in any doubt as to what to do then this book is a must to point you in the right direction.

The 28 page booklet is available from The Centre for Alternative Technology, price £4.95 Orders taken on Tel: 01654 703409

Tapping the Sun - A solar Water Heating Guide

This booklet answers many common questions with regard to solar water heating and also provides a useful resource guide.

The booklet is a available from CAT Publications Price £3-50

Telephone the sales line on 01654 703409

COMMENT

by Keith Brindley

It's spring, the weather's finally turning out nice, and when it's sunny in spring a young man's (and a young woman's, for that matter as I'm not sexist) mind inevitably turns to lighter things. Actually, come to that, I'm not ageist neither, so nor is a lighter mind restricted to the younger of us.

To the point - now's the time to pick up your computer and walk. Around the office, around the house, into the garden, round to the neighbour's for a chat. Wherever. The latest trend in computing is to be totally wire-free, and this month's Comment comes courtesy of my totally wire-less computer and - as the weather's particularly nice today - sitting in my garden under the shade of a beautiful, flowering Magnolia on a garden bench.

OK, the facts. There are basically three methods by which computers can be wire-less. The method used defines effectively how portable the computers actually are, and what you can do with your computer when operating in wire-less mode. Each method has its good points and, naturally, bad points.

First wire-less method is infrared. The Infrared Data Association (IrDA) standard has been around in one form or another for several years. As such it's a mature, proven, and very effective solution for wire-less communications over short distances. It's ideal, for example, to link a computer with a printer, with a mobile phone, or with a personal digital assistant (PDA). Its limits, on the other hand, arise from the fact that both devices have to be within just a few feet of and virtually pointed at each other - the acceptance angle for IrDA transmitters and receivers is within just a few degrees. Effectively, transmitter and receiver need to be within line-of-sight, pointed directly at each other, and not in harsh lighting conditions. So, although it's by definition wire-less, it's not exactly as free-ranging as it might otherwise be - no sitting in the garden while you're swapping files with others on your network, surfing the Internet, and printing at the same time using IrDA. Nevertheless, it has its uses, and is used very successfully for given applications and given circumstances.

Next up are the true wireless standards. Note that where before I used the term wire-less I now use the unhyphenated term wireless to describe communications now. While the hyphen is only a small loss, it signifies a change from infrared light in the IrDA standard, to using radio transmissions, and, as radio transmissions are by nature omnidirectional, some of the limits of the point-and-shoot IrDA wire-less device are instantly overcome.

There are two main wireless standards. First (historically, anyway) is the IEEE 802.11 wireless LAN standard. This is an 11Mbps method of providing computer-to-computer communications. It fully supports traditional LAN standards such as Ethernet, so several computers or peripherals can be connected and networked just as if they were hard-wired with networking cable. While it's not incredibly fast (its 11Mbps compares well with 10BaseT networks which allow 10Mbps communications, though not so well with newer 100BaseT systems with 100Mbps communications) it's absolutely ideal for wireless networking. As an example, I'm using an IEEE 802.11 standard system as I pen this month's Comment out in my garden at this moment. My computer (an Apple PowerBook laptop) has a wireless card fitted that allows me to be logged in my office network at all times. This can be in the garden, on the office, on the toilet, in my mate's house up the road, in fact, anywhere within about 50 metre of the wireless base station. With extenders (larger transmitters and/or aerials) this range can be increased to many kilometres if need be. The proprietary Apple method is known as AirPort, but it is a standard IEEE 802.11 base station, that can communicate with any computer with a standard IEEE 802.11 link. Two computers with IEEE 802.11 links can communicate in a peer-to-peer manner, or with an IEEE 802.11 base station such as the AirPort base station it's just as easy to link all network devices by wireless means. It's an Ethernet network - just without wires. So, from the garden (or wherever) I can swap files with other computers (even non-Apple machines) on my office network, surf the Internet, and print - all at the same time, and all as if I was physically cabled into the network.

The second wireless method, and the final wire-less method, is known as Bluetooth. Devices using the Bluetooth standard have been proposed, but to date only prototypes are available. Like the IEEE 802.11 standard, Bluetooth uses radio transmissions (actually at the same or similar frequencies to IEEE 802.11), but being rather weaker in strength, will operate over a more restrictive distance - up to 10 metre. Like IEEE 802.11 it allows networking, albeit only at 1Mbps (IEEE 802.11 is 11Mbps, remember, and even IrDA is currently 4Mbps with 16Mbps in development). However, as Bluetooth is simpler than IEEE 802.11 with less powerful transmitters, it is (or should be) cheaper to include in a device and, crucially, will consume less power. This makes it ideal for portable devices such as PDAs and, most importantly, mobile phones. Dial-up connection methods from, say, a PDA to a mobile phone onto the Internet can thus be made in quite a cheap way.

Computing-a-go-go - Apple's AirPort base station makes wireless computing an economical reality.

So the three wire-less methods form a collective whole method of portable communications. Which individual wire-less method you use depends on the type of communications you require. There are (or at least, very soon will be) cheap and easy links available for all three methods, and you'll simply buy the method that suits your requirements at the time. PDAs will have either IrDA or Bluetooth links fitted, as will mobile phones. Portable computers will have a mixture of IrDA, Bluetooth and IEEE 802.11 links fitted. Inevitably, there is a certain overlap between the three methods, which to the untrained eye might appear unnecessary. Horses for courses, and in reality the deciding factor is probably going to be distance. Very short links can use IrDA. Medium distance links can use Bluetooth (although more powerful transmitters can increase Bluetooth's range). Longest links, however, will need IEEE 802.11. Whatever you use, the future is most definitely portable and wire-less. If you've never tried computing without wires, then I suggest you beg, borrow, or steal a system to play on. Once you've tried it, sitting in the office at a desktop computer just doesn't seem right anymore.

Renovated equipment in use

Supercharging YOUR STEREO

Martin Pipe makes good hi-fi sound better.

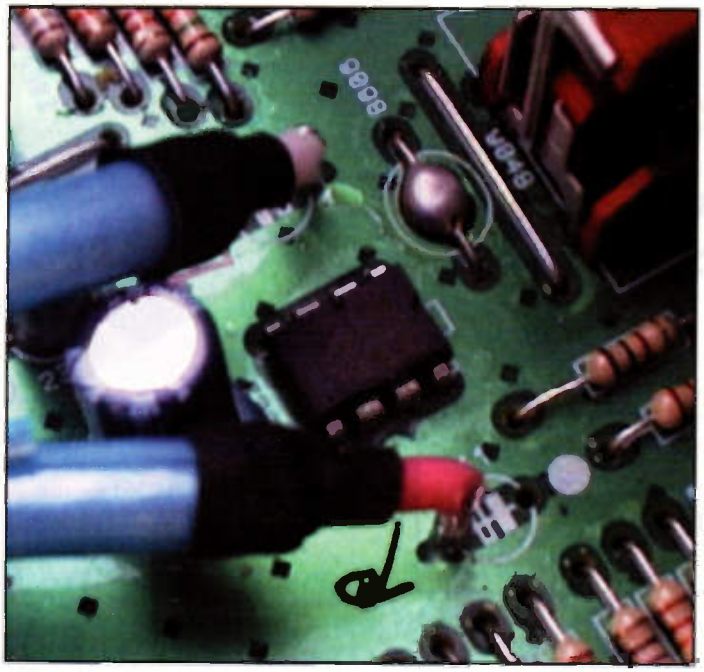
It's a sad fact, but hi-fi equipment is seldom as good as it can be. The actual designs are, in many cases, fine - but the manufacturers tend to specify the least expensive components wherever possible. This is particularly true of the lower and middle ends of the market. Within higher-end esoterica, where cost is no object, you'll find the best. But then again, you're paying for it in a big way! The lower-end mass-market stuff sells by the truckload, and hence savings of a few pence will work out to thousands of pounds over the course of a production run. Top-notch gear, in comparison, sells in relatively small quantities. Unfortunately, few of us can afford it. However, the sound quality of cheaper hi-fi products can be improved by selectively replacing components and paying attention to the details. OK, you won't end up with the sound quality associated with the very best gear, but the changes will deliver some worthwhile benefits. At the very least, you should be able to stave off the upgrade pangs for a little longer.

Boot-Sale Bargains

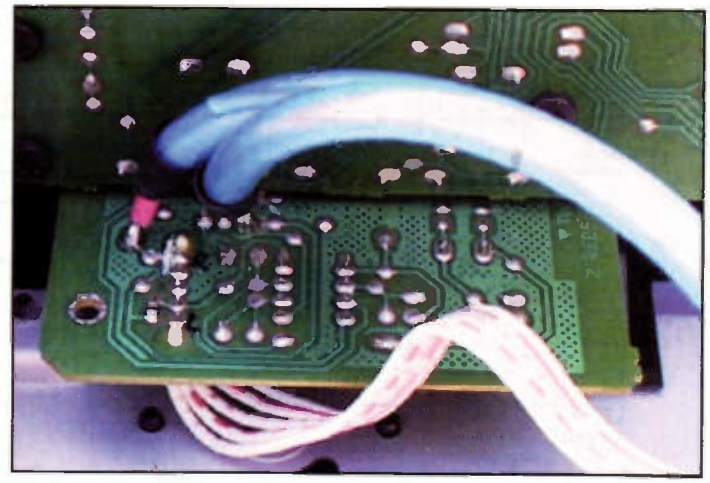
First on our list is a Philips CD692 CD player, which has been part of my hi-fi system for four years or so. This unit, then only three or so years old, was acquired at a car boot sale for a tenner. I don't know what the original retail price of this well-specified unit (in terms of features, certainly) was, but it's unlikely to have been more than £250. In other words, you can get bargains on the second-hand market if you know where to look. You don't always get it your own way - the reason for this player's bargain price, almost predictably, was its failure to work! Happily, this was simple to fix - the mains fuse had died, presumably through the fatigue caused by successive power on/off cycles (the dead fuse looked OK, with none of the black mess associated with 'blows', but nevertheless measured open-circuit). Replacing the fuse brought the player back to life. The sad thing is that even the stingiest of repair operations could have done the job for £20. I think this must tell us something about the increasingly throwaway nature of society - or perhaps something about the CD players sonics! After reassembly, I found that the sound produced was OK - but that's it. Bland and unexciting, with the finer details masked. In other words, a budget audiophile player could eat it for breakfast! Time, then, to get hold of a service manual and see what improvements could be made.

Our second item of equipment is a two-part Rotel amplifier dating back from the very early 1980s. This heavy preamplifier (RC1010) and power amplifier (RB-1010) combination, typical of the time, is said to be DC-coupled throughout. The preamp is interesting insofar that no bass/treble tone controls have been fitted. An early attempt at minimalism? Unfortunately, no - the RC1010 is equipped with a loudness compensator and sub-sonic filter. Round the back, amongst an array of phono sockets, is a pair marked 'tone send' in and out. In other words, you had to presumably buy a graphic equaliser if tone controls were required. A strange arrangement, seeing that the pre- and power amps are separate items. After all, the equaliser could be inserted between the two. More useful features include a head amp for moving coil (MC) cartridges (there are separate inputs for MC, and the more conventional moving-magnet cartridges), headphone socket, provision for two tape decks and the ability to listen to and record from different sources. The amplifier is a fancy Class A/B design, with a beefy 100W RMS per channel output, a pair of vertically-reading LED bargraphs to indicate output level, and facilities for two pairs of speakers. Both units have American-style 2-pin mains outlets on their rear panels, but they've been blanked off, presumably because they don't meet British safety standards.

This equipment was another boot-sale bargain - with a matching tuner (an early synthesiser design), the lot came to £25. On getting it home, I found that the preamp and tuner both worked. Unfortunately, the amp was dead on one channel. The massive output devices - a complementary pair - had both blown, presumably due to carelessness on the part of the previous owner. The driver circuit was checked, and was found to be OK except for a noisy transistor (2SC2631). All three devices were replaced. The power transistors are rather expensive, which perhaps explains why this system was discarded. The 2SC2921 (NPN) and 2SA1123 (PNP) sell for



New opamp and cables fitted to CD.



CD player headphone wiring.

around £8 each - but once the cost of labour, fault-finding and so on has been factored in, a £60 workshop bill wouldn't have been unreasonable. Not viable, perhaps, for equipment of this vintage. Do it yourself, and the work is a bit more justifiable. Note that the semiconductors associated with Japanese equipment are not the run-of-the-mill items available at your local Maplin shop - they have to be obtained from specialist suppliers. A list is given at the end of this article. One of the companies in question, Dial Electronics, specialises in tracking down obsolete devices that are no longer manufactured. This can be useful - if expensive - for older equipment, if a substitute device (hello, Towers!) cannot be found.

To help with fault-finding and repair, I obtained a copy of the manufacturer's service manual. These items of paperwork contain circuit diagrams, alignment procedures and parts lists. Some - notably those produced by Revox - contain full descriptions of the circuitry. Service manuals are also essential if you want to modify equipment - and we're not just talking about ones the manufacturer didn't have in mind! Many manuals also list changes implemented during the production run. Some may improve performance, while others may increase reliability. If your particular unit was one produced early on, then the service manual may help you to bring the equipment up to the same standard as the final batch. Manufacturers don't hold onto manuals for too long, and in most cases you're better off trying a third party for a photocopy. Because the CD player is under ten years old, we were able to obtain one directly from Philips. That's not to say you will be as lucky, particularly if the equipment is old.

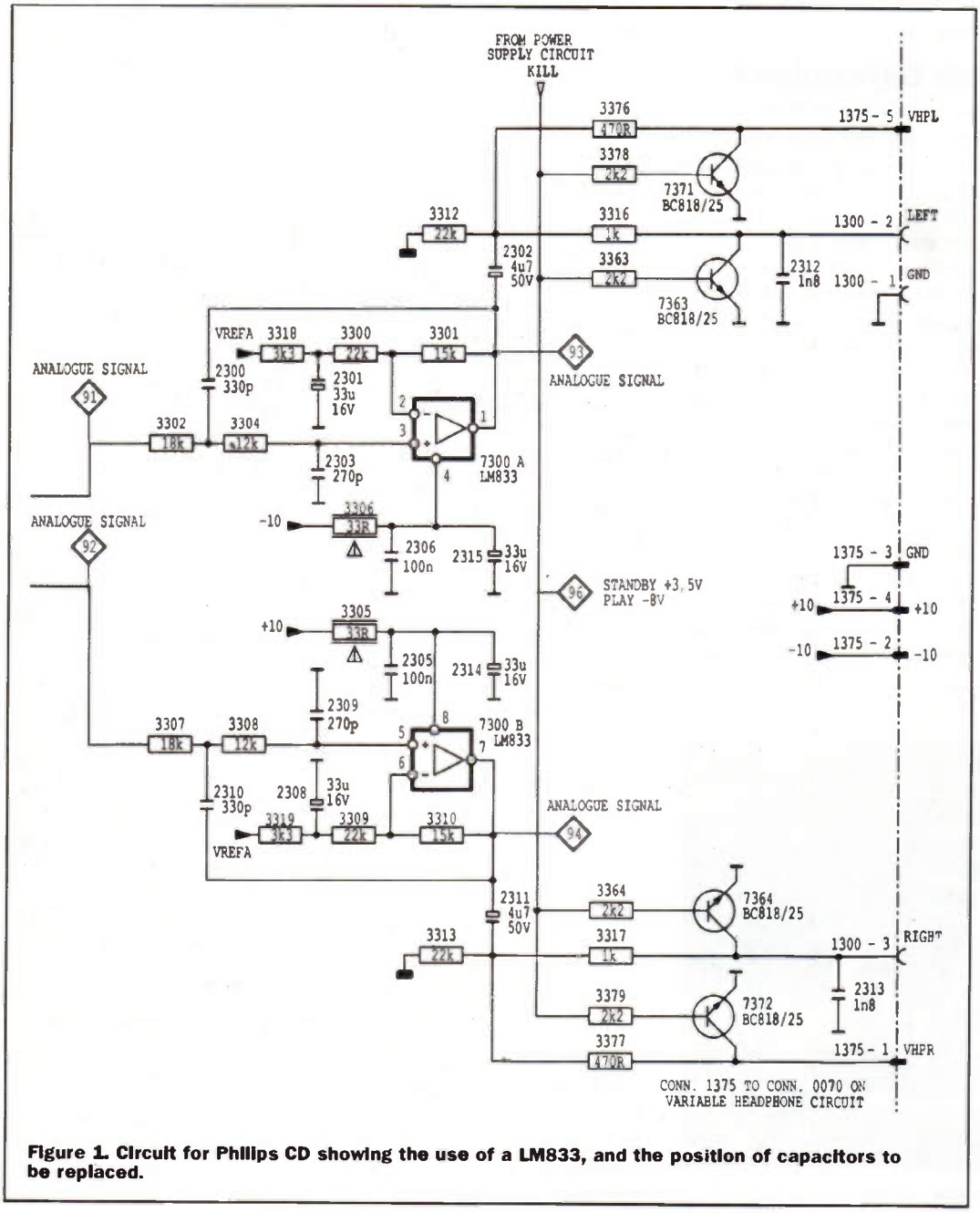


Figure 1. Circuit for Philips CD showing the use of a LM833, and the position of capacitors to be replaced.

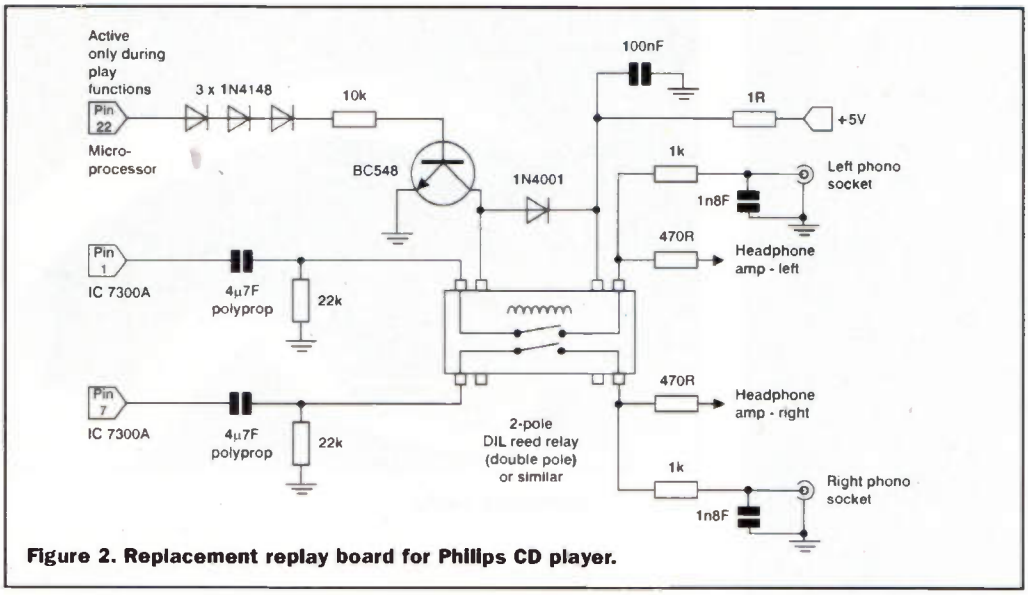


Figure 2. Replacement replay board for Philips CD player.

But then again, you might be - as we discovered when refurbishing a Revox A77 (refer to Issue 141), some main libraries may hold a copy or be able to get one! In the case of the Rotel, even they couldn't help! After some hunting, we discovered one company - Dorset-based D-Tec - that was able to supply a photocopy, and at a good price to boot. A list of service manual suppliers is also given at the end of this article. The English/French (!) Rotel manual, which covers both pre- and power amp, details manufacturer-sanctioned power-amp modifications for improving frequency response and preventing the risk of oscillation. These modifications had, fortunately, already been implemented on my particular sample. Still, it's nice to know! After repairing the power amp, I discovered that the sound produced by the system was not particularly inspiring. Bass, in particular, was rather muddy and indistinct. What's more, there was none of the pace, attack and drive that makes music exciting to listen to. Time, then, to open up the equipment, consult the service manual and see what can be done...

CD Difference?

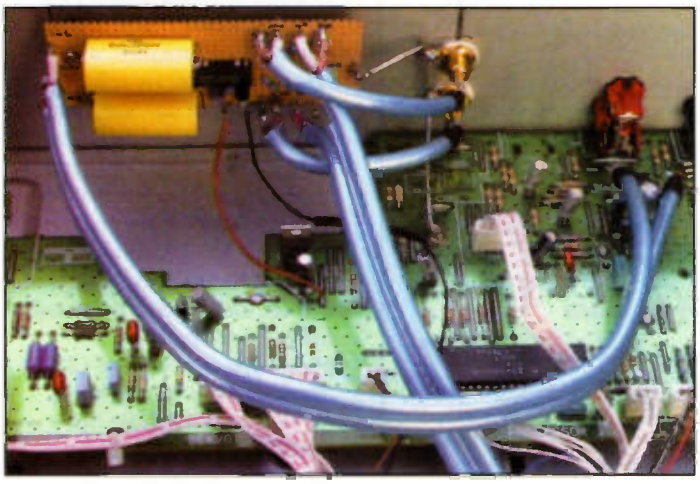
We'll start with the Philips player, because many of the modifications will also apply to other models. Within the CD692, the (bitstream) DAC is contained within a multi-function chip (the surface-mounted SAA7341) that also contains some of the CD player functionality (motor control, demodulation, error correction, SP/DIF output and so on). On which subject, the manual is a good buy if you've got the cheaper CD690 model. The manual caters for both units, which are basically identical. One of the most important features missing from the CD690 is the SP/DIF output. Following the manual, it should be easy to add one - you'll then be able to make digital recordings of your CDs with a MiniDisc deck. Unfortunately, the 'jungle-chip' design - one of the ways in which manufacturing costs are reduced - reduces the scope of modification. As a result, we were forced to concentrate on the analogue circuitry that follows the DAC - this is reproduced in Figure 1. Fortunately, this is an area in which the changes of most impact can usually be made. The cost needn't be prohibitive, and the sonic transformation quite astounding.

The output of the DAC is fed to a LM833 low-noise dual op-amp - one op-amp handles each stereo channel - see Figure 1. The LM833 is good for audio applications - but you can buy better although more expensive. To this end, I unsoldered the LM833 and replaced it with a Burr-Brown OPA2604 (Maplin order code AD58N). Each output is AC-coupled to the headphone and phono sockets with a 4.7µF electrolytic capacitor. Electrolytics are not particularly good from a sonic perspective - they restrict frequency response and aren't unknown to contribute 'coarseness' - and designers of 'real' hi-fi try to avoid them wherever possible. Indeed, they try to avoid capacitors altogether. To this end, I replaced the capacitors (2302 for the left channel and 2311 for the right, as the diagram shows) with polypropylene ones of the same value (JY82D). These were 'bypassed' by wiring polyester capacitors of lower value (100nF, WW41U) in parallel with them - these perform better at higher frequencies.

Before the audio signals wind their way to the headphone amplifier and output phono sockets, they're subjected to another potential nasty. A pair of surface-mounted BC818 transistors (7371/7363 for the left channel, 7364/7372 for the left) shunt the audio lines to ground when an audio signal isn't needed. This mute circuit is primarily included to prevent power-down 'thumps' that could damage speakers. Unfortunately the transistor is always in-circuit, mute condition or otherwise - and that's not good news as far as audio is concerned! The transistor acts like a tiny capacitor, the value of which varies according to the level of the signal. Theoretically, the value of this parasitic capacitance is too small to have an effect on audio. In practice, things are rather different. Some audiophiles have removed the transistors together and noted an improvement in fluency and clarity - although they must remember to turn the amp off before the CD player if they value their speakers...

An alternative mute circuit is thus desirable. I have implemented one using an encapsulated DIL relay that's only switched on when play and related features (search, etc.) are active - see Figure 2. Audiophile-grade players employ a similar arrangement. The relay is driven by a BC548, via a suitable output (pin 22) of the system control microprocessor (7700). There's a slight (1.5V) 'spike' here at switch-off, which was circumvented by connecting three junk-box diodes in series - the combined forward voltage drop absorbs the glitch quite effectively. The relay, together with the polyproylene capacitors, was mounted on a piece of matrix board fitted to the rear of the case - as one of the photographs reproduced elsewhere in this article shows. Unfortunately, Maplin no longer

CD player new phono sockets fitted.



Relay board fitted to back of Philips CD.

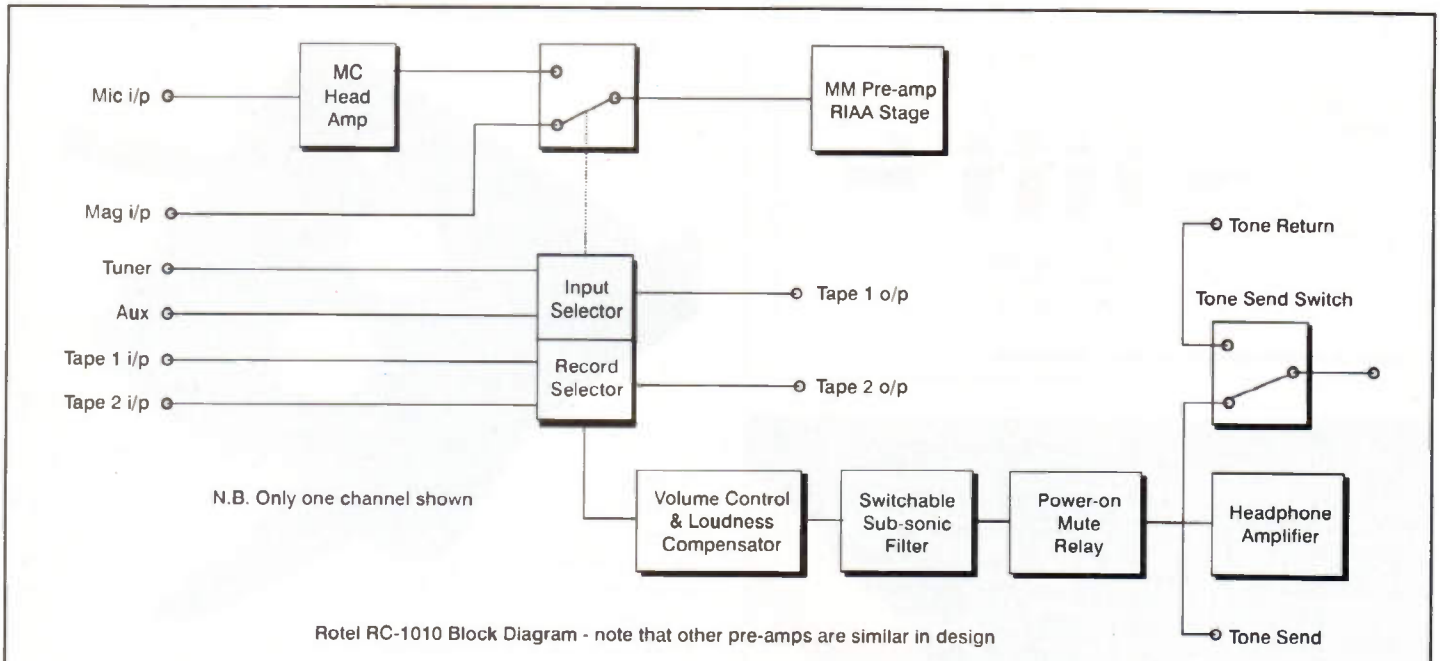
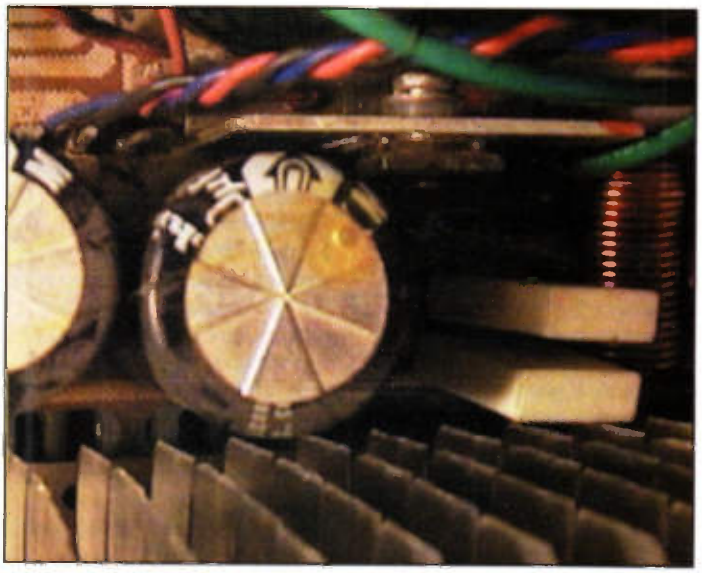


Figure 3. Block diagram of Rotel preamplifier.



Replace the capacitors near to the heatsinks.

The replacement psu capacitors are different in size to the originals.

sell double-pole DIL relays, and so you'll need to choose another type if carrying out this modification. Don't forget to put the protection diode in parallel with the relay coil - the prototype's DIL relay had one built-in. If the relay is to be powered by the CD player's own PSU, choose one with a minimal current draw. Bad news on the relay front, certainly, but Maplin does continue to sell high-quality gold-plated insulated phono sockets (JZ05F, black for left channel; JZ06G, red for right). These were fitted to the back panel, and the audio signals routed to these instead of the player's original sockets.

High-grade screened audio cable ('Shark' cable, XS39N) was used for all internal interconnections. To get signals from the main PCB, pins were soldered into the vacant positions where the electrolytic capacitors once went. The ground connections of the relay board and phono socket were connected to the CD player's PCB ground plane using 16swg tinned copper wire. The 5V for the relay board was obtained directly from the 5V regulator (7501). A lot of hassle, but was it worth it? The answer - a resounding yes! Lower frequencies were reproduced with more guts, and previously-unheard detail started coming

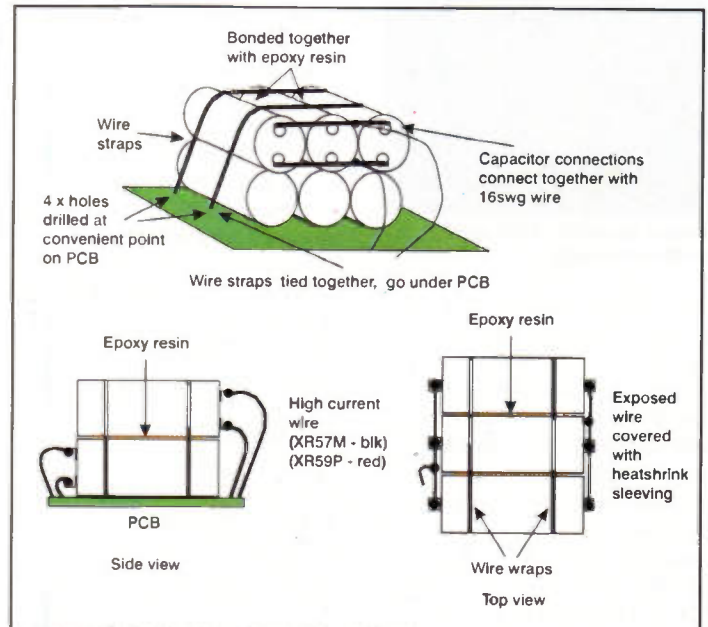


Figure 4. Assembly of psu capacitors.

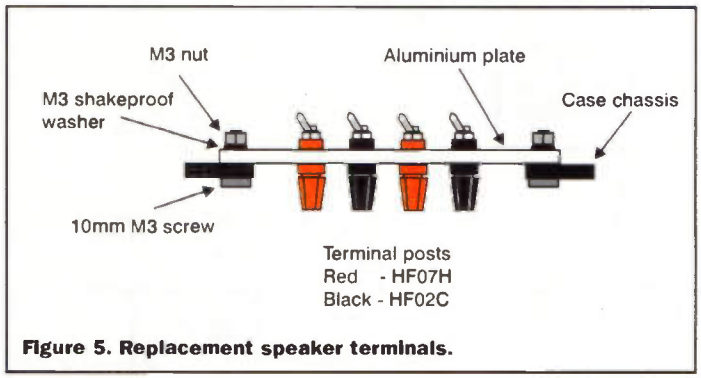


Figure 5. Replacement speaker terminals.

Marking the aluminium sheet to make the rear panel using the amplifier back cut-out as a template.

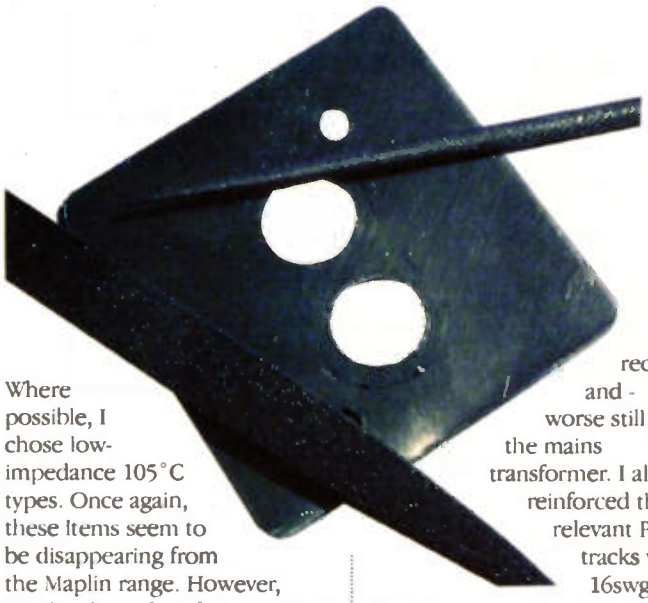
Power amplifier with new phono sockets.

out of the woodwork. Add to this a noticeable increase in spaciousness, ambience and overall musicality, and you know you're onto something! Although modifications of this nature won't convert an ordinary CD player into a £1000-plus 'superfi' two-box player, they do offer a significant improvement. A few hours work, plus £20 or so, gave my CD-692 a new lease of life. My only regret is that I didn't get around to it earlier...

Renovating the Rotels

Electrolytic capacitors have a finite useful life - conventional wisdom says about ten years or so. The warm environment of a power amplifier's innards can only accelerate their deterioration. Given the age of my RB1010, then, it's perhaps not surprising why the sound was so disappointing. Worse still, many of the electrolytics - all of which were rated at 85°C - were mounted adjacent to heatsinks. The caps of the six reservoir caps (three 8200µF/63V for each channel) were domed, leading me to believe that the gas release valves had operated at some point. One can't help thinking that the Rotel's previous owner had placed equipment on top of the amplifier, blocking the ventilation grille (perhaps the output transistors failed this way, due to thermal runaway). My first step was to replace the capacitors - a laborious task.

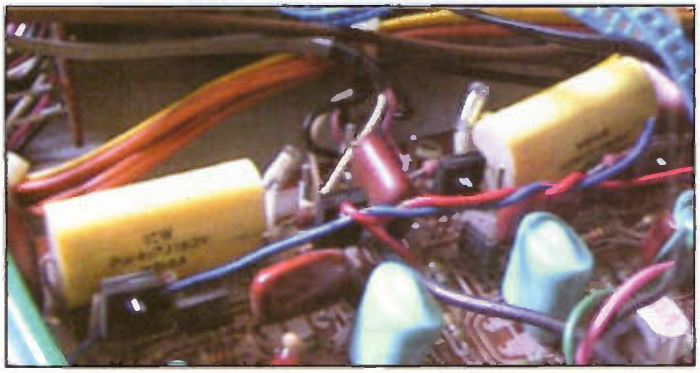
Aluminium panel for sockets.



Where possible, I chose low-impedance 105°C types. Once again, these items seem to be disappearing from the Maplin range. However, another line of 105°C capacitors has been carried across to the new catalogue. The six reservoir capacitors were each replaced by audio-grade 10000µF/63V types (TY98G) - not cheap at £11.99 each, and a bit of a gamble. The extra capacitance provided by the new capacitors - which itself totals over 10000µF - was unintentional, and a constraint of the limited variety available.

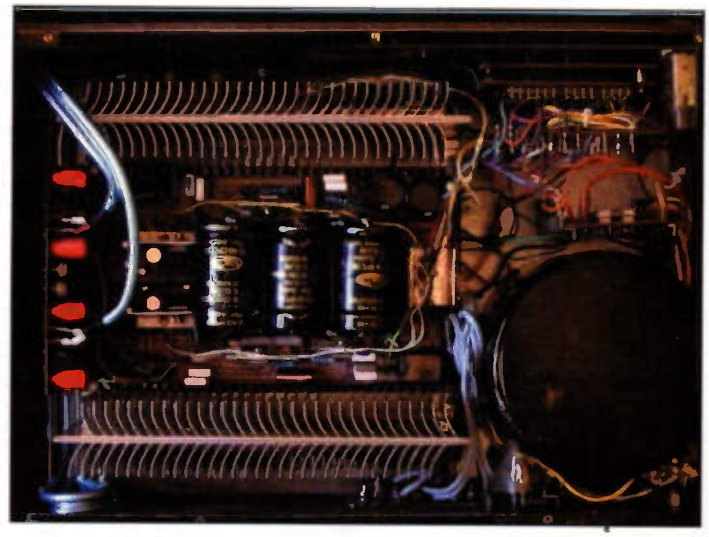
Increasing the reservoir capacitance can, however, have a positive effect - see Figure 4. There's more power to cope with sudden transients, which is good news if you listen to music with a wide dynamic range. You have to be very careful, though. In the worst case, the initial switch-on surge could place a strain on the rectifier and - worse still - the mains transformer. I also reinforced the relevant PCB tracks with 16swg tinned copper wire. The new capacitors were larger than the originals, and had to be mounted sideways (as the photos show). They were bonded together with epoxy resin, and held to the amplifier PCB with cable tie-wraps - holes were drilled in 'safe' areas of the board for this reason. The positive and negative terminals of each capacitor 'trio' were linked with 16swg wire, insulated with heatshrink sleeving. Other modifications to the power amplifier included replacement of the original spring-clip speaker terminals with binding post/4mm banana-plug types (HF02C, black for left channel; HF07H, red for right) - see Figure 5. At the same time, the phono sockets were replaced with gold-plated

Power amplifier with new speaker sockets.



Yellow high grade polypropylene capacitors fitted to pre-amplifier.

The original Rotel advert.



Inside finished amplifier.

insulated types (as per the CD player). The connectors were mounted on aluminium plates, which were bolted to the case where the original sockets went. New interconnections were made with high-quality cable. Finally, the dried-up thermal-transfer compound of heatsinked devices was renewed to aid reliability.

Despite its claim to be a direct-coupled design, there are coupling capacitors in the preamplifier's signal path (fortunately, the same is not true of the power amp). The MC head amp is input-coupled using 220µF non-polarised types, and output-coupled using 4.7µF types. Seeing that my Rega Planar 3 turntable doesn't have a moving-coil cartridge, I decided to leave these alone. However, the output of the MM stage - which is required - is coupled to the rest of the preamplifier using 4.7µF non-polarised electrolytics. These were replaced with polypropylene ones of the same value (JY82D). Again, 100nF polyester capacitors (WW41U) were wired in parallel for bypass purposes. The only other changes made were the replacement of the main smoothing capacitors (2200µF, 50V) with new ones. Other capacitors on the power supply panel - notably those adjacent to heatsinks - were also replaced. Others tested OK, and were left alone. They will need replacing at some point (as funds allow) but it has to be remembered that the preamps run pretty cool. I would have liked to replace the equalisation capacitors in the RIAA circuit with 1% polystyrene and polyester capacitors, but the stripped-down range featured in the latest Maplin catalogue has made this impractical.

One could bypass the aforementioned 'tone send' circuitry, but there's little point. A front panel switch effectively feeds the preamp output, or whatever's connected to the tone send input (return) phono sockets, to the output. The tone send output, which contains the stereo audio signals for equalisation, isn't located prior to the preamp's own tonal modificational circuits (subsonic filter and loudness control), balance and volume control - as can be seen from the block diagram of Figure 3. If it was, there could have been sonic advantage in feeding the power amp directly from here and using the power amp's input gain controls to modify volume and balance. Still, that may well be the subject for a future modification. But then again,

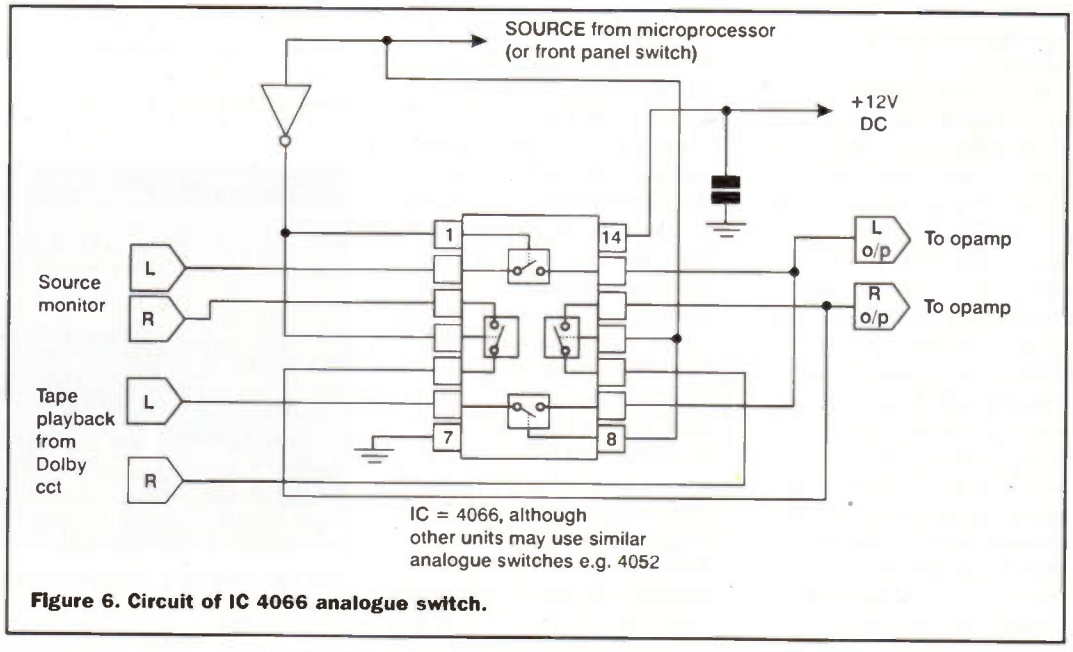


Figure 6. Circuit of IC 4066 analogue switch.

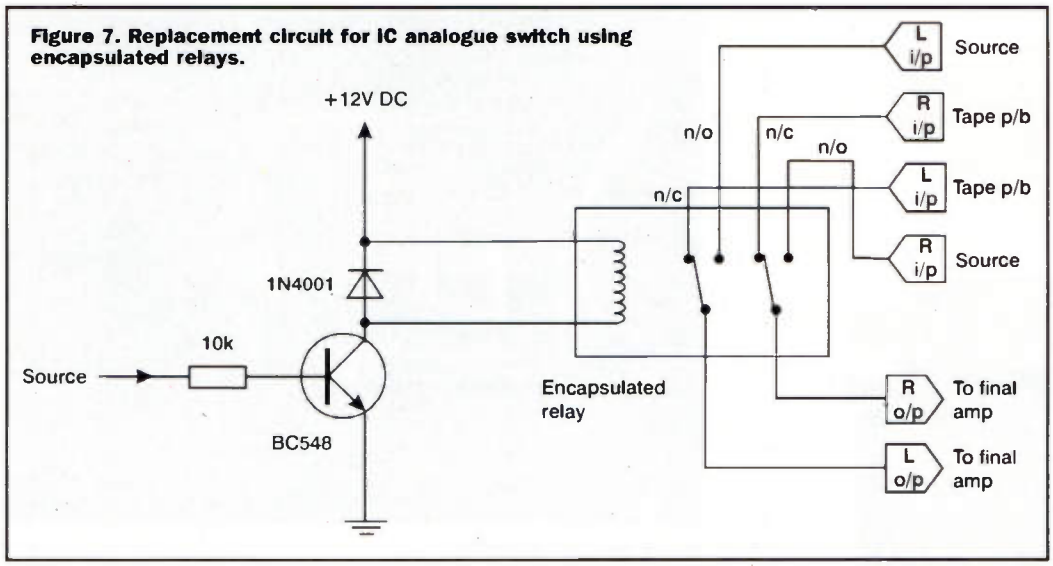


Figure 7. Replacement circuit for IC analogue switch using encapsulated relays.

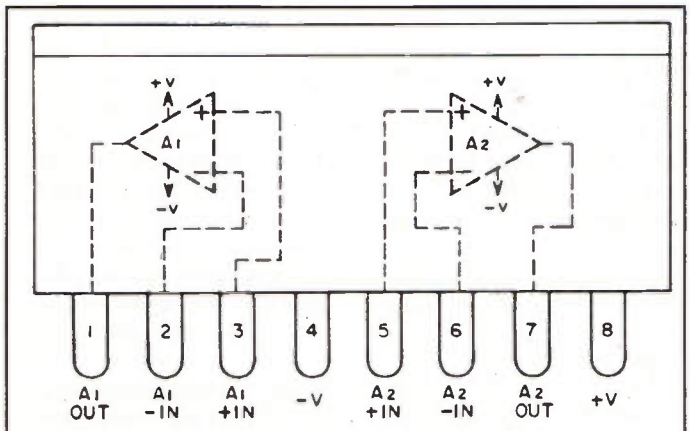


Figure 8. Pin diagram of SIL opamp used in Japanese equipment.

line level sources - such as CD players - can drive the power amp directly, and so there's perhaps little point. Simply remove the RC1010 out of circuit unless it's definitely needed (listening to vinyl, in other words). The preamp adds little sonic deterioration, though, and the advantage of convenience does - in all but the most critical of situations - outweigh minor sonic penalties.

When modifications have been made, it's advisable to set up equipment according to the service manual. With amplifiers, the tested gear required tends to be a signal generator, oscilloscope, high-impedance voltmeter and 4- or 8-ohm dummy load. In the latter case, a dummy loads can consist of 8 ohms-worth of wirewound resistors (25W 1-ohm jobs are handy). In some cases, non-inductive test loads are specified - which is interesting, seeing that speakers are very inductive loads! These aren't quite as easy to make; unfortunately, the range of suitable resistors sold by Maplin is rather limited. However, 128 1-ohm 0.6W resistors can be arranged to form a 75-watt non-inductive (well, low-inductive) 8-ohm dummy load. Basically 32 groups of four 1-ohm parallel-wired resistors are linked together in series. A boring job, it has to be said...

After the power amplifier's output stage bias current and DC offset had been adjusted, it was time for a listen. What a difference! The music didn't just plod along as once before. There was now a weighty, well-defined and articulate bass. Instruments now had drive and attack - in short, it appeared as if the musicians were at last enjoying themselves! Feeding the modified CD player directly to the power amp gave the best results of all. The overall sound created through my old B&W was nothing short of a revelation - it's hard to believe it's the same equipment! Open, clear and musical - and no giving up even at high volume levels. What's more, the stereo imaging was almost holographic. I could now easily pin-point the individual players - that's something that was difficult to do before. This battered old amp and CD player produced, between them, a sound that would be difficult to better for less than £1000.

Making the Switch

Many examples of modern hi-fi and audio-visual equipment make use of CMOS semiconductor switches (4066, 4052, 4053, etc.) in the signal path. Unfortunately, they're not hi-fi - at the very least, they contribute harmonic distortion figures of 0.03% or more. On the other hand, they're a cheap way of implementing reliable noiseless signal switching. They're commonplace in satellite receivers for the selection of sound channels and external decoders. One expensive 3-head tape deck - from a respected manufacturer who should know better - uses a 4066 to switch between source and off-tape monitoring modes. The basic idea is given in Figure 6. Note that the 4066 select lines are driven directly by the microprocessor. For better sound quality, one can specify a DPDT relay, as shown in Figure 7.

Tape decks, by the way, tend to use a fair quantity of op-amps. The devices found in Japanese decks (i.e. most of them) are not the 8 (dual/single) or 14-pin (quad) DIL packages that we know or love. To save space on crowded PCBs, the designers of such equipment tend to specify single in-line (SIL) packages instead. One of the most common components is the 8-pin SIL dual op-amp, the pin-out details of which are given in Figure 8. If you want to replace these op-amps (which tend to be of average performance) with better quality ones, then you could mount the DIL-packaged device of your choice on a small daughterboard, and wire that to the equipment PCB. Areas worthy of attention here are the final buffer stage of tuners, and the tape head pre-amp of cassette decks. Just make sure you have a circuit diagram or service manual before you begin...

Sources of service manuals:

D-Tec Tel: (01202) 870656

Mauritron Technical Services Tel: (01844) 351694

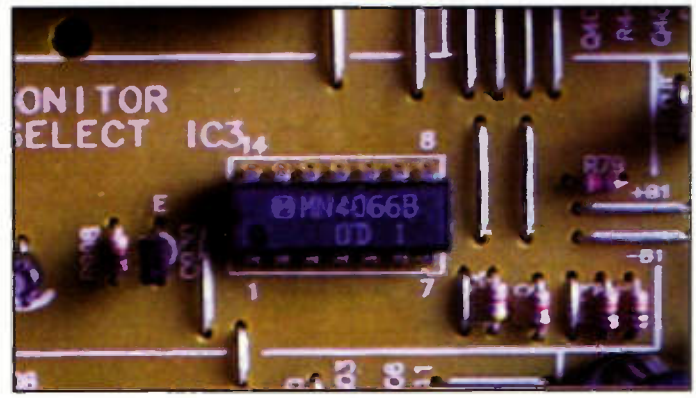
Technical Information Services Tel: (01357) 440280

Sources of obscure transistors:

Dial Electronics Tel: (0191) 417 7003

Economic Devices Tel: (01902) 773122

Grandata Tel: (0208) 900 2329



4066 IC used as a monitor/input select in a typical 3-head tape deck.

E-mail your views and comments to: AYV@maplin.demon.co.uk

Write to: *Electronics and Beyond*, P.O. Box 777, Rayleigh, Essex SS6 8LU

Environmentally Unfriendly Solar Power.

Dear Sir,

Your response to Brian Boggs's letter in the April issue was that it was interesting but that the facts and figures stated by him could not be verified. I would go one step further and argue that even if they are valid, they are in a real sense irrelevant to our future society.

We are a technological society, we take in raw materials and by the application of energy in various forms create the products our society needs for its functioning and survival.

Brian's arguments, are sound as far as they go, but do not take into account future resource depletion. We are all aware that fossil fuels, in any form, are going to run out eventually. It does not matter whether we are talking ten years or several hundreds in the future, we know it will happen.

Various renewable energy sources are currently under development, hence the whole drive of Brian's critical letter. If we ignore nuclear generation as undesirable, regard fusion generation as still a pipe dream, we are left with wind, water, wave, tidal, geothermal, biogas, photosynthesis, and solar. All of these alternative energy sources, with the exception of geothermal, are ultimately driven by insolation. Geothermal has limited availability.

So solar power is the primary energy source on our planet, our dwindling fossil fuels are stores of solar energy from the past. Wind, water, wave, tidal, biogas, and photosynthesis are all secondary energy sources, one or more steps down the chain of energy conversion from the solar input. When energy is converted from one form to another, there are always losses, the less links in an energy chain the less the losses. Therefore, the higher up the energy conversion chain we can reach, the more energy is potentially available, this means direct conversion of solar energy has to be our ultimate target.

If our society is to maintain its present, and growing, consumption of energy, then it has to be seeking now, while fossil energy still exists, alternatives for when these fuels are gone. Ultimately as our demands increase we are going to have to be able to utilise direct conversion of solar energy. Utilising secondary sources of energy such as wind or waterpower invariably means not only reduced efficiency but also an environmental penalty, solar panels however can replace a roof or a canopy without environmental impact.

The first motor cars were inefficient, noisy, slow, clumsy and cumbersome compared to a horse or pony and trap. They were rich men's toys. You can argue that they are still inefficient, but in all other respects they have vastly improved.

Solar panels are still at the level of the model T-Ford car, with the right commercial and consumer pressures they will develop and improve. Both the water heating, and photocell varieties will become more efficient, more cost effective, no doubt new, less energy intensive materials will become used in their manufacture. Actually this last statement is rather a chicken and egg comment, if a solar panel can produce energy efficiently, then collectively they can produce enough energy to produce more as needed.

So in summation to Brian I say don't knock it, yes it is economically and energetically unsound at the present, but we need this technology developed and up and running for the future. The learning curve needs to start now, not when the fossil fuels run out.

Ian McAlister
Surrey

Ian comments are very much in the vein of our reply to Brian's letter published in issue 148. We would add that perhaps it will take a strong government, or group of governments (EU?), to push forward the cause of non-fossil burning power generation. I am sure most of us would admit that the way we propel a car will have to change - but some would say preferably not in our life time! - and until we wake up to this fact little will be done to forward the cause. The Chancellor, by a back-door method, may be attempting to do just this by basing the tax on company cars (from April 2000) according to their emissions. In effect the bigger the engine the bigger the tax bill.

Very Environmentally Friendly!

Dear Sir,

I am writing in response to Brian Boggs' letter regarding the environmental impacts of various renewables.

Firstly, regarding methanol burning instead of petrol, I am afraid he has missed the point. The net carbon dioxide production of biofuels is almost zero. This is because energy crops (biofuels) absorb a similar amount of CO_2 during growth, as they give off when burnt. This compares very favourably to fossil fuels that are releasing CO_2 stored over millions of years, resulting in a net increase in free carbon dioxide.

Secondly regarding PVs, I am curious as to the assumptions made calculating the production of CO_2. The myth that PVs do not produce as much energy as they cost stems from the early days of satellite industry, which was much more concerned with weight and cell efficiency than energy cost.

Expert calculation of the energy payback of PVs suggests an energy payback of 2-3 years - see refs 1 and 2. Note that by energy payback I am referring to the time taken for generated energy to equal the energy cost of manufacture and installation. I am not aware of other CO_2 costs in production, other than those associated with the energy inputs.

This means that in three years the cells will have already produced enough clean energy to pay for their environmental cost.

Certain manufacturers are now giving 25-year guarantees with these products. I cannot believe that they expect them to last on average any less than this time. Based on the assumption that the panels will 'pay' for themselves in three years, it means that they will have produced at least 8 times as much clean energy in their working life as they have cost in production. Plus, they will have saved a proportionate amount of CO_2 production that would have been released by fossil fuels.

The manufacturing cost of batteries 'associated with PVs' is simply not an issue. Grid connected PVs do not use them (Mr Boggs is confusing the designs with 'stand alone' or independent power systems which often use battery storage)

Mr Boggs is confused when he claims that mini and micro hydro schemes often 'dump' their excess power. Again, he is referring to independent power supplies.

The majority of significant hydro schemes are grid connected and so do not produce an excess. Independent micro and mini hydro schemes often use heat dumps for controlling turbine speed and this 'excess' energy is deliberately put to use replacing heat provision that would have had to come from another source!

Electric vehicles do not omit CO_2 at their point of use, but the electrical energy used by the car may have come from CO_2 emitting fossil fuels or from clean renewable energy. Petrol powered cars always generate CO_2.

Finally I'm afraid that there is no evidence, or even a theory, to support the claim that wind power affects weather patterns. There is however plenty of evidence to suggest that CO_2 produced from all human activity is altering the global climate, and that such changes are increasing human suffering, and dramatically impacting on biodiversity.

Pete Geddes B.Eng (Hons)
Centre for Alternative Technology

References

1 Palz and Zibetta, 1992
2 Alsema, E.A, 1997

Thanks for that information, Pete. At the end of the day, I am sure most people prefer the overall concept of a cleaner environment, and I am convinced that this desire will push forward the progress and introduction of alternative technology.

Fuzzy LOGIC

Douglas Clarkson gets to grips with this 'strange' speciality subject

Introduction

The theory of Fuzzy Logic if presented as an academic speciality subject, can all too easily numb and paralyse the curious, inquiring mind. Also, trivialising it by absurd example can present a too lightweight approach when considering it for complex, real world applications.

The fact that Fuzzy Logic was invented in the West by Lotfi Zodeh in 1965 and initially taken seriously in the first place by the Japanese during the 1980's, confirms in some way the difference between Western Culture and Eastern Culture. In the West, for example, thinking is directed to determining absolutes - i.e. if things are either right of wrong, while in the East, it is perfectly acceptable to determine if an idea is more right than wrong or conversely more wrong than right.

Also, in many ways, the advent of the microprocessor was hailed in the west as the ultimate means of understanding and hence controlling systems. The reasoning behind this was that most physical systems if studied sufficiently well could have their behaviour expressed according to a model of input/output parameters so allowing such systems to be controlled successfully. The model of the controller with feedback is indicated in Figure 1, In this way continuous monitoring of input data parameters and output parameters reflecting system operation would allow the system to be controlled accordingly.

Control Engineering is a large and specialist discipline, but there are systems within this framework, which perhaps do not readily allow them to be effectively modelled and so this approach of control would not be appropriate. Also, it may be the case that while precise modelling is possible, it may not necessarily be valid or an economically viable approach to implement. In many ways, also, there is the difficulty of separating the 'hype' of Fuzzy Logic from the reality of its true role in Control Engineering.

The specialist control engineer will possess this degree of perspective. Other factors that may relate to the use of Fuzzy Logic concern development costs, production costs and maintainability of systems.

Traditionally Fuzzy Logic has been used as an active control device. It may take in a set of eight analogue or 'crisp' inputs, operating on these in a real time mode and outputting up to eight 'crisp' or analogue outputs. Plus, the processing cycle may be undertaken many thousands of times a second depending on the nature of the control system. Fuzzy logic has also been applied in other ways as a defined rule based system, for example, playing the Japanese stock market, so that the inputs and outputs do not necessarily need to relate to formal control engineering.

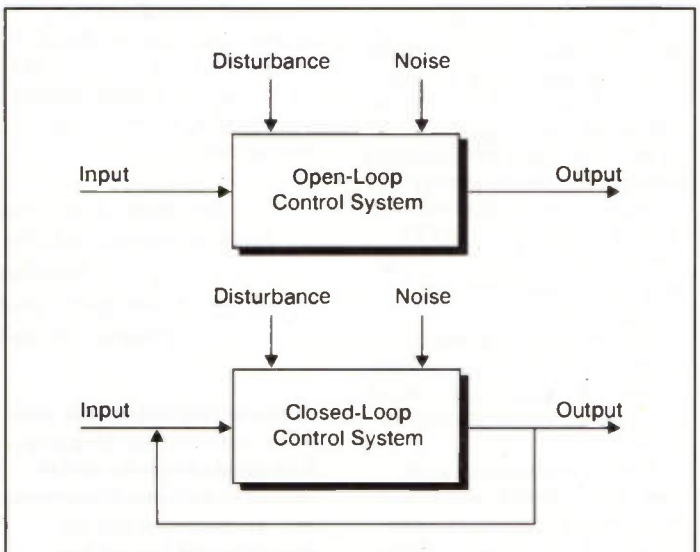


Figure 1: Conventional PID controller

Introducing Fuzzy Logic States

In Figure 2a, 2b and 2c we demonstrate the conventional Boolean logic states of functions T(a), T(b) and T(c) where the functions are either, COLD, WARM or HOT based on having value 1 or 0 based on threshold values of T0, T1, T2 and T3. This may appear to provide clarity in the analysis but if we consider points in Figure 2b and 2c bordering on WARM and HOT, we can move these points quite close together as we approach the value T2 and both systems will register different condition states - i.e. WARM and HOT. The approach of Fuzzy Logic is to utilise the structure of Figure 2d where the independent logic functions COLD, WARM and HOT can have varying function value between 0 and 1. For the functions referenced, there are temperatures that most closely define either COLD, WARM or HOT and the function takes on a value of 1. Also, there are temperatures that can be defined as partly COLD and WARM or partly WARM and HOT. In a real control application, it may be appropriate to have a range of around seven or eight such separate functions.

In a practical control problem, therefore, the initial approach is to define the main input parameters and establish the membership functions of the

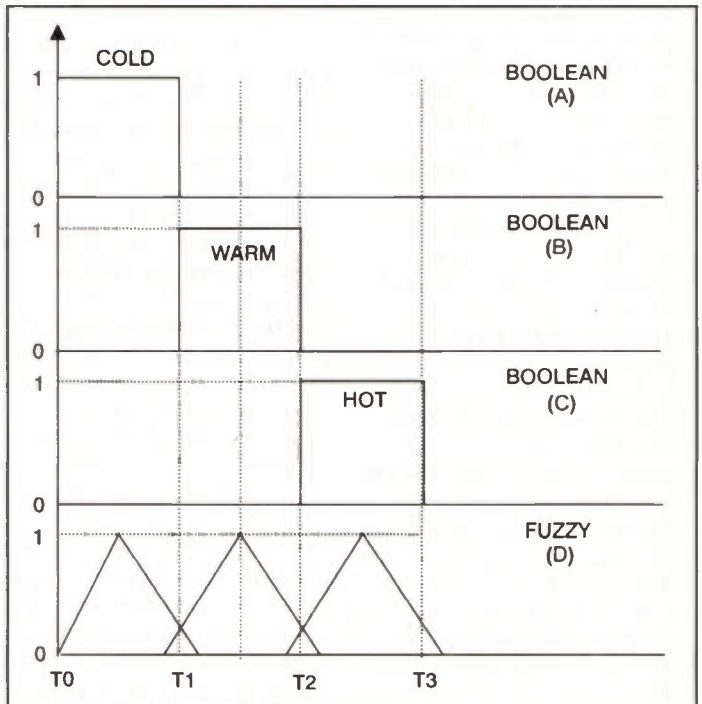


Figure 2a: Logic definition of COLD
2b: Logic definition of WARM
2c: Logic definition of HOT
2d: Fuzzy logic definitions of COLD, WARM and HOT

INPUT:SPEED	INPUT:BRAKE TEMP	INPUT:PRESSURE
very slow	very cold	low
slow	cold	moderate
moderate	warm	high
fast	very warm	
very fast	hot	

Table 1: Example of sub division of membership functions of inputs of speed, brake temperature and applied brake pressure in a brake control system.

parameter within the range of values of the parameters. Table 1 outlines some possible definitions for input parameters of a system.

Usually for a specific system the input parameters are self-evident. The sub division into membership functions, however, cannot be precisely defined but can always be altered in the light of experience with the actual control system.

A range of shapes has been used in defining such membership functions. The most popular is that of a trapezoidal or triangular shape, presumably because these are easier to implement. Also, models using more complex maths functions do not clearly produce systems of significantly higher output quality.

Specification of Membership Function

So-called membership functions should give continuous coverage of the parameters concerned. The structure of Figure 3, with for example, a gap in the distribution, would prevent any rule firing which referenced the values within the 'gap' area. The use of narrower membership functions results in a faster response while larger oscillations and overshoot and settling time are introduced when narrower membership functions are used. Also, while the use of narrow membership functions produces a system with lower steady state error, very narrow membership functions may prevent the steady state from being reached at all.

Fuzzy Controller

Design

The conventional approach of Boolean logic is illustrated in Figure 4a where a series of logic inputs is processed within a 'black box' system to produce a series of appropriate logic outputs. The conventional logic processing system is able to undertake such computations at great speed.

The comparable 'black box' design for a fuzzy controller is indicated in Figure 4b where a series of so called 'crisp' analogue inputs are processed according to 'fuzzy' rules and values for 'crisp' analogue outputs determined.

In terms of implementing such a system, it is entirely possible to utilise a PC with suitable analogue inputs and D/A outputs and do all the programming in a suitable programming language. The 'neat' solution is to use a specialised fuzzy logic controller which is specially designed for data input, fuzzy logic operation and defuzzification of the output parameters as 'crisp' analogue outputs.

Defuzzification

A 'fuzzy' controller will usually require its outputs to be presented as a 'crisp' , analogue output parameter. This process is termed 'defuzzification'. Where a specific output parameter has a final output function as indicated in Figure 5a, when a specific series of rules is implemented to contribute to the parameter, the hatched section of the output responses may be selected. It is required to translate this distribution of values to a specific 'crisp' value. The most widely used approach is that of

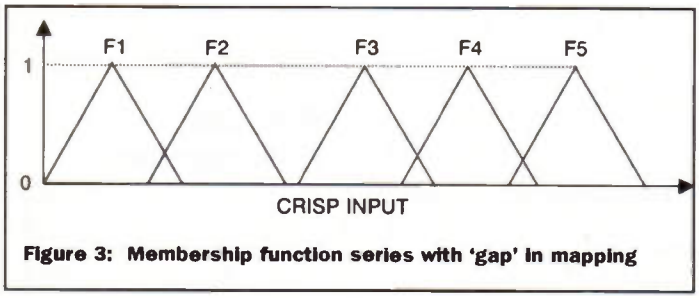


Figure 3: Membership function series with 'gap' in mapping

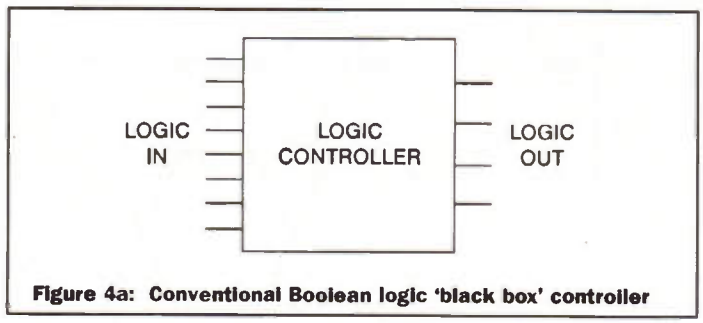


Figure 4a: Conventional Boolean logic 'black box' controller

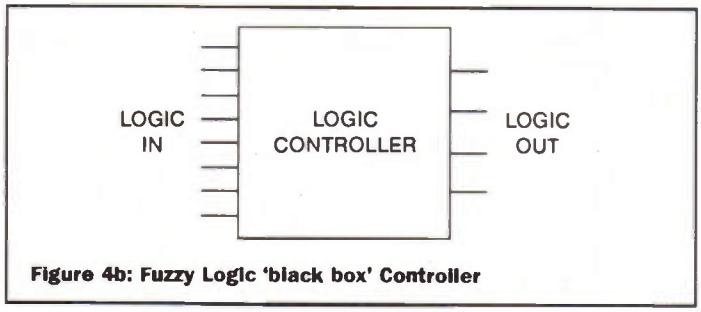


Figure 4b: Fuzzy Logic 'black box' Controller

the centre of mass or centroid function. For the specific example in Figure 5a, we can imagine the corresponding value to relate to the value of the parameter, where if we cut out the shape from cardboard, we could produce both sides to balance on the line defining the centroid value.

This is a process that is weighting therefore in both vertical and horizontal directions. In mathematical terms the centroid is defined as the sum of products of parameter value and membership value divided by the sum of corresponding membership values. The intuitive understanding of the point of 'balance' of the distribution is, however, a useful way to perceive its derivation. The distribution of the output function, however, may not be so well behaved.

Areas of 'result' may be dislocated as indicated in Figure 5b. In this eventuality it is common to derive the centroid value of the largest area and ignore the component of the smaller isolated section.

For a continuous function, the centroid is calculated by techniques of integration and this may result in slow inference cycles. With faster and faster processors, however, the disadvantage of integration should be less of a problem.

Learning By Example

It is very much the case that Fuzzy Logic is best understood by example, rather than introducing layers of theory. After all, it is much more relevant to learn how to ride a cycle rather than read about it from a manual.

Most examples relate to combinations of input parameters. We can consider a system where we have two

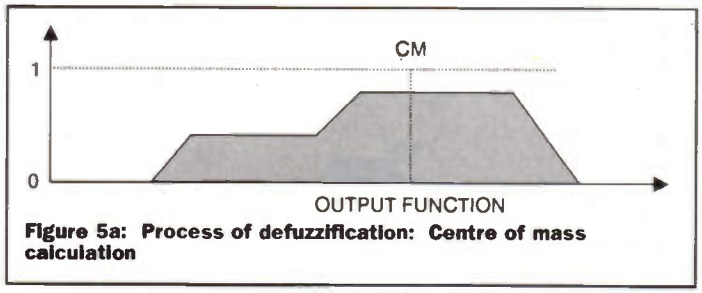


Figure 5a: Process of defuzzification: Centre of mass calculation

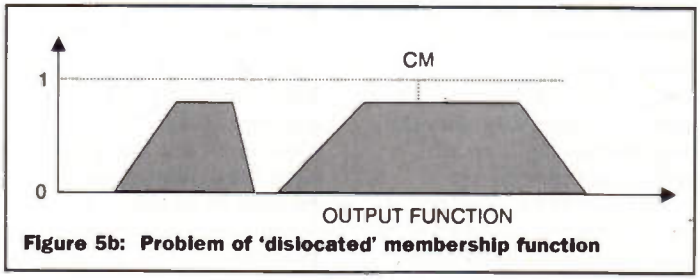


Figure 5b: Problem of 'dislocated' membership function

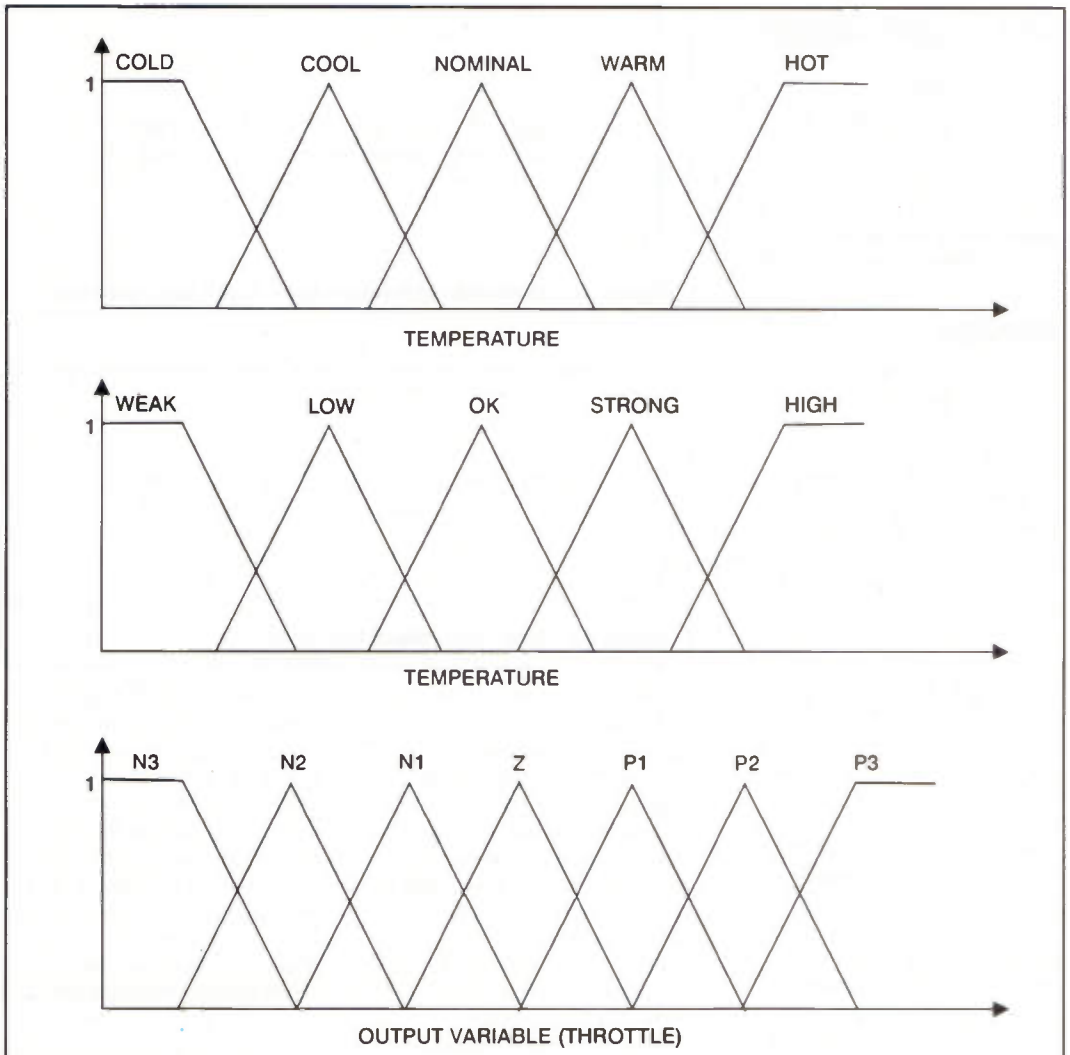


Figure 6 Membership functions of example system.

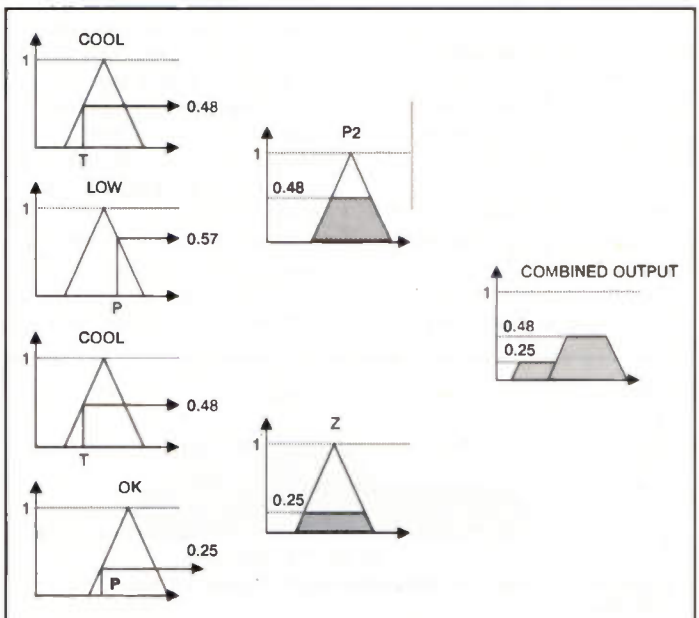


Figure 7: Process of calculating membership values from 'crisp' inputs for COOL function and LOW function.

input 'crisp' values of temperature and pressure and a derived output of throttle. The membership functions are defined in Figure 6.

Each input of a 'crisp' real world value maps to at least one membership function of the specific input parameter. In this example, at most two membership functions can be active at any one time for an input 'crisp' value. A series of rules can be established to define control of the system. These are:-

RULE 1: If temperature is cool AND pressure is weak THEN throttle is +3.
RULE 2: If temperature is cool AND pressure is low THEN throttle is +2.
RULE 3: If temperature is cool AND pressure is ok THEN throttle is 0.
RULE 4: If temperature is cool AND pressure is strong, THEN throttle is -2.

These various rules will 'fire' depending on the values of temperature and pressure. In the example of temperature being in the 'cool' state and pressure being in the 'low' and 'ok' states, rules 2 and 3 only will fire. Thus in a generalised system all the rules have to be checked before the process of determining output states can be completed.

In the example shown in Figure 7, a value of 0.48 is produced from the cool function and 0.57 from LOW function in evaluating the function of rule 2. It is common to evaluate the intersection of these two values as the minimum of the two values i.e. 0.48. This value is then applied to the appropriate throttle function +2 as indicated in Figure 7.

In a similar fashion, from rule 3, the value from pressure ok is 0.25 and the value from COOL is again 0.48. The intersection of these values is again taken as the minimum of the pair of values or 0.25. This value is then transposed to define the maximum value of the function throttles zero.

A specific 'crisp' value of throttle is produced by defuzzification, with the centre of mass or centroid method being the most common. Thus, this demonstrates the very basis of fuzzy controllers and which may be summarised as:-

1. identify the physical parameters as inputs and outputs
2. define the corresponding membership functions
3. establish the set of rules to define the control problem
4. select the function to determine AND between functions
5. select a specific set of 'crisp' inputs
6. operate rules and generate output function mapping
7. utilise defuzzification to generate 'crisp' outputs

The key thing to appreciate is that the model operates on 'crisp' one-value inputs.

It is also apparent that a complex model of the system has not been produced in mathematical form. All that has been undertaken is that the behaviour of the system has been monitored to understand the general interaction between the component systems and the rules carefully composed. Clearly, if these rules are themselves wrong or represent a gross oversimplification of the device then the performance of the model will be less than ideal. There is also the concept of 'designing in' out of tolerance behaviour, which may be introduced due to wear and tear on components. Presumably this can be introduced by creating rules which identify these situations and consequently alter system operation accordingly.

A Fuzzy Programme

Figure 8 indicates a very much simplified control system for a nuclear reactor based on neutron flux, core temperature

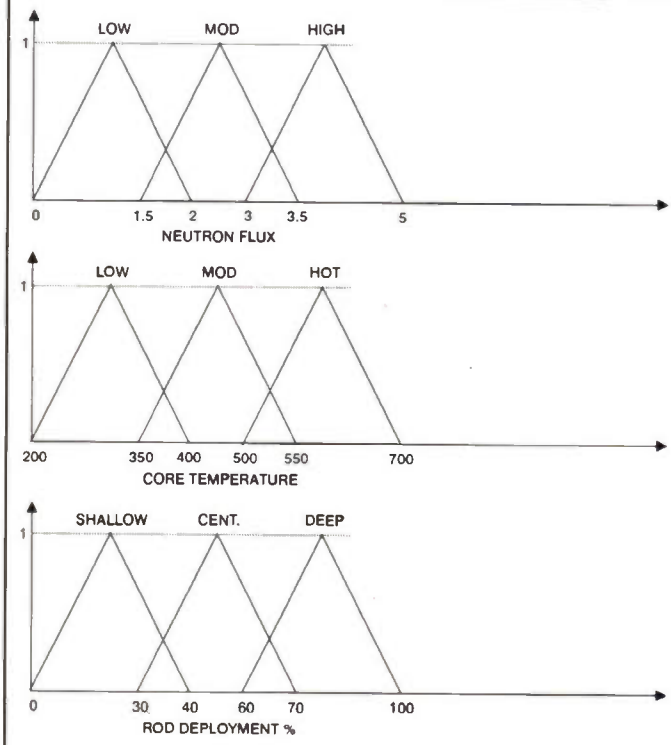


Figure 8: Very simplified example of control system for nuclear reactor.

and control rod deployment. The membership functions are symmetrical and this introduces simplicity into the subsequent calculations. It is quite possible to 'clone' this mini programme to include more rules and functions, provided the basics of the code is understood.

The set of rules to be implemented are:-

RULE 1: If FLUX is HIGH and TEMP is HOT then RODS is DEEP.
RULE 2: If FLUX is HIGH and TEMP is MOD then RODS is CENTRAL.
RULE 3: If FLUX is MODERATE and TEMO is HOT then RODS is DEEP.
RULE 4: If FLUX is MODERATE and TEMO is LOW then RODS is SHALLOW.
RULE 5: If FLUX is LOW and TEMP is LOW then RODS is SHALLOW.
RULE 6: If FLUX is MODERATE and TEMP is MOD then RODS is CENTRAL.
RULE 7: If RODS is LOW and TEMP is MOD then RODS is CENTRAL.

The values of parameters are as indicated and the associated programme in Microsoft QuickBASIC provides a value for rod deployment based on neutron flux and core temperature.

```
10 REM  nuclear reactor control- Fuzzy Logic programme
30 DIM  mset(1000) AS SINGLE, tset(3, 1000) AS SINGLE
   CLS : REM clear screen

inf:      REM start of calculation loop
          CLEAR : REM initilise values

PRINT     "input value of neutron flux in range 0,to 5.0"
              INPUT iflux
              IF iflux < 0 OR iflux > 5! THEN GOTO inf

intp:     REM input value of core temperature
          PRINT "input value of core temperature in range  200
   to 700 degrees C"
          INPUT itemp
          IF itemp < 200 OR itemp > 700 THEN GOTO intp

REM       rule checking
          totstat = 0
qrule1:   a = 3: b = 5: d = 500: e = 700: rl = 1
          GOSUB 11000:  IF g = 0 THEN GOTO qrule2
          rval(3) = h: REM intersection of values 'DEEP' rods

qrule2:   a = 3: b = 5: d = 350: e = 550: rl = 2
          GOSUB 11000: IF g = 0 THEN GOTO qrule3
          rval(2) = h: REM intersection of values 'CENTRAL' rods

qrule3:   a = 1.5: b = 3.5: d = 500: e = 700: rl = 3
          GOSUB 11000: IF g = 0 THEN GOTO qrule4
          rval(3) = h: REM intersection of values 'DEEP' rods

qrule4:   a = 1.5: b = 3.5: d = 200: e = 400: rl = 4
          GOSUB 11000: IF g = 0 THEN GOTO qrule5
          rval(1) = h: REM intersection of values 'SHALLOW' rods

qrule5:   a = 0: b = 2: d = 200: e = 400: rl = 5
          GOSUB 11000: IF g = 0 THEN GOTO qrule6
          rval(1) = h: REM intersection of values 'SHALLOW' rods

qrule6:   a = 1.5: b = 3.5: d = 350: e = 550: rl = 6
          GOSUB 11000: IF g = 0 THEN GOTO qrule7
          rval(2) = h: REM intersection of values 'CENTRAL' rods

qrule7:   a = 0: b = 2: d = 350: e = 550: rl = 7
          GOSUB 11000: IF g = 0 THEN GOTO proc1
          rval(2) = h: REM intersetion of values "CENTRAL' rods

proc1:    REM have completed rule checking
           IF totstat = 0 THEN PRINT "no rules valid": GOTO inf

REM initialise temporary  data arrays and main data array
FOR j1 = 1 TO 3
FOR jj = 1 TO 1000: tset(j1, jj) = 0:  NEXT jj
NEXT j1

FOR jj = 1 TO 1000:   mset(jj) = 0: NEXT jj: REM initialise master set

REM  operate on each output  function to form final set

REM check for conribution to 'SHALLOW' rods
try1: IF rval(1) = 0 THEN GOTO try2
x1 = 0: y1 = 0: x2 = 20: y2 = 1: x3 = 40: y3 = 0: map = 1
v = rval(1): GOSUB 12000: REM determine elements 1 to 400

REM check for contribution to 'CENTRAL' rods
try2: IF rval(2) = 0 THEN GOTO try3
x1 = 30: y1 = 0: x2 = 50: y2 = 1: x3 = 70: y3 = 0: map = 2
v = rval(2): GOSUB 12000: REM determine elements 301 to 700

REM check for contribution to 'DEEP' rods
try3: IF rval(3) = 0 THEN GOTO defuz1
x1 = 60: y1 = 0: x2 = 80: y2 = 1: x3 = 100: y3 = 0: map = 3
v = rval(3): GOSUB 12000

defuz1:  REM place entries in main set, selecting maximae

FOR jj  = 1 TO 400:  mset(jj) = tset(1, jj): NEXT jj

FOR jj  = 301 TO 700: IF tset(2, jj) > mset(jj) THEN mset(jj) = tset(2, jj)
NEXT jj

FOR jj = 601 TO 1000: IF tset(3, jj) > mset(jj) THEN mset(jj) = tset(3,
jj)
NEXT jj

REM compute centroid for defuzzification and report

ytot = 0: xytot = 0
FOR jj = 1 TO 1000: ytot = ytot + mset(jj)
xytot = xytot + mset(jj) * jj / 10
NEXT jj
centrv = xytot / ytot:  REM  centroid value
PRINT "Level of Control Rod deployment is   ";
PRINT USING "###.###"; centrv: PRINT " %"

GOTO inf: REM  calculate another loop

11000     REM rule check and intersection  calculation
          g = 0: REM status initialised
          IF iflux >= a AND iflux <= b THEN GOTO part2
          RETURN
part2:    IF itemp >= d AND itemp <= e THEN GOTO part3
          RETURN

part3:    REM rule is valid - calculate value Intersection
          REM for neutron flux
          m1 = (1 - 0) / ((b - a) / 2)
          c1 = 0 - m1 * a
          m2 = (0 - 1) / ((b - a) / 2)
```

```
        c2 = 0 - m2 * b
        IF iflux = a + (b - a) / 2 THEN outp1 = 1: GOTO qvr
        IF iflux > a AND iflux < a + (b - a) / 2 THEN outp1 =
            m1 * iflux + c1: GOTO qvr
        IF iflux > a + (b - a) / 2 AND iflux < b THEN outp1 =
            m2 * iflux + c2

qvr:    REM determine value for temp
        m1 = (1 - 0) / ((e - d) / 2)
        c1 = 0 - m1 * d
        m2 = (0 - 1) / ((e - d) / 2)
        c2 = 0 - m2 * e
        IF itemp = d + (e - d) / 2 THEN outp2 = 1: GOTO
            inters
        IF itemp > d AND itemp < d + (e - d) / 2 THEN
            outp2 = m1 * itemp + c1: GOTO inters
        IF itemp > d + (e - d) / 2 AND itemp < e THEN outp2
            = m2 * itemp + c2

inters: REM select minimum of values
        h = outp1
        IF outp2 < h THEN h = outp2
        PRINT "rule " + STR$(rl); " is valid ";
        PRINT "values (flux,temp) are ";
        PRINT USING "##.###"; outp1; outp2;
        PRINT ":intersection is ";:PRINT USING "##.##"; h
        g = 1: REM code to indicate rule was valid
        totstat = totstat + g
        RETURN

12000   REM fill discrete values into output function
        m1 = (y2 - y1) / (x2 - x1)
        c1 = y1 - m1 * x1
        xl = (v - c1) / m1
        xr = x3 - (xl - x1)
        m2 = (y3 - y2) / (x3 - x2)
        c2 = (y3 - m2 * x3)

    REM have computed the three extents of line in output function
  FOR jj = INT(x1 * 10) TO INT(xl * 10)
    tset(map, jj) = m1 * (jj / 10) + c1
    NEXT jj: REM left positive gradient section

    FOR jj = INT((xl * 10)) TO INT((xr) * 10)
  tset(map, jj) = v: REM level portion
  NEXT jj:  REM  flat central portion

  FOR jj = INT(xr * 10) TO INT(x3 * 10)
  tset(map, jj) = m2 * (jj / 10) + c2
  NEXT jj:  REM right negative gradient section
  RETURN
```

The structure of fuzzy logic implementation lends itself in particular to the use of sub routines. One key one (11000) is used to check which rule fires and if so determine the values of the membership functions. The subroutine at 12000 determines the values of the 'result' within the specified output function.

The system performs a true 'centroid' calculation and this is where lies some of the more complex calculations and for some slight delay in calculating the centroid value. In this solution, the total extent of the output is defined in 1000 finite elements.

It is quite apparent, however, that if only one output function fires, the output value corresponds to the central value of that function. These values are respectively 20%, 40% and 80%. It is where there are combinations of output functions that the centroid calculation will indicate different values.

Summary

The field of Fuzzy Logic is beginning to gain some respectability within technical/academic circles and the information relating to such systems is becoming increasingly available. They certainly present a new way to consider physical problems of control and very likely also have applications in complex fields such as risk analysis related to financial markets and medical diagnosis.

Further Reading

Fuzzy Controllers: Leonid Reznik, Newnes, 1997

<www.embedded.com/97/feat9512.htm>

<www.isis.ecs.soton.ac.uk/research/nfinfo/fuzzycontrol.html> (read the web pages first)

De Magnete: THE BIRTH OF BRITISH SCIENCE

by Gregg Grant

Introduction

It's a frequently debated question among historians of science and technology as well as scientists when did British science begin? When - or for that matter where - was its point of creation?

People generally are rightly sceptical of too pat answers, and scientists and engineers more suspicious of them than most. Nevertheless, in this new millennium we could, it seems to me, add the 400th anniversary of the birth of British science.

In 1605 Francis Bacon, philosopher and lawyer wrote, somewhat disparagingly, in his Advancement of Learning that 'Gilbertus our countryman, hath made a philosophy out of the observations of a lodestone,' [1] in his book De Magnete which had come out five years earlier.

Although Bacon has his rightful place in the history of science, through his powerful advocacy of what has come to be known as scientific method, he was no scientist, even an embryo one. Consequently he could hardly be expected to comprehend the significance of a work generally regarded as the first book on the physical sciences to be based entirely on experiments, indeed on the very methods Bacon himself would later contend would be the way forward.

More than this however, De Magnete can be regarded as the beginning of British science as it is frequently considered to be the first great scientific book written in English.

The Author

William Gilbert was born in Colchester, Essex, in 1544. He studied medicine at Cambridge, where he demonstrated his intellectual versatility and curiosity by carrying out chemical experiments and becoming deeply interested in astronomy. Indeed his reading in medicine and other disciplines was extensive.

To get some idea of the breadth and depth of Gilbert's learning, the curious can do no better than note the authors quoted in De Magnete. They range from the ancient Greek authorities, through the embryo scientists of the medieval period such as Petrus Peregrinus to those of his own time, such as William Borough, Robert Norman and Tycho Brahe.

Gilbert was elected a Fellow of St. John's College in 1561 and - eight years later - he moved to London, setting himself up in practice as a physician. Such was his success that he made a great deal of money, as well as becoming president of the College of Physicians in 1599. In the following year he was appointed Physician to Queen Elizabeth, a post he would continue to hold under her successor, James I.

Gilbert's magnetic experiments were conducted over an 18-year period and at his own expense, which bit deeply into even his wealth. Indeed his account of this work demonstrated that he '. . . was content to go his own way, in advance of his time.' [2]

The Book

De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure Physiologia Nova or, 'On the Great Magnet of the Earth,' was, quite simply, unique (see Figure 1). Apart from being the first scientific treatise in English, it had a number of other distinctions and innovations to its credit.

To begin with it was substantial, comprising six books of 115 chapters, in all some 120,000 words with a good chapter index. It was also illustrated with some 90 woodcuts, of both lodestones and the equipment Gilbert used in his experiments.

One radical departure from other explanatory tomes was the use of margin stars, of two different sizes. There were '. . . large ones for the most important and small ones for the others. There was almost one for each page, 21 large and 178 small, so prolific was his work.' [3] Moreover, De Magnete would be reprinted in 1628, and again in 1633.

Gilbert also dismissed myths and legends concerning the lodestone as well as correcting the views of earlier experimenters, one of whom was the Italian physicist Giambattista della Porta. The founder of the first scientific society in 1560, until it was suppressed by the Inquisition, as well as being the author of the first Western book on kites and kite flying, della Porta had also looked into magnetism.

One of his ideas was that magnetic attraction was the result of '. . . eternal combat between magnet and iron within the lodestone.' [4] Gilbert proved this not to be the case and - in the process - let it be known that della Porta's work was akin to the ramblings of an old woman. The Italian, for his part, thought that Gilbert was no gentleman!

But, despite their undoubted scientific achievements in this field, both held some curiously old fashioned views regarding magnetism. Gilbert for example thought that it was the force holding objects on the surface of the earth, in short a form of gravity, and della Porta too held no less strange ideas.

Its Contents

Peter Peregrinus first studied magnetism in Western Europe in 1269. A military engineer and strong advocate of the ideas of Roger Bacon, he was taking part in the

siege of an Italian city when - to relieve the inevitable boredom - he wrote to his friend Syergus of Foucaucourt concerning his experiments.

Peregrinus described lodestone and its characteristics, including its north-seeking properties. He was the first experimenter to use the term magnetic pole and explain that, when split in two, a magnet does not simply become two unipole pieces of magnetic material: it becomes two magnets.

Nothing further would be written about magnetic phenomena until 1581, when Robert Norman's A New Attractive was published. An instrument-maker by profession, Norman's book contained a description of the magnet and what its author termed 'a newe discovered secrete' concerning its behaviour.

This was the '. . . phenomenon which now goes under the name of magnetic 'dip' [5] This is the needle's inclination to the horizontal, which differs from one location to another. Norman was the first investigator to make this aspect of the compass known to the world at large. In fact no less than a quarter of De Magnete was '. . . taken up by problems of navigation and nautical instruments since they had sparked his theory of electricity and magnetism.' [6]

Gilbert indeed fully acknowledged his debt to the Elizabethan sailors, shipwrights, sailmakers and mathematicians the men who, in the vessels they designed, built and manned, had so humbled the Spanish Armada in 1588.

Gilbert's work was the most thorough study of magnetism since Peregrinus and one of the most extensive studies of the subject ever written. He discussed magnetism in every detail including the magnet itself, the magnetic compass and the phenomena of repulsion and attraction. He was the first investigator to use such expressions as electric attraction, and electric force, and he coined the term electric for materials that behaved like amber and non-electric for all other substances.

Gilbert made a sharp distinction between the attraction exercised by amber - what we today would term electrostatic attraction - and magnetic attraction. He further pointed out that amber was not the only substance which, when rubbed, attracted light objects. He also explained that all magnets have a field around them, which affects iron objects close to it. This field he termed 'the orb of virtue.' He was also the first man to put forward the view that terrestrial magnetism and electricity were two linked manifestations of a single force.

These achievements were all the more astonishing when the only magnets available at that time were natural ones, in other words lodestones like the ones illustrated in Figure 2.

They were in fact rare and therefore expensive. Gilbert explained how attaching soft iron pole-pieces to them could increase the strength of pieces of lodestone.

Another feature of Gilbert's book was his establishing the techniques for magnetising steel rods by stroking them with a piece of lodestone. Another of his discoveries was that if iron bars were left lying in the direction of the earth's magnetic field, they slowly became magnetised.

Another of Gilbert's discoveries was that a body's magnetisation can be destroyed by heating it to the point where it becomes red. However, when heated iron cools, it acquires a small intensity of magnetisation in the north-south direction from the earth's magnetic field.

He also established that, even without heating, soft iron became slightly magnetised by the earth's field. This happened either slowly over a number of years, or more rapidly if the sample is hammered.

Gilbert also discovered the screening, or shielding, effect of iron. In his experiment, he found that a sheet of iron could shield the area on one side from the magnetic field of a piece of lodestone on the other.

Gilbert's De Magnete made three distinguished contributions to the advance of science, the first of which '. . . was the ordering and extension of magnetic knowledge, on the basis of experiments originated or verified by himself. The second was the ordering and extension of electrical knowledge, in the same way. The third . . . the greatest, was his conception of the earth itself as a great magnet.' [7]

This last was brilliantly demonstrated by what has come to be considered some of the most telling illustrations in this work, the tellellae.

Having carved his small planets from lodestone, Gilbert then brought them into contact with a wide variety of materials such as wood, water, sundry metals and - of course - slivers of iron representing compass needles.

With the latter, he demonstrated the changing dip of the magnetic needle with latitude, the magnetised iron for example lying horizontal to the Earth's surface at the equator whilst at the poles, the needle is vertical. Thus Gilbert had demonstrated the effect of the Earth's magnetic field, as well as establishing that Norman had indeed been correct in his conclusions regarding the 'dip' of the compass.

So thorough were Gilbert's experiments that few advances would be made in either electricity or magnetism until the laws of the latter were established by Charles-Augustin de Coulomb with his Torsion Balance* in 1785.

Indeed almost half a century later, Gilbert's book still contained almost all the knowledge then current about magnetism. The subject only began to move forward with William Sturgeon's development of the electro-magnet in 1825 and the later, outstanding, work of Michael Faraday, Siméon Poisson, Joseph Henry and James Maxwell.

When the Centimetre-Gram-Second (CGS) system of units of measurement was introduced, towards the end of the nineteenth century, the unit of Magneto Motive Force (MMF) was termed the Gilbert in his honour. It represented the MMF resulting from the passage of $4\pi ab$ amperes through one turn of a coil. The unit is equal to $10/4\pi$, which approximates to 0.795775 ampere-turn.

* See Electronics & Beyond article 'What's In A Name' Part 6, on Page 56, Issue No. 116, 1998.

REFERENCES

1: Armytage, W.H.G. (1973): A Social History of Engineering. Faber & Faber, London. Page 63.
2: Chapman, Sydney (1944): William Gilbert and the Science of His Time. 'Nature,' Vol. 154, No 3900. July 29th, 1944. Page 133.
3: Atherton, W.A. (1984): From Compass to Computer. San Francisco Press Inc., P.O. Box 6800, San Francisco. Page 15
4: Ibid [3], Page 15.
5: Ronan, Colin A. (1983): Cambridge Illustrated History of the World's Science. Cambridge University Press/ Newnes Books. Page 316.
6: Op. Cit. [1], Page 68.
7: Op. Cit. [2], Page 134.

TECHNOLOGY WATCH

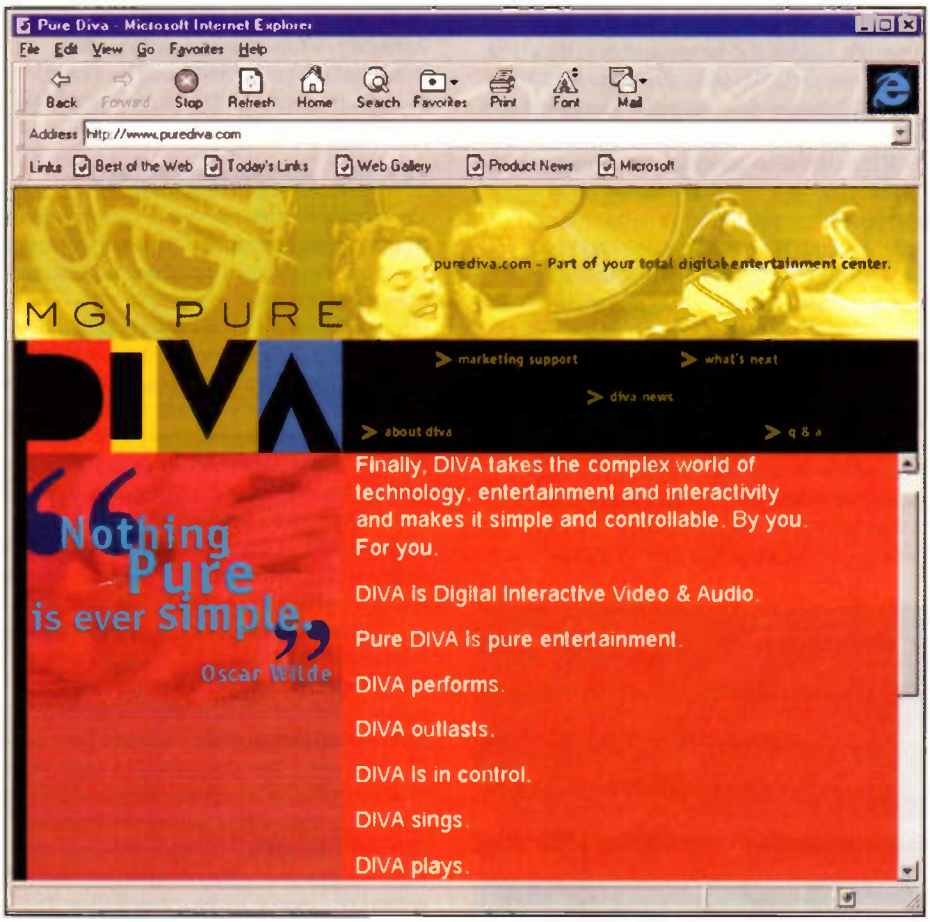
With Martin Pipe

Poor old JVC. For the last 25 years or so, the company has profited substantially from the VHS (Video Helical Scan) standard that it invented. Think of the countless millions of VHS VCRs that have been sold over the years, and then consider that JVC earned a royalty on each and every one.

The spoils are perhaps deserved, because the Japanese Victor Company was victorious in its fight to make VHS the domestic analogue standard over Betamax and V2000. Since then, JVC has recognised the shift towards digital video, and brought VHS kicking and screaming into the digital age. D-VHS recorders are now available in the UK, albeit expensively. In other words, they are not - yet - a mass-market product.

By the time they are, it could be too late. Unfortunately for JVC (and its long-term financial well-being) the rest of the industry is beginning to experiment with alternatives to tape. Indeed, some manufacturers have announced when they plan to stop VHS production entirely. Toshiba, for example, reckons that it will stop making VHS VCRs within ten years. One of the disc-based alternatives is DVD-RAM that we examined in an earlier Technology Watch. Another is hard-disk recording - and this one could make it big. At the moment, some PC suppliers are bundling their Pentium III-based products with MGIs PureDiva, which will allow video sourced from a tuner card to be compressed to MPEG-2 format in real-time, and saved to the hard disk. The software also features a timer for unattended recording. Great from a technology perspective certainly, but PureDiva would - in reality - sing out of tune for most consumers. After all, who wants to leave their PC on when they go out and on their return be forced to watch their favourite programme on a computer monitor?

The remote handset supplied with the Philips TiVo set-top box, which is currently available in the US.



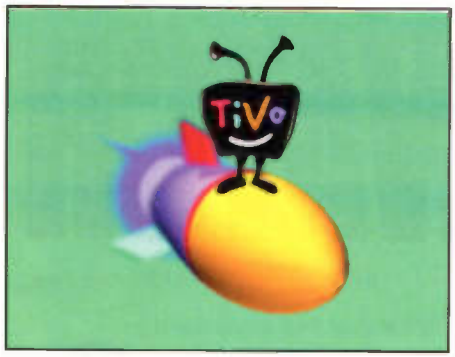
One of the first hard-disk MPEG-2 recorders is the PureDiva system available from MGI. Its currently being bundled with some PCs.

BSkyB/TiVo

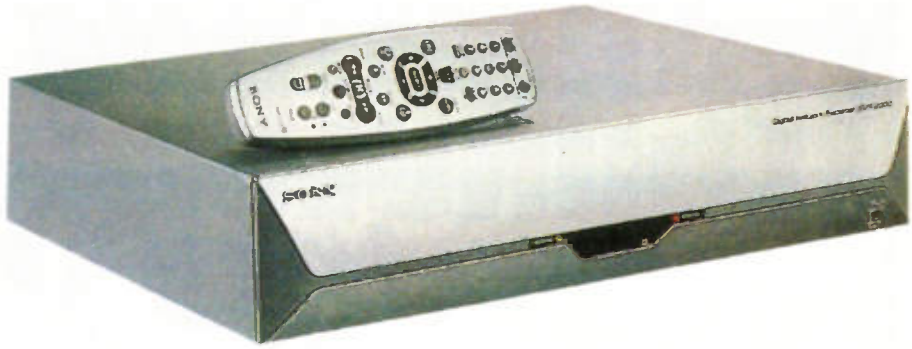
Rather more promising are the steps now being taken by broadcasters. Our own BSkyB recently joined forces with an American company by the name of TiVo, which has developed a friendly user interface. TiVo-equipped set-top boxes are already available in the US, where they've apparently enjoyed a fair degree of commercial success. The idea is that the compressed digital datastreams carrying

JVCs last stand for the VHS medium - Digital VHS. This machine could, however, be used to archive programmes from the set-top box via FireWire.

Alternatives to hard disk recording from Pioneer and Philips. These machines make use of removable, rewritable phase-change media.



Your choice of TiVo logo...



Sony has announced a TiVo-compatible set-top box. And this is what it looks like...

the TV programme are saved straight to a computer-style hard disk drive built into the set-top box. The TiVo system, known as PersonalTV, allows customers to customise their timeshift recordings. The handset supplied with the current Philips boxes features a pair of buttons marked with thumbs up and thumbs down symbols. Viewers use these to set their preferences - in other words, what they like and dislike. The hard disk will then automatically record a personalised schedule of favourite programmes. It's a natural partner for Sky, because there are now so many channels available. Its all too easy to miss a show because you simply weren't aware of it! In the American implementation of TiVo, the set top box makes a nightly phone call to a central computer system so that it can collect up-to-date programme information. For this reason, the TiVo set-top box is equipped with an internal modem. Exactly why this information isn't broadcast over the air is beyond me. Perhaps TiVo gets a cut from any phone revenues (although Americans get free local calls, they have to pay for long-distance ones!). Note that the current generation of Sky Digiboxes incorporate modems too. Interestingly enough, under the terms and conditions of their contract, Sky subscribers have to have their Digiboxes permanently connected to a phone line...

When it's time to watch the programme, you would simply select - via an on-screen menu - the time-shifted programme of interest, and the stream would be played back through the box's digital decoder circuitry (as if it were a live programme) and fed to your TV. Its not known when the Sky/TiVo system will be launched, or indeed how much it will cost. In my opinion it can not come soon enough. None of the current generation of Sky Digiboxes has any sort of timer, and you could hence only timeshift from one channel using your existing VCR. Ironically enough, most of the analogue receivers that Sky wants to upgrade from do have timers that will change channel at a predetermined time. These timers complement the ones fitted into VCRs, and help you make the most of that expensive subscription! No phone calls are involved, either. The first recording set-top boxes will undoubtedly be stand-alone items, but in time we can expect to see hard disk recorders being built into the TV set itself. A hard disk would also improve the flexibility of future Internet TVs, since downloaded information can be saved. Frequently accessed Web pages would be cached, making them appear quickly.

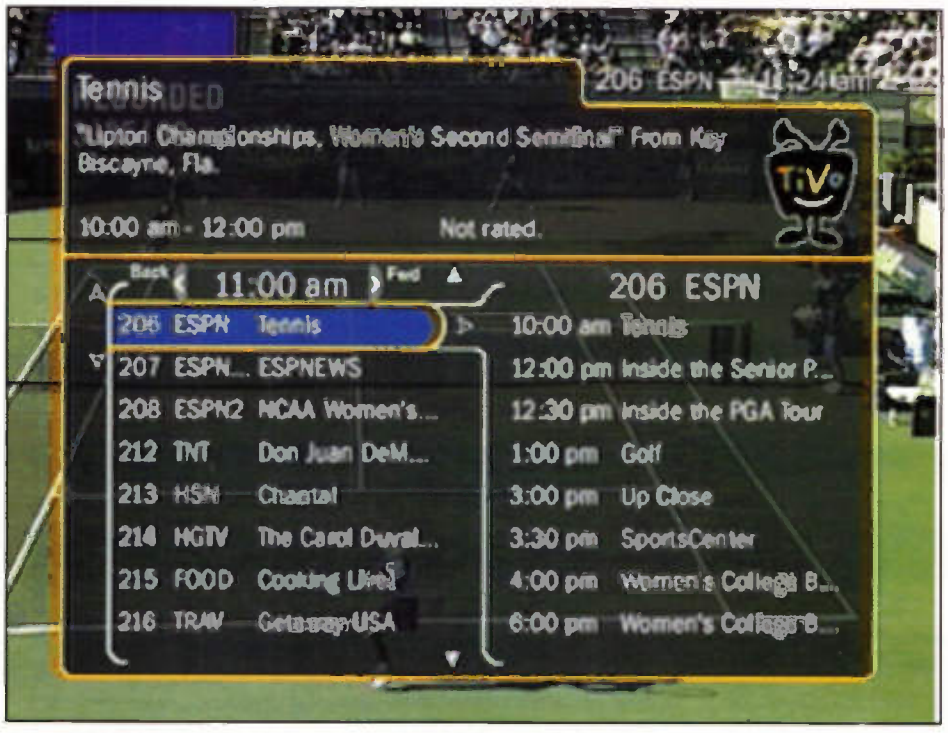
You Run the Show™

Other Advantages?

There's absolutely no loss of quality relative to the original broadcast, because it's exactly the same datastream - nothing added, and nothing taken away. Hard disk recording also opens up another exciting possibility - watching one digital programme while recording another. At present, you have to buy two set-top boxes (and, in most cases, take out two subscriptions) if you want to do this. Unfortunately, it's not quite as easy as that. For a start, the set-top box would need two tuners, because the two programmes in question may be carried via digital multiplexes on different frequencies. Another advantage of hard-disk recording is non-linear playback. Access to programmes will be instant, because there's no tape to fast-forward or rewind. Disk media allows you to 'jump' to a particular recorded section without trouble - witness how easier CD is to use when compared to tape. Hard-disk recording also opens the possibility of noise-free trick-frame and perfect pauses, although the MPEG compression system makes this rather difficult in theory. Still, the boffins do appear to have cracked it. The TiVo system allows viewers to pause any TV broadcast and resume from where they stopped, perform an action replay or play in slow motion.

Disadvantages?

Once that hard disk is full up, programmes will need to be 'deleted' so that space is released for more recording. Then there is the issue of defragmentation - something that none of the manufacturers have talked about. PC users know that if a hard disk is used frequently, the various files get spread out all over the platter, particularly as the drive begins to fill up and the drive seeks out the dwindling resource blank sectors.



Five screenshots of the American implementation of TiVo in use.

Recording set-top boxes would probably be based around high-capacity PC drives, like this 25Gb IBM model

The result is a noticeable drop in data rate. This isn't particularly good news for digital video - even the relatively low-bandwidth MPEG-2. Manufacturers of PC non-linear editing systems recommend a periodic defragmentation, or even reformatting the disk.

Bandwidth Issues

Theres another bandwidth-related issue. Data rates slow down as a hard disk fills up, even if it was defragmented beforehand. This is because theres less data-carrying disk surface area the further you move into the disk. But then again, there might be no need to worry. The equipment might employ some wonderful and efficient new formatting system, rather than the old-fashioned tracks and sectors associated with PCs. Having said that, computer hard disks - capacities of 20Gb or so have been discussed - are likely to be specified, on account of their low price nowadays. Note that the set-top box software will probably have a delete function that simply reformats the hard disk.

With respect to the first issue, there's nothing to stop you from dubbing the programmes you want to keep onto VHS. Simply connect up your VCR to one of the set-top box's Scart sockets. S..ds Law dictates that you will be in a hurry to go out when you discover that the hard disk is full, and you'll have to delete... Even if you do have time to dub, the loss in picture quality (and sound quality, if your VCR is a non hi-fi model) will be obvious... That said, these new set-top boxes might well have FireWire terminals so that you can link up one of the new generation of digital video recorders (DVD-RAM, Digital VHS and so on). Hmmm - it all sounds like exciting stuff. In the States, hard disk recording has reached an advanced stage. Machines from Sony and Sharp - as well as the aforementioned Philips - are available. Their machines offer rather impressive recording times of up to 30 hours. The Sony machine also has a high-quality (9-hour maximum) recording time.

Navigating your way around all this footage, and setting the machine to record it in the first place, could be quite difficult - and that is why electronic programme guides (EPGs) like TiVo are so important. Competing systems include Replay, and Microsofts WebTV. Software (i.e. availability of rental cassettes) helped to determine the outcome of the analogue format wars. Software of a different kind determines ease of use, which will be the biggest influence on the success of hard disk recording, and the system that finally wins.

Hard disks combine low cost with massive storage capacity, but they will eventually go the way of the dinosaur. The home entertainment gear of the future will employ solid-state memory, rather than discs. This consumes less power, is more compact, and more robust - important if you are designing camcorders. Future AV gadgets might not even require wired connections, which is good news for camcorder users. Right now, a new short-range wireless data transmission technology is beginning to make its presence felt. Although the current incarnation of Bluetooth is too slow for high-quality digital video, this will change in time. Imagine a situation whereby you can watch TV programmes and video recordings - or surf the Net - on any TV in the house! Bluetooth, the in-depth subject of a previous Technology Watch, could also allow other consumer appliances to talk to each other. For now, Bluetooth is restricted to rather more mundane tasks, such as synchronising palmtop computers with mobile phones.

Martin Pipe welcomes comments and ideas. E-mail him as: martin@webshop.demon.co.uk Or look out for him online! His ICQ ID is: 15482544

Corrigenda

The Very Long Waves May 2000 (Issue 149)

Due to a publication error, Figure 11 in the first part of 'Very Long Waves' (Issue 149) was incorrectly reproduced. The correct Figure 11 is shown here.

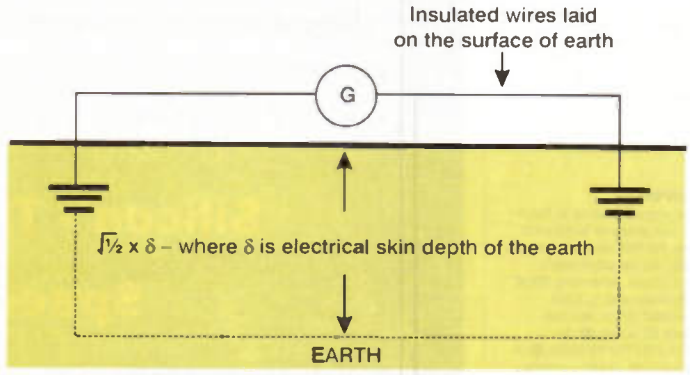


Figure 11. EM induction, the Preece's system - a grounded wire forming a closed loop. Although the earth current is distributed over a volume, the net effect is as if the current were in the form of a vertical filamentous loop. As an energised loop it creates an electromagnetic filed. As a passive loop, it responds to electromagnetic fields and EM waves - current flows through the loop. I offer no explanation as to how a magnetic field causes current flow lines to connect the pair of earth electrodes.

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.

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