

# ELECTRONICS

and Beyond

<http://www.maplin.co.uk>

OCTOBER 2000 NO. 154 £2.65

## Display Search

Cheap mass-produced plastic displays are on the way



## Fantastic Plastic



The disposable electronics age is coming

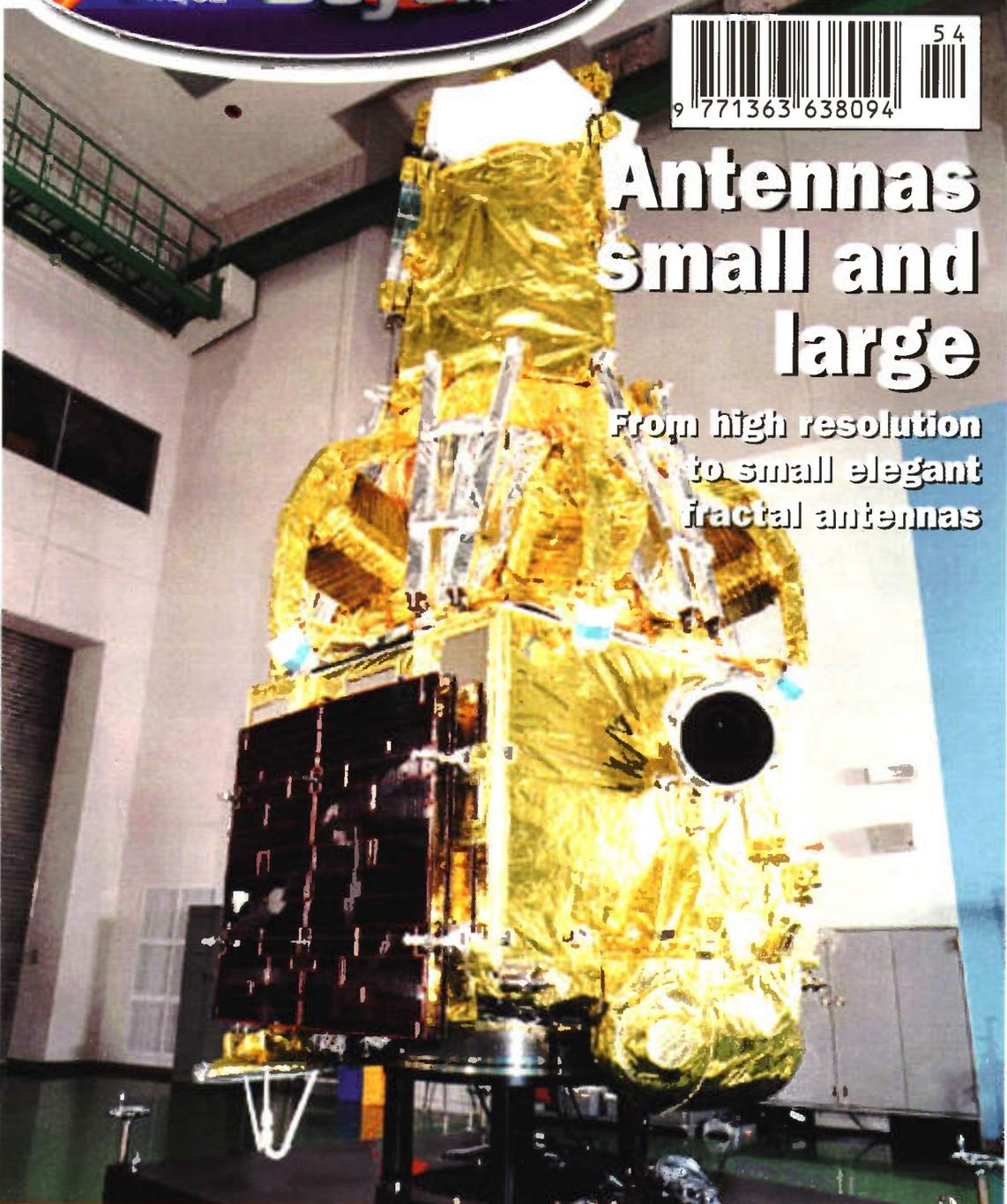
## Wave Power

Energy for free, from the waves at sea



## Antennas small and large

From high resolution to small elegant fractal antennas



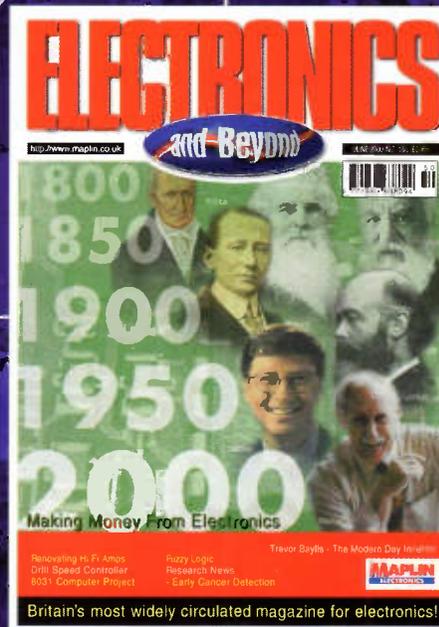
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# THE MAPLIN MAGAZINE ELECTRONICS

October 2000

## and Beyond

Vol. 19 No. 154

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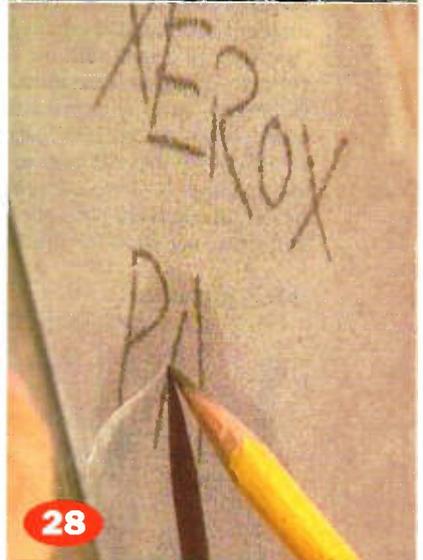
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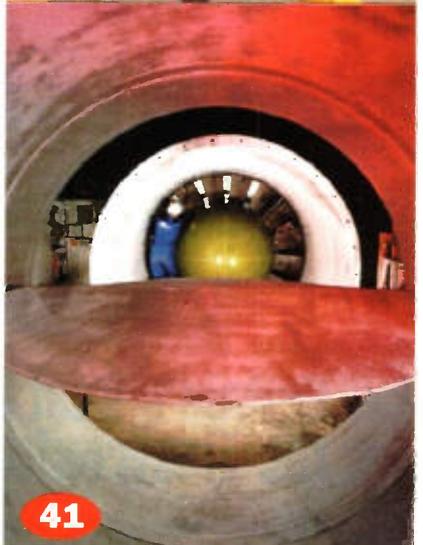
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# ELECTRONICS and Beyond

You may think there are many consumer electronic items that are excellent value for money these days. So much so that some items, like the mobile telephone, has almost become disposable at the end of contractual periods. The way we use electronics will soon change further as we enter a disposable electronics age. Leading the way is the area of Plastic electronics and it is now starting to take one of the front seats in our research activities. Apart from being mechanically forgiving, it could be very cheap to manufacture with the high volumes expected, and its this that could make it disposable. We could see these disposable circuits being introduced onto packaging for the consumer industry. Giving food labels the degree of intelligence could provide information on stock level, condition and whether its needs to be reordered.

We've already covered the concept of Wearable computers and no doubt will feature them again when plastic flexible microprocessors become a truly wearable item. Even a plastic laser has been developed at Bell Labs. No doubt you will want to read more in our 'Plastic articles, this month.

## End of an Era

This will be the last magazine under the banner of Maplin Electronics. The amateur electronics enthusiast industry has changed greatly in recent years and 'Maplin' has moved with the times. However it is certainly not the end to innovative practical ideas in electronics and it is in this area along with all the latest developments that Electronics and Beyond will set its course. We still want to hear your ideas and any applications you have using micro controllers, processors and just plain simple circuits that provide innovative solutions for the 21st Century.

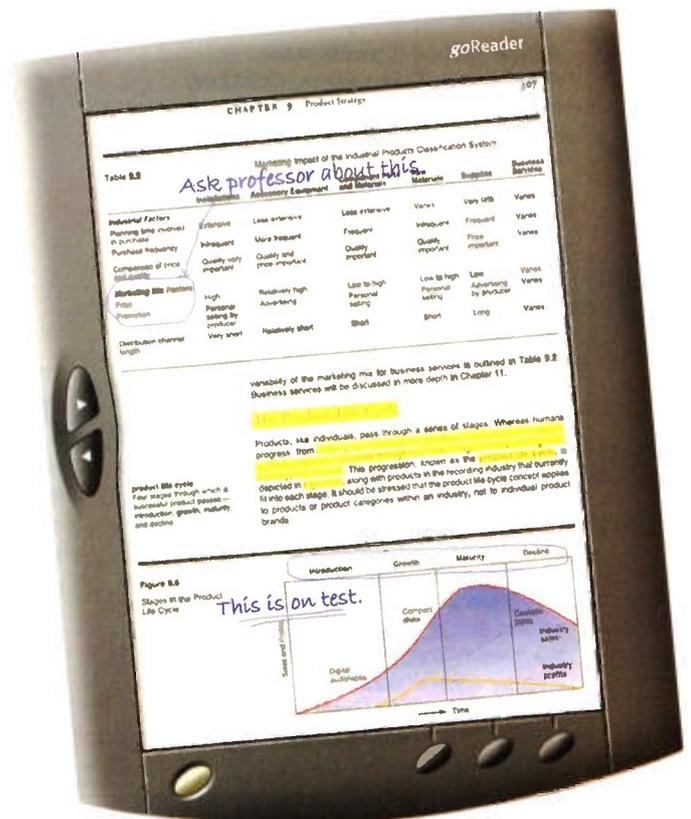
Paul Freeman-Sear



**Britain's Best Magazine for the Electronics Enthusiast**

# NEWS REPORT

## goReader Wins Wind River Cool Customer Design



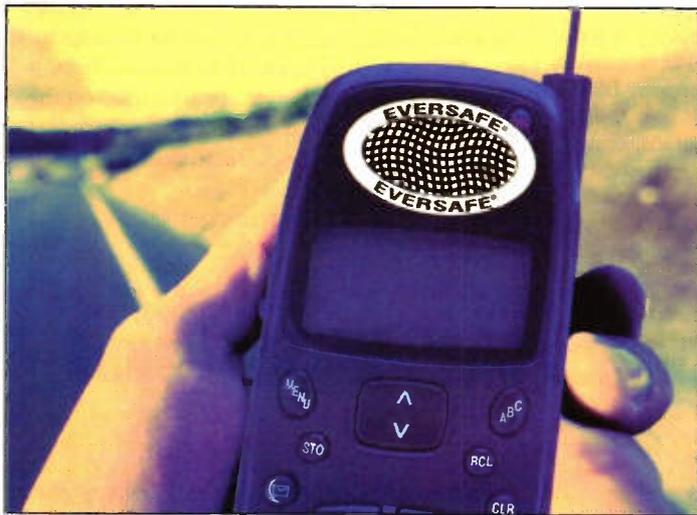
As part of a new, ongoing program designed to recognise cool applications of its embedded software, Wind River has named the e-textbook developed by goReader, a cool customer design.

The goReader e-textbook runs on Wind River's VxWorks real-time operating system and its Java-technology-based

Personal Jworks software, allowing students to download an entire degree's worth of textbooks off the Internet, at a fraction of the cost of buying hard-copy books.

For further details, check: [www.windriver.com](http://www.windriver.com). Contact: Wind River, Tel: (01793) 831831.

## Shielding Mobile Phone Users from Radiation



If you are worried about radiation from a mobile phone, Lone Star Telcom may have just the thing for you. Its Eversafe Radiation Protection Shield is made of electrically conductive nets of weaved carbon, lead, and potassium fibres. The shield has been tested by three independent laboratories and confirmed to intercept up to 99% of radiation emitted by cellular and 900 MHz cordless phones.

For further details, check: [www.eversafeusa.com](http://www.eversafeusa.com).  
Contact: Lone Star Telcom, Tel: +1 888 722 8505.

## Bolton School Races to Victory in Micromouse Grand Prix

Two young engineers from Bolton School have won first prize in a national racing competition for robotic mice. Chris Chisnall and Peter Scott raced to victory in the Formula 1 finals of the Y2K Micromouse Grand Prix.

The competition for 9 to 18 year olds was organised by the Institution of Electrical Engineers (IEE), Europe's largest engineering society. Pupils were challenged to design and build their own 'Micromouse', a small robotic vehicle capable of navigating around circuits and mazes at speed.

The team from Bolton School reached the finals of Y2K Micromouse Grand Prix after successfully winning their regional heats earlier this year with their micromouse called Blip Squeak. For further details, check: [www.iee.org.uk](http://www.iee.org.uk).  
Contact: IEE, Tel: (020) 7240 1871.

## Tiny Launches Broadcast Entertainment from PC



Tiny Computers has launched the first home personal computer package that turns the PC into a home entertainment hub.

The proprietary TinyWave technology allows users to broadcast DVDs from their personal computers to their televisions without cables or wires.

Users can also play music from CDs on their computer and hear it on their stereo system, or incorporate sound from their home stereo systems while they play DVD-based games.

For further details, check: [www.tiny.com](http://www.tiny.com).  
Contact: Tiny, Tel: (0800) 7834575.

## AMD Boosts Battery Life for Notebook Computers

AMD has announced 550 MHz and 533 MHz versions of its Mobile AMD-K6-2+ family of processors featuring its AMD PowerNow! technology. The new processors deliver a combination of high performance and innovative features, while enabling significantly extended battery life for notebook PCs.

AMD PowerNow! technology extends battery life of notebook systems by up to 30%. While competitive offerings require the user to manually select a performance or battery saving mode, AMD's automatic mode delivers performance on demand and optimises power consumption transparently to notebook users.

Hewlett-Packard has selected the AMD-K6-2+ processor featuring AMD PowerNow! technology to power four new models of its HP Pavilion N3300 notebook PCs, with processor speeds ranging from 500 to 550 MHz. The HP systems are shipping now. Other system manufacturers who are offering AMD-K6-2+ notebooks include Compaq, Fujitsu, and NEC.

For further details, check: [www.amd.com](http://www.amd.com).  
Contact: AMD,  
Tel: (01276) 803100.

## Counterfeiters Hotline in Bid to Stop Illegal Software Use

Microsoft has announced an anti-piracy free phone hotline number operated by dedicated anti-piracy consultants based in the UK. The centre will provide a confidential service for callers to report the illegal use of Microsoft software. Microsoft expects the centre to receive over 500 calls a month from individuals blowing the whistle on their former employers or resellers who suspect their competitors of selling illegal software.

For further details, check: [www.microsoft.com](http://www.microsoft.com).  
Contact: Microsoft,  
Tel: (0345) 00 2000.

## ARM Offers Low Cost Evaluation Board

ARM announced the availability of Evaluator-7T, an ARM7 core-based evaluation board that provides a low-cost platform for running benchmarks and testing code prior to full system design. The board, which supports the ARM Thumb instruction set, is available immediately priced around £120.

The ARM7TDMI evaluation board features a Samsung KS32C50100 microcontroller, 512K boot ROM, SRAM, two serial ports, and LEDs for user I/O. It also comes with power supply, and evaluation copy of the ARM Developers Suite (ADS) toolkit, firmware, debug monitor, documentation, and software examples.

For further details, check: [www.arm.com](http://www.arm.com).  
Contact: ARM,  
Tel: (01223) 400400.

## Philips to Double CD-RW Production Capacity

Philips is to double production capacity of CD-RW drives based on growing market demand. The company's optical storage group expects to reach this goal by the end of next year, achieving a total output capability of 20 million units annually.

Experts predict that industry wide shipments of CD-RW drives will exceed 35 million this year, and that media manufacturers will ship more than 3 billion CD-R/RW discs in the same timeframe.

For further details, check: [www.philips.com](http://www.philips.com).  
Contact: Philips,  
Tel: +31 40 272 20 91.

## Meeting CO<sub>2</sub> Targets Could Create 250,000 Jobs

The Potsdam Institute for Climate he sustainable technology sector is a new, exciting and rapidly expanding area of the economy that could create an extra 250,000 jobs within the next ten years. The sector includes energy conservation, renewable energy production, eco-construction, organic growing, development, conservation and ecological restoration.

The Sustainable Careers Handbook is the first careers book in Britain to provide a complete step by step guide to working in this area. School leavers and undergraduates are taken from first thoughts to first job but there is also help for people with established careers who want to work in a more sustainable way.

For further details, check: <[www.cat.org.uk](http://www.cat.org.uk)>.

Contact: Centre for Alternative Technology, Tel: (01654) 702400.

## ntl Opens Radio Communications Centre for London

ntl has opened a new £3 million flagship customer support centre in central London for all its London-based radio communications activities. The 25,000 square foot facility occupies a premium business park location on the South Bank and includes a high-tech Network Management Centre. Among ntl's London customers supported from the centre are the Metropolitan Police, London Fire Brigade, National Crime Squad, HM Customs & Excise and special government services.

For further details, check: <[www.ntl.com](http://www.ntl.com)>.

Contact: ntl, Tel: (0800) 052 1815.

## IBM and Compaq in Storage Pact

IBM and Compaq Computer have formed an alliance to integrate their data storage systems, creating greater ease of use for customers. The plan, which will cost £600 billion over three years, will allow the companies to resell each hardware and software to create data storage solutions.

For further details, check: <[www.ibm.com](http://www.ibm.com)>.

Contact: IBM, Tel: (0990) 426426.

## Engineer Succeeds in Getting Dr Who Story Published

Quantum Electronics production engineer, Peter Grehan, has fulfilled something of a childhood dream by writing a spin-off adventure story based on the popular BBC series 'Dr Who'. His original script was taken up by production company BBV and turned into an audio play.

The story is based around the Sontarans, one of the most popular villains in the series exceeded only by the 'Cybermen' and 'Daleks' in popularity. The script entitled 'Sontarans - Silent Warrior' was released in audio format by BBV in September last

year and is reportedly selling well.

Peter's writing is a far cry from his normal duties as a production engineer at contract manufacturer Quantum Electronics, where he'll normally be found writing assembly instructions used on the shop floor for building customers' products. For further details, check: <[www.quantum-electronics.co.uk](http://www.quantum-electronics.co.uk)>.

Contact: Quantum Electronics, Tel: (01633) 654600.

## Lord Sainsbury Opens Multi-Million Pound CDT Facility



Cambridge Display Technology (CDT) has revealed the next phase of its development as Minister for Science Lord Sainsbury opened the company's new multi-million pound chemistry facility, focused on the development of Light Emitting Polymer (LEP) technology.

LEP technology will form the backbone of a new generation of 'plastic electronics' in the future and is already set to answer the needs of emerging mobile applications, such as mobile phones and personal digital assistants (PDAs).

In June CDT and Seiko-Epson demonstrated the world's first full colour ink-jet printed LEP display, made using red, green and blue polymer materials and an industry first ink-jet printing process developed for the project.

The colour display not only achieves colour quality equal to current liquid crystal display (LCD) technology but will also significantly reduce the manufacturing cost of producing displays required for tomorrow's market in mobile phones and PDAs. Beyond this, CDT expects this

technology to penetrate all other display markets.

The new facility will help CDT drive the development of the technology on a number of fronts. Research and development will focus on extending lifetime and reliability, developing more efficient light emitting structures, designing manufacturable processes and devising effective driving schemes.

LEP displays are expected to be brighter, lower in cost, consume less power, provide wider viewing angles and weigh less than traditional flat panel displays.

They will be ideal for outdoor and emergency lighting conditions and will be capable of operating at extreme temperature variations.

Another advantage of LEPs is that in the future they can be utilised not only on glass but also on flexible substrates, which will position LEP's as the basis for new products such as virtual reality headsets and flexible or formable displays.

For further details, check: <[www.cdt1td.co.uk](http://www.cdt1td.co.uk)>. Contact: CDT, Tel: (01223) 723555.



## Pocket Camcorder Pushes Miniaturisation Limits

Canon has introduced the Elura 2MC, a hybrid digital video camcorder with performance features to meet a variety of still, motion and multimedia image capture needs.

With multiple shooting modes and connectivity options, the Elura 2MC is highly versatile, complementing DV-ready computers, televisions and VCRs for video editing, printing and sharing images.

For further details, check: <[www.canon.com](http://www.canon.com)>.

Contact: Canon, Tel: (020) 8451 3336.



## Voice Recognition Handheld is Compaq



Compaq has added voice recognition to its iPAQ Pocket PC thanks to PocketScript's Speech-Driven Interface. The iPAQ wireless technology enables real-time network connectivity, synchronisation and constant e-mail access.

The iPAQ Pocket PC has the flexibility to transform into any number of devices to enable real-time information access through an expansion system. For further details, check: [www.pocketscript.com](http://www.pocketscript.com). Contact: PocketScript, Tel: +1 513 398 7900.

## Fuji Camera Integrates Hot Technologies

The Fujifilm FinePix 40i Digital Camera is an ultra-compact portable device that combines three of today's most popular mobile platforms - digital imaging, MP3 audio and digital video - into one product. Fujifilm is the first manufacturer to pair MP3 audio technology with a high-resolution digital camera.

Featuring the same Super CCD image sensor found in Fujifilm's FinePix 4700 ZOOM digital camera, the FinePix 40i captures sharp and colorful pictures. It has an equivalent ISO sensitivity of 200, built-in flash, five programmed exposure modes, a USB port for the quick and easy transfer of images and a generously sized 1.8-inch LCD, considering the size of the camera.

Compatible with wafer-thin SmartMedia cards, the removable storage media of choice for many digital camera and portable MP3 player users, the



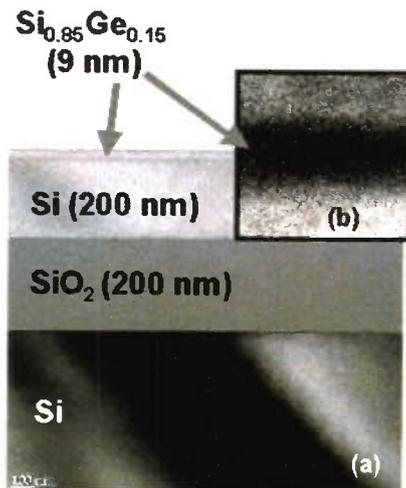
FinePix 40i also can capture 80 seconds of continuous AVI video with sound. For further details, check: [www.fujifilm.com](http://www.fujifilm.com). Contact: PocketScript, Tel: +1 513 398 7900.

## Silicon Genesis Extends Silicon-On-Insulator Technology

Silicon Genesis, developer of unique Silicon-On-Insulator (SOI) wafer technologies, has extended its manufacturing process capability to the fabrication of integral high-mobility silicon-germanium layers in SOI wafers designed to enhance the performance of high-speed logic, communication and fibre-optical components.

In its SOI fabrication facility in California, Silicon Genesis demonstrated its ability to cost-effectively integrate a high-mobility sub-layer of silicon-germanium (SiGe) alloy within the silicon SOI device layer. Such layers are expected to be highly beneficial for high-speed devices by providing carrier paths with higher electrical mobility than pure silicon.

For further details, check: [www.sigen.com](http://www.sigen.com). Contact: Silicon Genesis, Tel: +1 408 871 3939.



## Apple Unveils Optical Mouse and Professional Keyboard

Apple has launched an innovative optical mouse and a sleek new full-size pro keyboard, both of which are housed in stunning, crystal-clear enclosures and come standard with all of Apple's new desktop computers.

Apple's optical mouse provides precise positioning without a mouse pad on almost any surface and features an ergonomic, full surface button and comfortable elliptical shape. The sleek new pro keyboard offers full-size function and navigation keys, volume control and disc eject keys, as well as two USB ports.

For further details, check: [www.apple.com](http://www.apple.com).

Contact: Apple, Tel: (0800) 783 4846.

## Apple Introduces New Colours iMacs

Apple has introduced an entirely new iMac line that starts at around £649 and features four new models in stunning new colors. All four iMac models include Apple's new optical mouse and pro keyboard as standard. The new iMac colors are Indigo, Ruby, Sage and Snow, and join the prized Graphite color in the line.

The new iMac family offers fast PowerPC G3 processors now running at up to 500MHz and larger storage up to 30GB. The iMac DV models also include iMove 2, the next version of Apple's easy-to-use consumer digital video editing software.

For further details, check: [www.apple.com](http://www.apple.com).

Contact: Apple, Tel: (0800) 783 4846.

## Bluetooth Made Legal in France

France's National Agency of Radio Frequencies has lifted a controversial ban on electronic devices containing Bluetooth wireless communications technology. The radio spectrum used by Bluetooth conflicted with the band used for French military communications, which ranges from 2.446 GHz to 2.483 GHz.

For further details, check: [www.bluetooth.com](http://www.bluetooth.com).

Contact: Bluetooth, E-mail: [bluetooth.support@ecs.ericsson.se](mailto:bluetooth.support@ecs.ericsson.se)

## Whirlpool Goes Wireless with Nokia

Nokia and Whirlpool are developing appliances that can be turned off and on via mobile phones or other wireless devices. The companies plan to target European consumers, who are more receptive to the idea of communications networks based on radio links rather than cable.

For further details, check: [www.nokia.com](http://www.nokia.com).

Contact: Nokia, Tel: (020) 7437 4380.

## Microsoft in 'Complicated' situation with Telewest

Microsoft's plans to take a 30% stake in cable company Telewest Communications could be halted, with the publication of a European Union draft decision recommending that the deal be blocked on grounds the investment threatens to inhibit competition in the European digital-television market.

A recent announcement by United Pan-Europe Communications (UPC) that it plans to buy Liberty Media's 25% stake in Telewest, complicates Microsoft's position. Microsoft owns 8% of UPC, in addition to a £3 billion stake in Liberty Media parent AT&T.

For further details, check: [www.microsoft.com](http://www.microsoft.com).

Contact: Microsoft, Tel: (0345) 002000.

## Intermec Launches Mobile Phone and PDA Bar Code

The Intermec Technologies scan engines, which range in size from a sugar cube to smaller than a paper clip, are based on Intermec's miniaturized light emitting diode (LED) technology.

They can be incorporated into personal communications and information devices such as mobile phones and personal digital assistants (PDAs) to allow consumers to use the information power of traditional bar code technology.

Shoppers already are scanning bar codes from household pantry items to create online grocery lists, and retailers are linking product-related bar codes with specific Web addresses. New uses are emerging daily.

For further details, check: [www.intermec.com](http://www.intermec.com).

Contact: Intermec Technologies, Tel: (0118) 923 0800.

## Cadence and Hewlett-Packard in Design Alliance

Cadence and Hewlett-Packard have announced a five-year alliance where they will jointly develop, market, and sell new products and services for the electronic design market.

The two companies said this will enable customers to improve the speed and quality of the design of microprocessors that power computerised devices from mobile phones to Internet appliances and powerful servers.

For further details, check: [www.cadence.com](http://www.cadence.com).

Contact: Cadence, Tel: (01344) 360333.



## Wireless Points Let Users Stay Connected Whilst Roaming



Intermec Technologies has introduced a wireless LAN access point that lets mobile computing clients roam anywhere throughout an enterprise without losing their network connection.

Intermec's 2102 Corporate Access Point operates with industry standard IEEE 802.11b high-rate and OpenAir wireless technologies, supporting up to 11MB per second data rates.

For further details, check: [www.intermec.com](http://www.intermec.com).

Contact: Intermec Technologies, Tel: +1 425 348 2600.

## Applied Materials Announces Unique Capacitor Dielectric



iga-Cap TanOx Centura, is a high-productivity system for the deposition of high k tantalum pentoxide ( $Ta_2O_5$ ) dielectric films in advanced DRAMs developed by Applied Materials.

The system integrates the proven chemical vapor deposition and rapid thermal processing technologies to provide a production-worthy process to enable denser, more powerful memory chips.

The Semiconductor Industry Association defines the need for high k dielectric materials such as  $Ta_2O_5$  to replace currently-used silicon oxides and nitrides in order to continue reducing memory cell size and achieve higher chip densities required for new high performance devices.

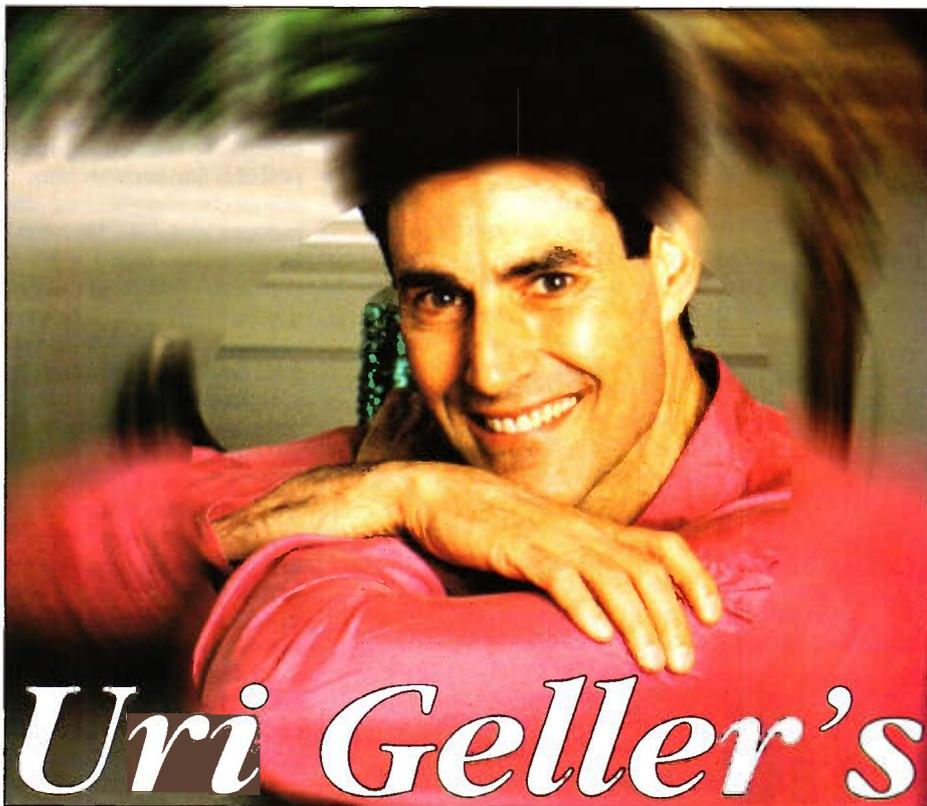
$Ta_2O_5$  allows chipmakers to reduce capacitor dimensions by enabling the storage of the required charge in a

smaller structure.

For further details, check:

[www.appliedmaterials.com](http://www.appliedmaterials.com).

Contact: Applied Materials, Tel: (01403) 222345



# Uri Geller's EXTENDED REALITY

## The Dream Connection

In October 1966 a ten-year old Welsh girl named Erin Jones startled her mother by suddenly announcing "Mummy, I'm afraid to die".

"Why do you talk of dying, and you are so young? Do you want a lollipop?", Mrs Jones replied.

"No," said Erin, "but I shall be with Peter and June" (two of her friends at Pantglas School in Aberfan.) These were her own and her mother's exact words, later written down and signed by both parents.

On 20 October, Erin insisted on telling her mother about a strange dream she had just had. Mrs Jones was busy, but Erin insisted: "No, Mummy, you must listen. I dreamt I went to school and there was no school there. Something black had come down over it.

On 21 October, Erin Jones went off to school as usual. At a quarter past nine an enormous mound of coal came sliding down the hill above the school, and within minutes the school was indeed not there. A total of 128 children and sixteen adults were buried alive. Erin was eventually buried next to Peter and June, probably at her parents' request.

One of those who hurried to the scene at one of the worst civil disasters in British history was psychiatrist Dr J. C. Barker, who came to do what he could for the grief-stricken parents of Aberfan. He was immediately surprised by the number of

people who also seemed to have seen the catastrophe coming. Eventually, after making an appeal in the press, he collected 36 cases in which dreamers seemed to have picked up some of its details, two of them actually named Aberfan as the scene of their dreams. Luckily, several people had described their dreams to others before the tragedy, so Dr Barker felt there was good evidence for premonition at work.

Naturally, there were those who objected that since there are fifty million people in Britain, and up to three or four times that number of dreams dreamt every night. Somebody somewhere is bound to dream about everything going black or a group of Welsh children going up to heaven (as two of Barker's informants did).

However, the traditional belief that dreams can show us glimpses of the future goes back a long way. The ancient Egyptians, Greeks and Romans reported several such dreams, which were usually taken to be messages from the gods, and people are still regularly reporting them today.

Is there any way, you might ask, that we can prove that people really can dream into the future? Can they do it in front of witnesses, in properly controlled conditions? The answer is yes. At the time of the Aberfan tragedy, experiments had been going on for several years in the sleep laboratory of the Maimonides Medical Center in New York, with some very intriguing results.

The dreamers would lie in a cubicle, closely watched by one of the researchers, who would wake them up when their rapid eye movements indicated that they had just had a dream. Meanwhile, another researcher would be concentrating on a photograph or a painting, trying to project the image into the dream. Again and again they found that they could, and in one unusual experiment there were no less than 2,000 participants, members of the audience attending a concert by The Grateful Dead being held some 45 miles from New York.

They were shown a slide of 'The Seven Spinal Chakras', a painting of a man meditating, with a bright halo around his head and vivid colours emanating from the supposed energy centres of his spine. The dreamer, a young Englishman named Malcolm Bessent, described meeting a man "who said he'd invented a way of using solar energy" and "was suspended in mid air". He then specifically mentioned "an energy box and a spinal column". This was just one of sixteen experiments Bessent did, fourteen of which were rated by independent judges as hits.

The Maimonides team noticed a curious thing. Not only was Bessent very good at picking up images being beamed to him, but also he could even receive them before they were sent. So they ran a series of experiments in which pictures were only selected after he had described his dream. One night, he reported "Birds. I just have a feeling that the next target material will be about birds." And so it was - about nothing but all kinds of birds.

One such result can be seen as just another of those coincidences. Yet there were dozens of similar ones in the Maimonides series, which lasted several years and involved several different dreamers, some of them just as successful as Bessent. It can now be said, supported by masses of evidence, that precognitive dreaming has been shown to be possible.

This does not mean, of course, that everything we dream about is going to come true. It does suggest, though, that we should pay more attention to our dreams than we usually do. They may be trying to tell us something important.

Uri Geller's novels *Dead Cold* and *Ella* are published by **Headline** at £5.99.

*Mindmedicine* is published by **Element** at £20. Visit him at [www.uri-geller.com](http://www.uri-geller.com) and e-mail him at [urigeller@compuserve.com](mailto:urigeller@compuserve.com)

This plastic chip, manufactured by Philips, still works after having been bent double

# Electronics GOES PLASTIC

By Mike Bedford

## An Unlikely Material

The dictionary defines a plastic as a synthetic polymeric organic substance that can be given any permanent shape. It goes on to list a number of properties of plastic, one of which is its electrical insulation. As such you'd expect its use in electronic components to be restricted to applications where insulation and dielectric properties are important - e.g. in insulators and as the dielectric in capacitors - and in mechanical components such as boxes where price and weight are more important than electrical properties. And if you look through the current issue of just about any electronic component catalogue, these are exactly the sorts of places you'll find plastics. There are plastic instrument cases; plastic is used as the insulation of wires and

cables; polyester, polycarbonate, polypropylene and polystyrene turn up as the dielectric in capacitors; there are plastic bolts, plastic brackets, plastic connector shells and plastic knobs. By implication, the sorts of places you wouldn't expect to find plastics are in applications where conduction is required. So, for example, you're not likely to find plastic wires, plastic transistors, plastic batteries or plastic ICs. However, if the work currently being carried out in research centres around the world comes to fruition, all this may change and these will be exactly the places you'll find plastic in the future. Yes, electronics is going plastic and progress is more developed than you might think. Partially plastic batteries are already on the market and plastic display screens are not far behind. This is our look at the future of

electronics - a future of plastics rather than of metals and silicon.

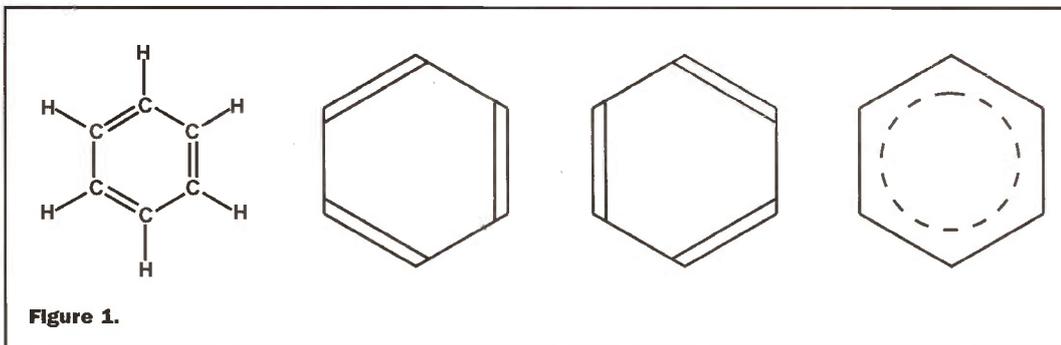
## A Bit of Chemistry

Before we look at any particular plastic components we need to take a step back and think, in general terms, about why metals conduct, why, conventionally, plastics don't conduct, and what can be done to make plastics which will conduct. Now this could all get very heavy so let's forget about energy bands and energy gaps and let's give equations a very wide berth. Just let's take the rather simplistic view that the electrons in a metal are not associated with individual atomic nuclei and are, therefore, free to move within the piece of metal as a whole. Since the flow of an electrical current depends on the movement of electrons, this explains why metals are good conductors of electricity. Plastics are polymers: they have huge molecules which take the form of chains of some repeating group of atoms - the base molecule from which the plastic is made. So, for example, by polymerising the small organic molecule known as urethane, the plastic known as polyurethane is produced. And here the atoms in the molecules are bonded together chemically by a type of chemical bonding which is referred to as covalent. To cut a long story short, this means that the electrons in a block of ordinary plastic are all localised either to individual atomic nuclei or are associated with the individual chemical bonds which hold the atoms together to form the molecules. These bonding electrons are, therefore, associated with a pair of atomic nuclei. And with all the electrons being restricted to specific nuclei or specific chemical bonds, there's no way that electrons can flow through a piece of plastic and, therefore,

no way that an electrical current can flow.

That's the conventional story so what about conducting plastics? First of all let's backtrack to something you're probably familiar with from school chemistry lessons - the benzene molecule. Benzene is a hydrocarbon - that is, it is composed entirely of carbon and hydrogen atoms. However, unlike the linear hydrocarbons - methane, ethane, propane, acetylene and the like - the carbon atoms which make up the molecule's backbone form a ring. In fact, they form a six-membered ring, a structure which crops up very frequently in organic molecules. The first part of Figure 1 shows how six carbon atoms and six hydrogen atoms are joined together to form a benzene molecule. You'll notice that the molecule is depicted as containing alternate single and double bonds. Single bonds contain two electrons, one from each bonded atom, whereas double bonds contain four electrons, two donated from each of the atoms, and are stronger as a result. Normally organic chemists show this structure in the shorthand form which is shown in the second part of Figure 1. In this type of diagram, there's assumed to be a carbon atom at each end of the line (although there are no ends, of course, in a ring) and at each place where the line bends. Atoms other than carbon and hydrogen would be shown, if there were any, and the hydrogen atoms necessary to ensure that each carbon atom has the requisite four bonds are there by implication even though they're not shown. However, this isn't the only way we can think of a benzene molecule - the third part of Figure 1 is another possibility. The fact is that, so long as they're alternate, it just isn't possible to state which of the bonds are single and which are double. Really, both these forms are just convenient ways of showing a benzene molecule and it's more accurate to say that the electrons which make up those six bonds are delocalised around the ring. A benzene ring is, therefore, sometimes depicted as shown in the fourth part of Figure 1.

The large chains which constitute the molecules in a polymer or plastic can also have alternate single and double bonds. Such polymers are



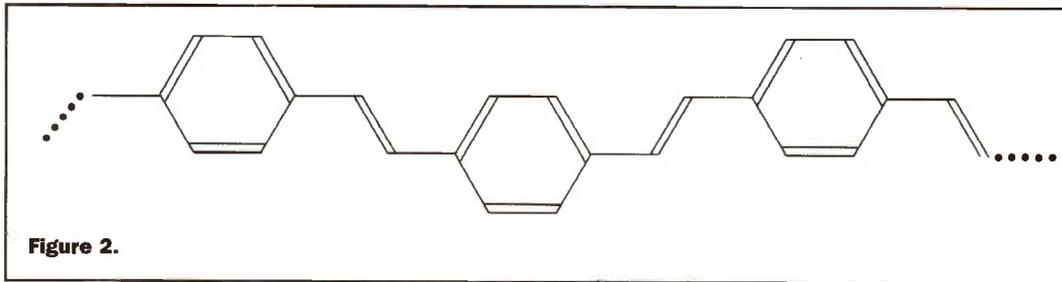


Figure 2.

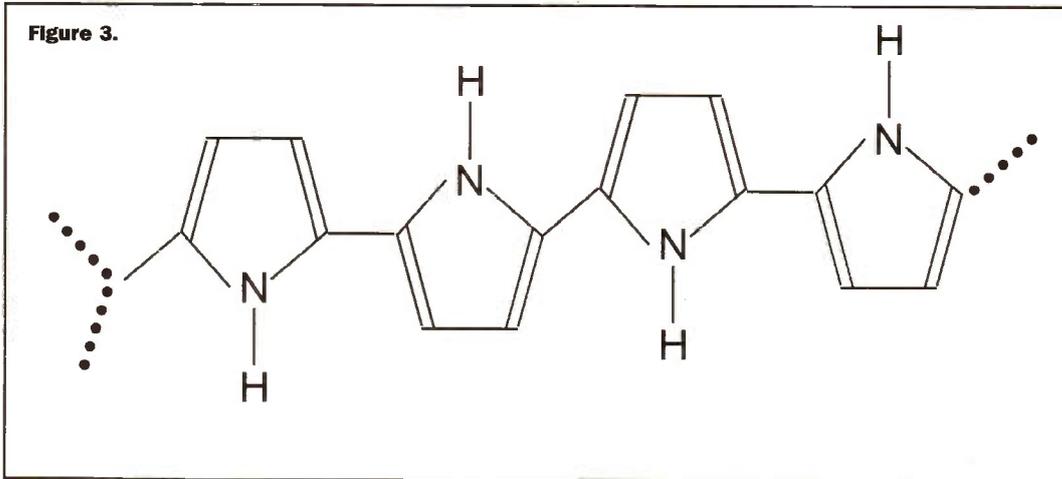


Figure 3.

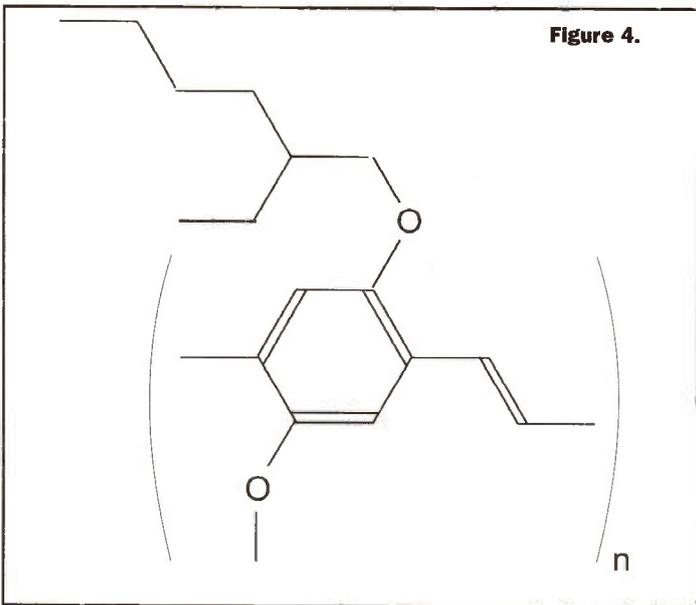


Figure 4.

referred to as conjugated. And by following the same argument we'd have to say that we can't say where the single and double bonds actually occur. In other words the electrons in the bonds which connect together the carbon atoms along the back bone would be free to move along that chain at will. This sounds like a recipe for electrical conduction - along the length of a single molecule, even if not throughout a complete piece of plastic. However, experience suggests that a degree of mobility of electrons from one molecule to another is also possible and that this can be enhanced by causing the molecules to line up with one another rather than being in their normal

spaghetti-like arrangement. In practice, the characteristics of polymers which have this delocalisation of electrons along the chain can be fine tuned to produce the properties either of a conductor, an n-type semiconductor or a p-type semiconductor. And these three types of material, together with conventional plastics as insulators and dielectrics, are all that is needed to form the basis of most types of electronic component. Figures 2 and 3 show a couple of conjugated polymers - PPV or Polyphenylvinylene and PPy or Polypyrrole respectively - and you'll see that the chains have necessary alternate single and double bonds. In fact, these raw polymers tend not to be used,

despite their electrical properties. Instead, side chains are often added to the molecule to make the plastic's properties more suitable. This involves putting more complicated groups in place of some of the hydrogen atoms which, although they're not shown in the shorthand notation used in Figures 2 and 3, are present, nevertheless. This substitution can make the plastic more soluble, an important property if anything useful is to be done with them, it can turn it from a semiconductor to a conductor, it can make it more stable, and it can alter the colour of light produced in polymers used for organic LEDs. In Figure 4 we can see how PPV is modified to produce a soluble, yet still conjugated, polymer. I've drawn PPV in a rather more abbreviated form here than previously but the convention - of showing the repeat group in brackets with an "n" outside the brackets to indicate that it's repeated many times - is quite straightforward. We'll look further at these side chains later.

## Light Emitting Polymers

Since I've now touched on them, plastic LEDs, otherwise known as Light Emitting Polymers or LEPs would make a good starting point for our tour of plastic components. These are especially interesting since,

unlike some of the other plastic components we'll look at, the LEP has escaped from the research labs and is well on its way toward commercialisation.

The construction and operation of an LEP is very simple, at least conceptually. To make an LEP, simply sandwich a piece of suitable semiconducting polymer between positive and negative electrodes. Now apply an electrical current to the electrodes and electrons, injected at the cathode, will combine, within the polymer, with holes injected at the anode. Whenever an electron combines with a hole, a photon, the frequency of which depends on a property of the polymer referred to its band gap, will be emitted.

Accordingly, the device will appear to glow. Practicalities are a bit more involved and issues such as ensuring that one of the electrodes is transparent, and that the electrodes are matched to the polymer in such a way as to ensure efficient electron transfer, have to be addressed. The construction of a typical LEP is shown as Figure 5. As in this example, PPV has formed the basis of most practical LEPs and researchers have shown that, by varying the groupings attached to the side chains, the band gap can be altered. This provides a way of fine tuning the frequency or wavelength of the light, that is its colour. In Figure 6, the various positions, R1 to R6, at which the addition of side chains can be used to alter the light colour are indicated. Figure 7 shows the spectra of LEPs produced using PPV derivatives with substitutions at four of these positions. Scientists at the University of Rochester have gone one stage further in producing a single device which can emit light throughout a range of colours depending on how it's driven. Specifically, colours from red to blue can be produced by varying the voltage applied to the polymer. Clearly such a device would be very attractive as the active element in display screens since it would no longer be necessary to arrange for a pattern of devices, each responsible for one primary colour, to be arrayed across the screen. The team have also talked about the possibility of using LEPs as light sources as opposed to indicators. This is starting to happen already with inorganic

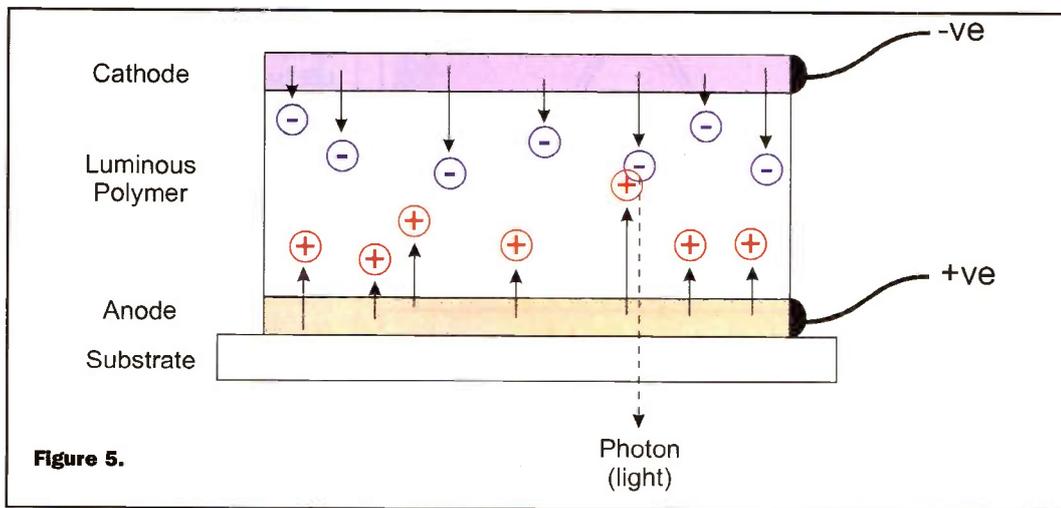


Figure 5.

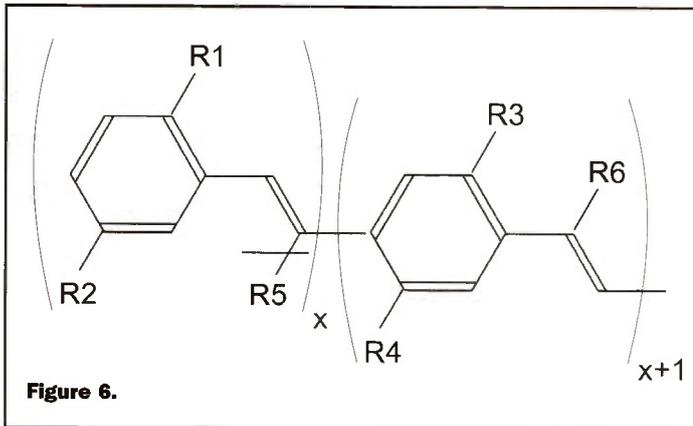


Figure 6.

LEDs - you can buy cycle lamps and head-mounted lamps for cavers based on LEDs, for example. However, the introduction of organic LEDs will hasten this trend due to the massive cost reduction on offer. And because LEPs can be produced as huge sheets whereas inorganic LEDs are severely limited in their size, we might even see the introduction of diffuse lighting sources such as the domestic lighting panels which have been predicted by futurologists since the fifties.

In the nearer future, though, both Philips and Cambridge Display Technology Ltd. (CDT) are in the process of bringing single colour devices to market. Efficiencies are good, exceeding that of incandescent bulbs and approaching that of the best inorganic LEDs. Devices with a range of colours from the near infra red to purple (and white by mixing) have been demonstrated. Large panels have been produced for back-lighting displays but a major aim of CDT is to produce a flat panel display which will compete with today's LCD screens. The company has joined forces with inkjet printer company Seiko-Epson to develop a method by which the necessary pattern of red, green

and blue LEPs can be printed onto the surface of a transparent plastic substrate. The resultant screens will be much thinner and lighter than conventional screens, they'll be much more efficient, they'll exhibit a wide 180° viewing angle. Furthermore, the individual LEPs will have a fast switching time, thereby permitting full motion video to be displayed. There's also the tantalising possibility of a rollable screen too.

## Plastic Transistors & ICs

We've seen that it's possible to make plastics which are insulating, conducting or semiconducting so it will come as no surprise that all-plastic transistors or ICs can be fabricated. So, although it would be superfluous to describe, in detail, how plastic transistors work - after all it's much the same as the way silicon ones work - it would be interesting to take a look at the manufacturing process. As we'll see, this is a much less demanding operation than that required to produce silicon chips. We'll look here at the steps necessary to produce a MOSFET-type device (not an actual MOSFET, of course, since it contains neither metal oxide nor silicon) and you'll notice that, unlike the case with a silicon device, the need for etching is removed.

The transistor is manufactured on an insulating plastic substrate, such as polyimide, onto which a layer of conducting polymer,

polyaniline (PANI) for example, is deposited to form the two bottom electrodes - the source and the drain. Typically, the PANI will be applied from solution using a technique called spin coating. This involves a drop of the polymer, in solution, being allowed to fall on the substrate which is rotating rapidly. Centrifugal forces cause the solution to spread out over the surface of the substrate after which the solvent evaporates leaving a thin layer of the polymer, a few nano-metres thick. Typically, in the case of an electron layer in a transistor, a 200nm layer is used. The PANI solution used also contains a so-called photo-initiator which is key to the next step. The electrode layer is now irradiated with ultra violet light through a mask which defines the shapes of the first two electrodes - the source and the drain. The presence of the photo-initiator causes the resistance of the irradiated areas to increase, by a factor of  $10^{10}$ , thereby turning it into an insulator. The non-irradiated areas - the electrodes - remain conductive. Heating then causes the remaining photo-initiator to evaporate. A 20nm layer of semi-conducting plastic, poly (2,5-thienylene vinylene) (PTV), and a 250nm layer of the insulating polymer polyvinylpyrrolidone (PVP) are now deposited, once again by spin-coating. Finally another 200nm layer of PANI, together with the photo-initiator, is added and this is irradiated to form the third electrode, the gate, in the same way that the first two electrodes were produced. Figure 8 shows summarise of the key steps in

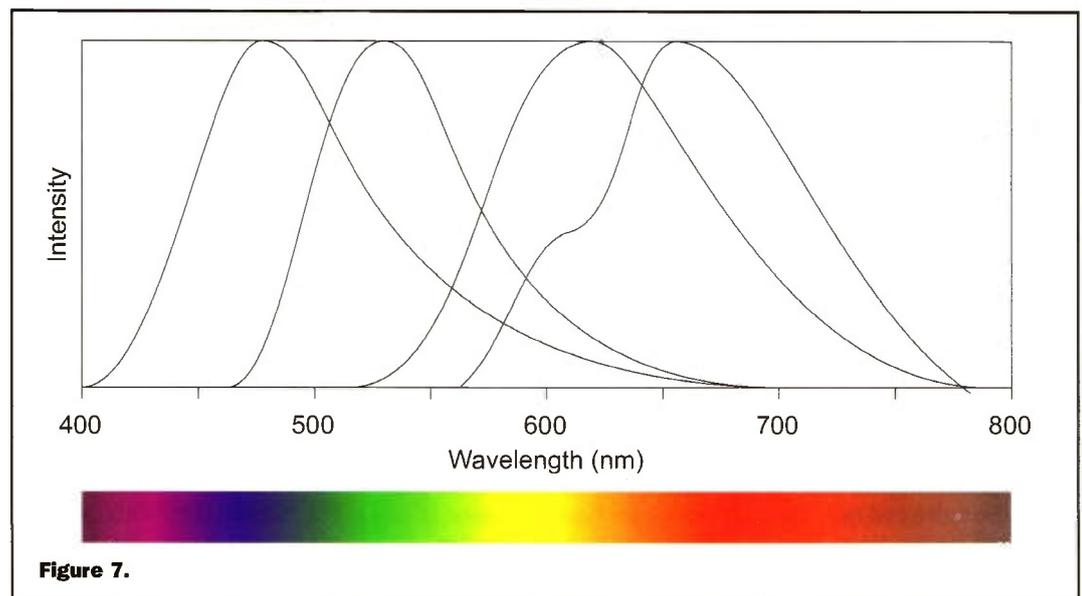


Figure 7.

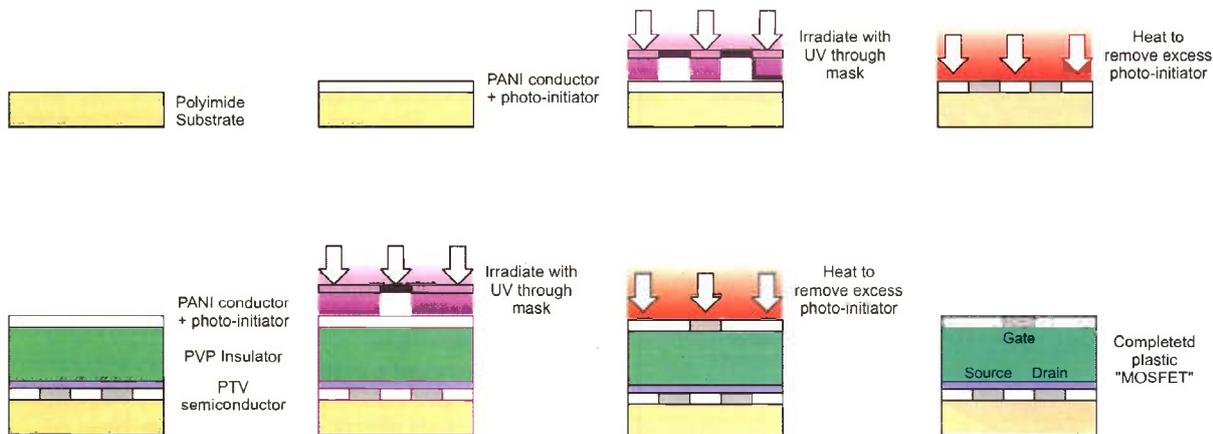


Figure 8.

this process.

So plastic transistors and plastic ICs are easy to make but what of their electronic properties - how do they compare to the equivalent silicon devices from a performance perspective? The bad news is that, so far, they suffer by comparison in a number of important respects. Specifically the minimum feature size is much greater than that achievable with silicon, the electron mobility is lower, and the resistance of the conducting layers is greater than that of the aluminium or copper used in conventional ICs. The lower electron mobility results in a longer switching time and hence a lower maximum clock speed; the higher resistance will result in much greater heat dissipation. Clearly this would marginalise plastic technology for applications like microprocessors. However, we mustn't lose sight of the fact that this is still very early days for the plastic transistor so improvements are likely to be rapid. And even if the problems of low electron mobility and high resistance cannot be overcome, making the technology unsuitable for high performance components, there are many other applications which require lower performance but for which the ease of manufacture and low price of plastic electronics will be the primary driving factor.

## Plastic Batteries

If you use portable electronic equipment such as laptops, mobile phones and camcorders, you can't fail to have noticed the rapid developments in battery technology which has taken place over the last few years. NiCds have been replaced by NiMH batteries to

address environmental concerns about the toxicity of cadmium, and these are now in the process of being replaced by Lithium-ion batteries (Li-ion) in order to give a higher energy density. However, work is in progress to bring us plastic batteries with a correspondingly higher energy density in terms of Watt hours per litre and Watt hours per kilogram. And whereas the completely plastic battery is still in the research labs, a half-way solution, namely the lithium polymer battery is already on the market. Although the battery's electrodes use inorganic materials, the breakthrough is the use of a specially formulated polymer which acts as a solid electrolyte. Claimed advantages include ease of manufacture, low cost, ruggedness and safety compared to the lithium-ion battery's highly flammable liquid electrolyte. The lithium polymer battery is also extremely thin giving rise to a wide range of possible form factors. It can be rolled up to produce conventional cylindrical batteries, it can be folded in a zigzag manner to give prismatic batteries, or it can be used unfolded thereby giving a large but extremely thin battery which, for example, could be housed in the lid of a laptop PC.

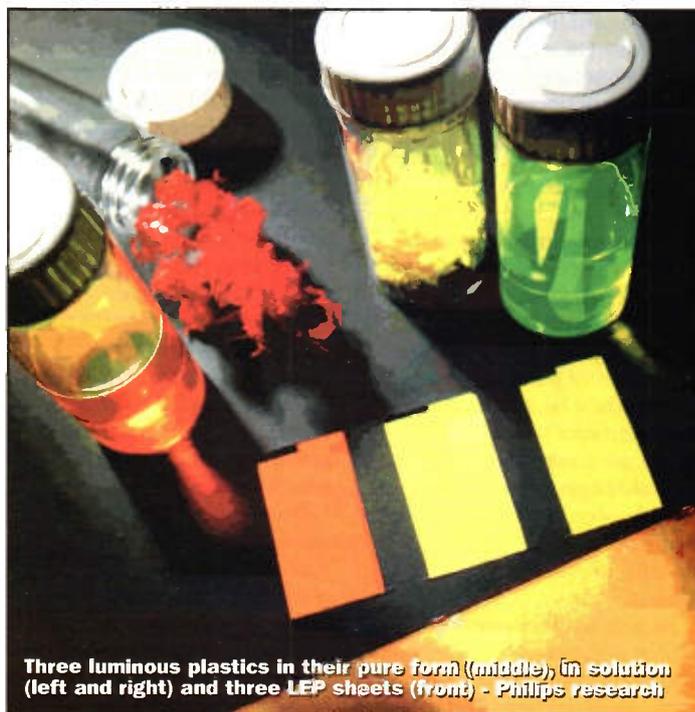
However, what's far more interesting than the lithium polymer battery is the concept of the all plastic battery, something which has been developed by researchers at Johns Hopkins University in Maryland. In a conventional battery, the potential generated is a result of the difference in energy between the two metals which form the anode and the cathode. The difficulty which had to be overcome to develop the all-plastic battery was that

most conductive polymers tend to have approximately the same energy as each other. Exactly how this was overcome is unclear - clearly they're holding this one close to their chests - and the chances are that most of us wouldn't properly understand if full chemical details of the polymers were provided. However, indications are that conductive polymers called fluorophenylthiophenes are used as the electrodes and that a single cell can generate a potential of around 2.5V. The arrangement of the Johns Hopkins all-plastic battery is shown in Figure 9.

## Plastic Photocells

We started off our tour of plastic components by looking at LEPs - polymer devices which convert electricity into light. To round off our brief look at

what's been done with plastics, let's take a quick look at a device which does the opposite, that is one which converts light to electricity. These photocells or, more accurately, photovoltaic diodes, work in much the same way as LEPs in reverse. So when the semiconducting polymer is subjected to light with energy greater than the band gap, a separation of charges takes place. This results in an electrical potential being developed between the electrodes and permits a current to flow when a load is applied. However, a device with the same structure as an LEP would not operate in this way and, for reasons I don't intend to get embroiled in here, two different polymers with different electron affinities are required. One of the most successful photovoltaic diodes has been produced using



Three luminous plastics in their pure form (middle), in solution (left and right) and three LEP sheets (front) - Philips research

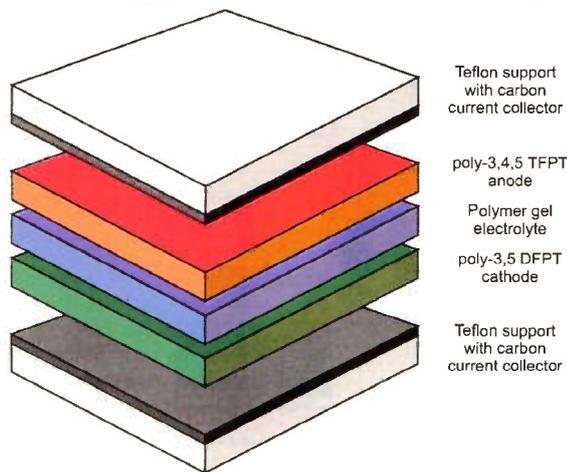


Figure 9.

cyano-PPV (CN-PPV) and another PPV derivative called MEH-PPV. Unlike the case with organic LEDs, though, it is still early days for organic photocells. Although a high terminal voltage of 2V has been developed, a significant amount of improvement will be necessary before the efficiency reaches that of equivalent inorganic devices.

## But Why Plastic?

So we've seen that many types of electronic components have already been made entirely out of plastic and researchers will, no doubt, produce many others. Just because something is possible, though, it doesn't necessarily mean that there's a good reason to do it. So why are so many people getting so excited about the prospect of all plastic components? What advantages are on offer compared to making components out of conventional inorganic materials? OK we have seen some advantages of particular plastic components over their regular counterparts - for example we've seen that some plastic LEDs are colour-tunable - and there are, no doubt, many other advantages of specific devices. What I want to address here is a more general question, though. Forgetting any specific unique properties of particular devices, why might it be a good thing for electronics to go plastic? There are a number of reasons and, although a few have already been hinted at, it will be useful to sum up the benefits of plastic components here.

Benefit number one is cost. Silicon is expensive to purify and to process. Plastic, on the other hand, is cheap and the

printing and other processes used to create components out of conducting polymers are much less costly than the etching processes used in manufacturing traditional silicon chips. And the difference in cost is really very significant. In general, some cost reductions brought about by a new process or a new technique simply results in the price of certain commodities decreasing. On other occasions, a dramatic reduction in cost will make possible something which was previously out of the question. Pundits suggest that the cost reduction associated with plastic electronics will be a case in point. Philips, for example, are talking about a time, perhaps not too far in the future, in which chips will be incorporated into the packaging of groceries. Rather than having to scan each item as it goes through the checkout, therefore, RF scanners will read the identity of all the items in a trolley as it's pushed through the checkout. There's also talk of intelligence in the kitchen which will read the goods' packaging to warn you when they have passed their "best before" date, and to automatically re-order goods as the intelligent bin recognises that you've thrown away a particular wrapper. This is just a single example but, in a phrase, the promise of the plastic revolution is electronics everywhere.

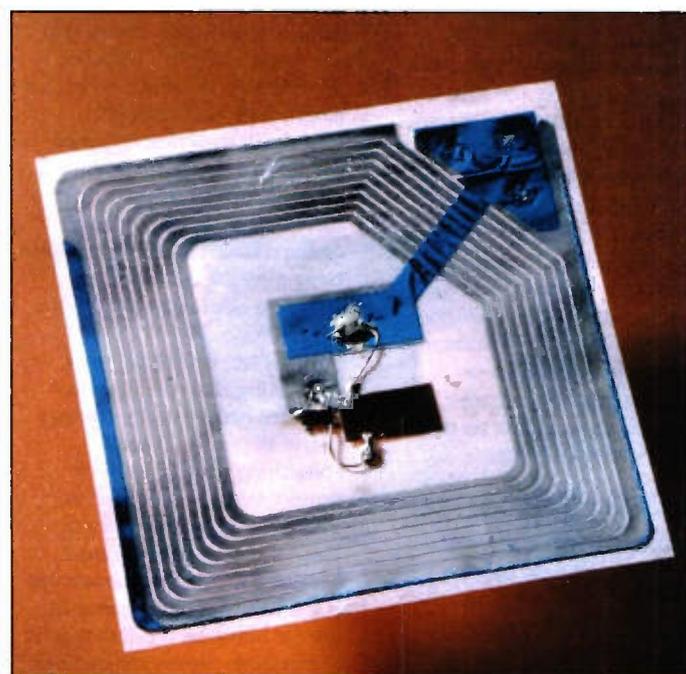
Benefit number two is durability. A circuit made of conducting and semiconducting plastics printed onto a plastic substrate will withstand any amount of rough handling. Plastic circuits will survive being dropped and they've

been shown to continue to work even after having been bent double. And with the trend toward pervasive communication and computing facilities gaining pace, ever more durable electronics will be paramount. Plastic is also lighter than metal and the weight difference is likely to be most pronounced in batteries - traditionally heavy components - than elsewhere. Lighter batteries could well be important on-board spacecraft and may also give a boost to the much vaunted electric car. And although there are undoubtedly others, the final benefit of this new technology that I want to mention here is that, unlike silicon which, in its crystalline form, is brittle, most plastics are flexible. This could give rise to a whole range of intriguing developments from roll-up TV and laptop screens to circuitry which can be incorporated into clothing for truly go-anywhere electronics.

## The Future's Plastic... or is it?

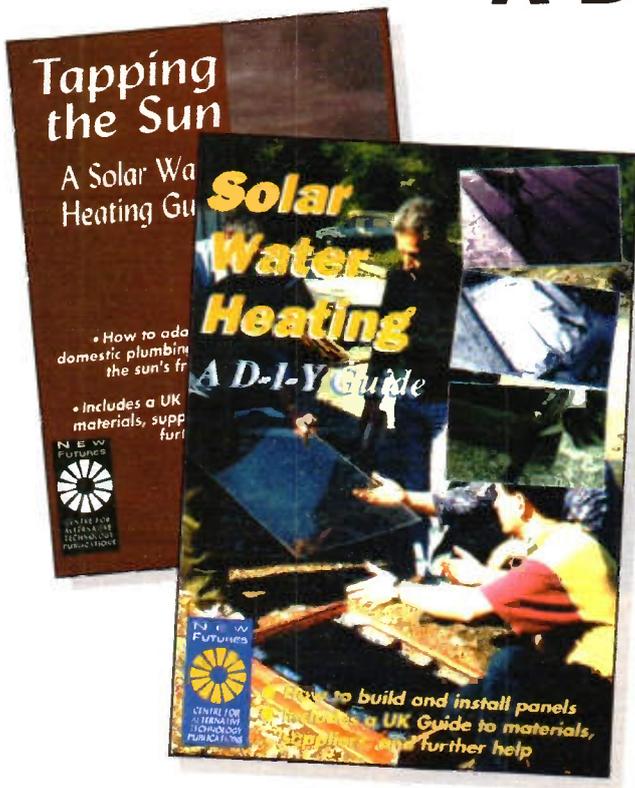
Not long ago, had a feature on plastic electronics appeared in an April issue of *Electronics & Beyond*, many readers would have assumed it was a spoof article. Today, although plastic components haven't yet reached the mass market, this is big news. Yes, there's a lot of hype, there's a lot of talking of brave new worlds made possible by this new

technology, but there's also substance to some of these predictions. As we've seen, just about any electronic components can be made from plastic and although, in some areas, the performance is still some way short of that of conventional components, this is still early days for plastic electronics. In all probability, advances will continue to come thick and fast and there's every possibility that a day will come when plastic will be able to compete with silicon for performance too. Not that plastic is lagging behind traditional components in all areas - in opto-electronics, for example, plastics seem to offer a win-win situation. Not only do LEPs offer all the inherent advantages of plastic - polymer screens are also brighter and more efficient than standard LCD screens. It's all too easy to make rash predictions when writing about new developments but, as we all know, many scientific discoveries come to nothing. So is plastic the shape of things to come or just a flash in the pan? I can end in no other way than with that time honoured cliché - watch this space.



Philips believe that the plastic revolution will mean that electronics will turn up everywhere. This plastic circuit is an RF tag for grocery packaging. The coil is the RF circuitry, the black area in the middle is the chip - Philips research

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# Windpower Workshop

by Hugh Piggott

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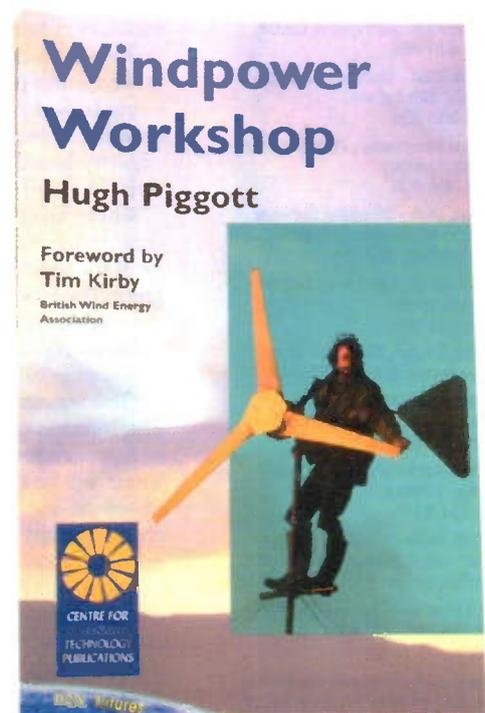
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## **About the author**

Hugh Piggott has taught many courses and written a best selling book called Scrapyard and Windpower. He runs his own company, Scoraig Wind Electric, has made and installed hundreds of turbines and generators, and is a consultant to several wind turbine manufacturers.



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.

## September 2000

**3 to 5 Sept.** European Computer Trade Show (ECTS), Olympia, London. Tel: (0208) 742 2828.

**10 to 13 Sept.** PLASA - Light & Sound Trade Show, Earls Court, London. Tel: (0207) 244 6433.

**13 to 14 Sept.** OnBoard - Electronics Assembly Exhibition, Olympia, London. Tel: (01799) 528 292.

**13 to 14 Sept.** ECIF - Electronic Components Industries Fair, Olympia, London. Tel: (01799) 528 292.

**17 Sept.** National Vintage Communications Fair, NEC, Birmingham. Tel: (01392) 411 565.

**19 to 20 Sept.** Call Centre Expo, NEC, Birmingham, Miller Freeman. Tel: (0208) 742 2828.

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

**22 to 23 Sept.** Leicester Amateur Radio Show, Donington Exhibition Centre, Derby. Tel: (01455) 823 344.

**26 to 27 Sept.** Business Systems Show G-MEX Centre, Manchester. Tel: (07000) 464 336.

**26 to 28 Sept.** GIS - Geographic Information Systems Exhibition, Earls Court, London. Tel: (0208) 742 2828.

**27 to 28 Sept.** Communications for Business, Barbican Centre, London. Tel: 01923 676 867.

## October 2000

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

**4 to 5 Oct.** Softworld Accounting & Finance, NEC, Birmingham. Tel: (0208) 541 5040.

**9 to 11 Oct.** TMA33 - Telecommunications Managers Association Exhibition, Stakis, Metropole, Brighton. Tel: (01372) 361 000.

**11 to 12 Oct.** SIF - Small Business IT Show, Bournemouth International Centre. Tel: (01934) 420 365.

**11 to 12 Oct.** TEST - Electronic Testing Exhibition, NEC, Birmingham. Tel: (02476) 230 333.

**11 to 12 Oct.** Webmaster - Web & Internet Show Olympia, London. Tel: (01256) 384 000.

**11 to 12 Oct.** JAVA - Computer Software Trade Exhibition & Conference, Olympia, London. Tel: (01256) 384 000.

**15 Oct.** National Vintage Communications Fair, NEC, Birmingham. Tel: (01392) 411 565.

**17 to 18 Oct.** Property Computer Show, Barbican Centre, London. 01273 836 800.

**18 to 19 Oct.** PHOTONEX/FIBRE EXHIBITION, NAC, Stoneleigh, Coventry. 01932 866 766.

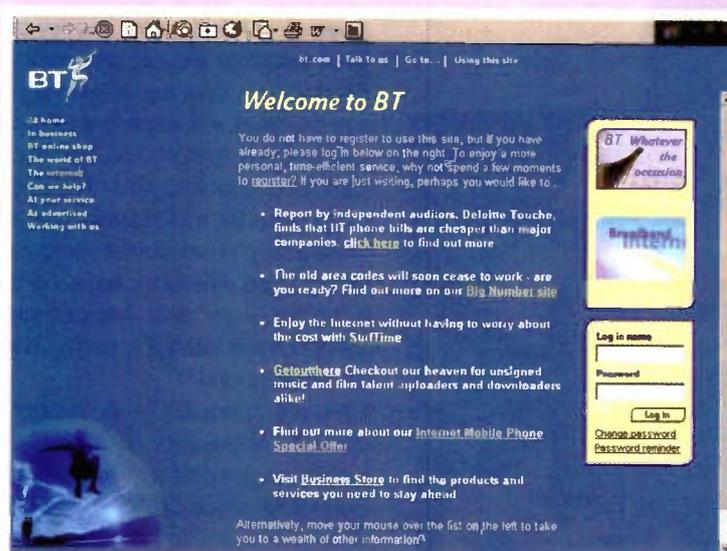
**25 to 26 Oct.** Accounting IT, Business Design Centre, London. Tel: (0207) 221 1155.

**24 to 25 Oct.** OSPMA FieldComms - Industrial Networking Show, Telford International Centre. Tel: (0207) 417 7400.

**31 Oct to 2 Nov.** Voice Europe Olympia, London. Tel: (01244) 378 888.

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?



## Business Culture Must Evolve With Technology, Says BT's Bonfield

BT's chief executive, Sir Peter Bonfield, has called for a shift in business culture to enable Britain to exploit fully the benefits of Internet-based communications technology.

Speaking to an audience of business leaders at the Digital Britain Summit in London in July, Sir Peter said, "We need to realise that this is more than just a change in technology. Looking at the technological side, digital Britain is certainly taking shape. But we also have to make a psychological change."

He emphasised that, taken together, a shift in business culture combined with full use of new technologies can transform the outlook for business and public institutions. "The changes being brought about by the Internet, by mobile communications, and by high-speed, high-capacity, broadband services are irreversible ones," he said.

While the communications revolution will create winners and losers over the next few years, Sir Peter rejected the notion that there was a great divide between the so-called dot coms and the traditional companies. "The divide is simply between those who use the Internet to create sustainable value, and those who don't," he said.

"The winners are not all trendy new start-ups. The Internet can mean success for Tesco as much as Amazon; for WH Smith as much as Excite. The losers will be the businesses that miss the chance to sell on-line; the businesses that miss the chance to buy on-line; and the businesses that miss the chance to reach new markets on-line."

The technology - the hardware, software, networks and applications - are already well advanced, with a new Internet user coming on line in the UK every 10 seconds and a new mobile phone user every three seconds. Announced just a month ago, BTopenworld, the mass-market broadband portal delivered via ADSL, already has

more than 77,000 advance orders.

But in itself, technology is not enough to transform competitiveness and the outlook for national prosperity. Digital Britain has to be a place of ubiquitous and imaginative Internet activity.

"Some of the biggest obstacles to these changes are not physical ones at all - they are in our minds," Sir Peter said, adding that in the new economy speed and flexibility are vital to a company's success.

Sir Peter said: "A big part of it is giving people responsibility - saying to people 'this is your project, you own it, now you go and

do it'. The other important thing is to get people talking to each other.

"In any organisation there is a pool of expertise - product knowledge, market knowledge, customer knowledge, process knowledge. We have to find ways in which individuals can share the knowledge from that pool.

"The new economy demands not only open markets so we can trade competitively; not only open systems so we can interconnect; but open minds - so we can genuinely 'think out of the box'." For further details, check: <[www.bt.com](http://www.bt.com)>. Contact: BT, Tel: (0800) 800150

## Byers Launches Package for UK Science and Innovation

Some of the world's top scientists are to be paid up to £100,000 a year from a special fund so the UK can attract the best academics to work in this country. The move would help deliver scientific brain gain.

It is part of a comprehensive package of measures to keep the UK in the vanguard of world science unveiled by Trade and Industry Secretary Stephen Byers in July.

The measures were outlined in the Science and Innovation White Paper Excellence and Opportunity - a science and innovation policy for the 21st century published last month. It sets out proposals which would mean:

- Closer links between universities, businesses and industry;
- greater exploitation of science, bringing greater wealth and innovation;
- and builds on the £1 billion of Government investment in world class infrastructure.

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



## Garage.com Launches Bootcamp for European Start-ups

Garage.com, an online venture capital company that helps entrepreneurs and investors create, build and fund promising early-stage technology companies, announced it will present Bootcamp for Start-ups on 4 to 5 September at the Royal Lancaster Hotel in Hyde Park, London.

Garage.com's Bootcamp for Start-ups is a series of two-day conferences designed to prepare entrepreneurs worldwide to start and grow new high tech businesses. At Garage.com's Bootcamp for Start-ups, high tech industry experts provide valuable information about raising capital, hiring top talent, building buzz and launching a product.

"European companies are leading the way in developing cutting-edge technologies, especially in the wireless and communications markets. Bootcamp for Start-ups provides European entrepreneurs an excellent opportunity to learn about the challenges they'll face as they build their businesses," said Garage.com boss Guy Kawasaki.

Katia Verresen, managing director of Garage.com in Europe, added, "The speakers at Garage.com's Bootcamp for Start-ups Europe are start-up experts who will specifically address issues that European entrepreneurs will encounter as they build their start-ups. The information from Bootcamp for Start-ups is invaluable to any early-stage European high tech entrepreneur." For further details, check:

<[www.garage.com/bootcamp](http://www.garage.com/bootcamp)>.

Contact: Garage.com, Tel: +1 650 470 0950.

## Minister Reassures Jodrell Bank Scientists on Future Funding

Science Minister Lord Sainsbury issued a statement this month in a bid to reassure scientists at the Jodrell Bank radio telescope on the facility's future, following media speculation around the UK's participation in the European Southern Observatory (ESO).

"The Particle Physics and Astronomy Research Council (PPARC) has reassured me that it has no plans to close Jodrell Bank," said Sainsbury.

"No decision has been taken by the Research Council about joining the ESO. However, if we did join then Jodrell Bank's radio frequency capability would complement the ESO's optical and infrared telescopes.

"PPARC has confirmed that it has no plans to change Jodrell Bank's funding. We are also spending £2 million on upgrading the Lovell telescope, which will again make Jodrell Bank a world leader in radio

astronomy."

For further details, check:

<[www.dti.gov.uk](http://www.dti.gov.uk)>.

Contact: Department of Trade and Industry, Tel: (020) 7215 5000.

## Boost for Innovative Small Satellites

A bid to make environmental disaster monitoring faster and cheaper was backed this month by Science Minister Lord Sainsbury.

He announced funding from the British National Space Centre (BNSC) for three small satellite projects under the MOSAIC programme. MOSAIC is the BNSC Small Satellite Programme.

The three winning projects are:

- TOPSAT, a mission led by Defence Evaluation Research Agency (DERA) to deliver low cost, relatively high resolution images direct to local users wherever they need them.
- GEMINI, from Surrey Satellite Technology (SSTL), to develop a low cost small geostationary satellite for telecommunications.
- Disaster Monitoring Constellation (DMC), also from SSTL, to develop a network of affordable micro-satellites, which could provide daily imaging of disaster areas, and thus help get help rapidly to where it is most needed.

Under the MOSAIC programme £15m has been made available over three years from 2000/01 for project support to partnerships involving both industrial partners and end users. Successful proposals will be part funded up to the level of 50%. The remainder of the funds can be made available either by the industrial or user partners.

For further information, check:

<[www.bnsc.gov.uk](http://www.bnsc.gov.uk)>.

Contact: British National Space Centre,

Tel: (020) 7215 5000.





# Nomad:

## THE THINKING ROBOT

*The ability to learn sets humans apart from machine. Stephen Waddington describes a research project, that scientists claim has, the intelligence of a small child.*

It is not science fiction. Researchers at the Neurosciences Institute in La Jolla have designed a machine that thinks. The machine's brain is called Darwin, after the 19th century biologist who conceived the theory of natural selection. Under Institute director and Nobel laureate Gerald Edelman, the Darwin series of thinking brains began in the mid-1980s. Today, Darwin 6 consists of a realistically designed simulation of a nervous system housed in a mobile platform called Neurally Organised Mobile Adaptive Device (NOMAD).

The research is conducted in the Institute's W.M. Keck Foundation Laboratory of Machine Psychology.

Unlike a robot, NOMAD is an autonomous being, used as a tool to study how the brain controls behaviour. According to neuroscientist Jeffrey Krichmar, NOMAD is at the behavioural level of an infant.

"NOMAD starts naive and learns from experience. It has a preference for light and a specific taste, but no other experience or programming," Krichmar explained.

### Controlled by Simulated Brain

NOMAD's behaviour is controlled by the activity of its simulated brain cells, allowing

researchers a unique window into how the human brain works and how brain mechanisms produce the range of behaviours associated with higher brain functions.

NOMAD can interact with its environment by sensing light and taste and by moving around and grabbing play blocks with striped or spotted patterns.

"Since NOMAD is attracted to light, it will steer toward a block and pick it up. When it grabs the striped block, it gets an electrical charge," explained chief engineer James Snook.

"In the simulated brain, this conductivity registers as good taste. Blocks with spots give no charge, hence, bad taste. As

NOMAD's gripper holds the block, the brain associates the taste with the pattern it sees. After learning, it will stop picking up bad tasting blocks. It will approach them and after seeing the pattern, will remember that they taste bad and move away," said Snook.

"We are adding a third sense to NOMAD's repertoire; an auditory system," said Krichmar. The simulated auditory system has areas to categorise and locate a sound, he added. A tone is associated with the taste of the block (high-pitched from a striped block, low-pitched from a spotted block). When the block detects NOMAD's presence, it starts to beep.

### NOMAD's Future

Future plans are to give NOMAD a long-term memory that will enable it to remember objects and events and put them into context.

"Our main objective is to use NOMAD to test theories of the brain," Krichmar explained. "By analysing its brain we hope to better understand how the human brain works. With this brain we can also model neurological diseases."

The implications of this research may include the development of better diagnostic tools for patients with neurological diseases, and improved methods for learning.

"Perhaps most exciting," Snook added, "will be the development of new pattern-recognition devices, based on the brain, that will communicate with digital computers."

Other discoveries at The Neurosciences Institute include demonstrating that fruit flies sleep, which could offer clues into sleep disorders. The Institute also showed that instinctive behaviour can be transferred between one species of animal to another by transplanting early brain regions of the quail to chickens.

For more information on The Neurosciences Institute and the NOMAD project check:

[www.nsi.edu](http://www.nsi.edu).



THE  
NEUROSCIENCES  
INSTITUTE

# Wave guide opens new avenues in TELECOMMUNICATIONS

Scientists at MIT claim to have developed the perfect cable. Electronics and Beyond investigates.

Building on the perfect mirror they created in 1998, Massachusetts Institute of Technology (MIT) researchers have proposed a new kind of coaxial cable that may be able to quickly and efficiently shoot light over long distances and around sharp bends while retaining its polarisation.

With its ability for higher capacity, this cable may be able to transmit much more information more efficiently and cheaply than current methods. It also could lead to significant miniaturisation of integrated optical devices.

"What's important about this is that it has opened a new direction for experimental research that was not possible before," said John Joannopoulos, Francis Wright Davis Professor of Physics at MIT and the team leader. "It's important to push along in this direction and see if we can find materials and fabrication approaches that will make this happen.

"We do know that if we can do what the theory says, then it will happen. This may be a breakthrough in bridging the very different requirements for transmitting infrared and radio frequencies" at opposite ends of the energy spectrum.

## Reflective Mirror

The familiar metallic mirror is omnidirectional, which means it reflects light from every angle. It also absorbs a significant portion of the incident light in the optical regime.

Dielectric mirrors, unlike metals, do not conduct electricity so their response to light



OmniGuide

OUR Mission

mission team tech press contact us

News

"A revolutionary new twist for optical cable", *NSNRC*, July 20, 2000.

"MIT researchers' theoretical waveguide may open new avenues in telecommunications and optical devices" *MIT News*, July 20, 2000.

More on OmniGuide in the news.

To develop a revolutionary optical transmission system for telecommunication applications

Currently we are developing the all dielectric OmniGuide Fiber, which utilizes an optical confinement mechanism based on the principle of omnidirectional reflection. Presently conventional optical transmission systems rely on fibers which either waveguide light through a high dielectric core or free-propagate it in space. The OmniGuide Fiber combines the advantages of both approaches. It allows, for the first time, the waveguiding of light in air at communications wavelengths. This could substantially reduce or even eliminate the need for amplifiers in optical networks. Secondly it will offer a bandwidth capacity that could potentially be several orders of magnitude greater than conventional single-mode optical fibers.

Elimination of the need for optical amplifiers will cut the cost of deploying and maintaining optical networks. Combined with the increased bandwidth, it will allow network operators to slash cost-per-bit dramatically.

OmniGuide Fiber

OmniGuide Fiber will guide light through air, and not through silica glass, as is done by today's industry leaders. This will result in the following advantages over today's leading optical fibers:

- Lower attenuation.
- Increased power per channel.

can be very different. Light travels in dielectric materials at speeds that are lower than in air. When light traveling in a particular direction through one type of dielectric material encounters another type, part of the light is reflected while the other part is transmitted at a different angle.

Dielectric mirrors are made of multiple layers of transparent dielectric materials. Such materials, which can be made to be extremely low loss compared to their metal counterparts, are used to reflect a prescribed range of frequencies coming from within a limited set of angles. Dielectric mirrors are used in devices such as lasers, which need low losses and high reflectivity.

The new kind of mirror developed in 1998 by Fink, Fan, Joannopoulos and Thomas - dubbed the perfect mirror - reflects light from all angles and polarisations, just like metallic mirrors, but also can be as low-loss as dielectric mirrors.

## Building on Perfection

The researchers then made a tube out of the perfect mirror to create an omnidirectional wave-guide. Unlike conventional wave guides, which need to

make wide turns to ensure that the light within them does not escape, the omnidirectional wave guide can turn light quickly and efficiently in small spaces.

This would allow a slew of new technological advances in devices such as an optical chip, which cannot now be miniaturised because bending the light's route takes up so much space. In addition, the new wave guide can accommodate a much wider bandwidth of light.

Thomas said that the wave-guide might have applications in medical lasers, among other devices.

Taking the wave-guide a step farther,

Joannopoulos proposed that the omnidirectional reflector could be fashioned like a conventional coaxial cable, which consists of a tube of metal with a metal core snaking down its centre. Coaxial cable is used to transmit radio and microwaves, which have large wavelengths, but it is not good for light energy at the smaller-wavelength, higher-frequency end of the spectrum, such as infrared.

Fibre optic cable was created to fill that need. But light transmitted through fibre optic cable does not maintain its polarisation. This is important for certain high-tech applications. Using dielectric materials instead of metal or fibre optics may bridge both worlds.

"This coaxial omniguide may be able to replace what metal does, and also do the job at wavelengths where metal doesn't work," Joannopoulos said. "And the nice thing about it is that whatever you put in, you get out. This could make a big difference" where polarisation is an issue.

The next step is to prototype and test the coaxial omniguide. Fink, Joannopoulos, Thomas and others have launched a start-up company, OmniGuide Communications at [www.omni-guide.com](http://www.omni-guide.com), to explore its practicality.

# Display SEARCH

*The search is on for a new type of display to meet the requirements of emerging display applications. Here Electronics and Beyond examines one possible solution.*

In the current boom for communications products, companies are jostling for their place in the emerging markets armed with devices promising the consumer, 'information anytime, anywhere, anywhere'. With mobile devices becoming common place there is suddenly a growing demand for high information content displays, which are affordable, energy efficient and light-weight.

But until now, the technological problems involved in producing displays giving access to all that information have not been successfully addressed. Liquid crystal display (LCD) technology used in most of today's laptops, mobile phones and personal display assistants (PDAs) is still too expensive, complicated and flawed to provide an adequate solution, fuelling a search for a replacement technology.

## Fantastic Plastic

Now Cambridge Display Technology (CDT) believes they have the answer in the form of a new type of display developed using Light Emitting Polymers (LEPs). CDT is confident that it is the replacement required to meet

emerging product requirements, and you can understand why when you look at the high definition, colour and possibly video needs of the next generation of mobile phones. All other contenders, including Field Emission Displays (FEDs) and Plasma displays, are still either too costly or impractical for their use as screens in mobile phones.

Danny McCaughan, CDT's chief operating officer, claims that, "LEP displays now offer the colour range, flexibility, brightness, low cost and low power characteristics the market is looking for".

Working with Japanese firm Seiko Epson, CDT has produced a prototype display, which can show moving pictures at video rate. The prototype LEP display has a resolution of 200 x 150 pixels and measures 16 levels of grey scale - achieved through a combination of time modulation and the use of sub-pixels. It offers a colour quality

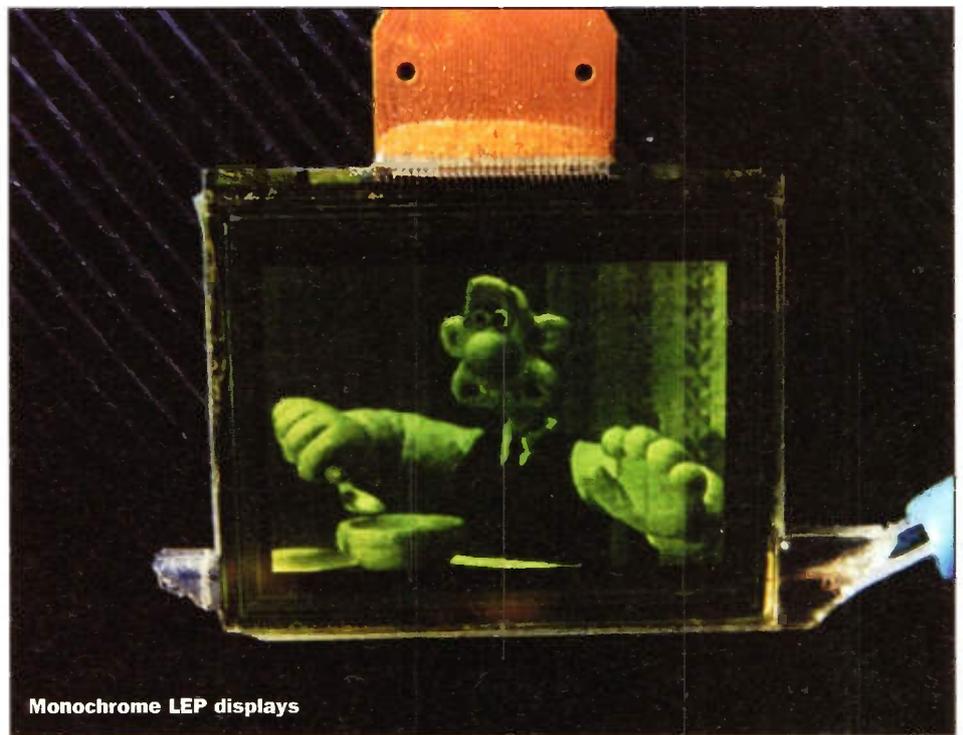
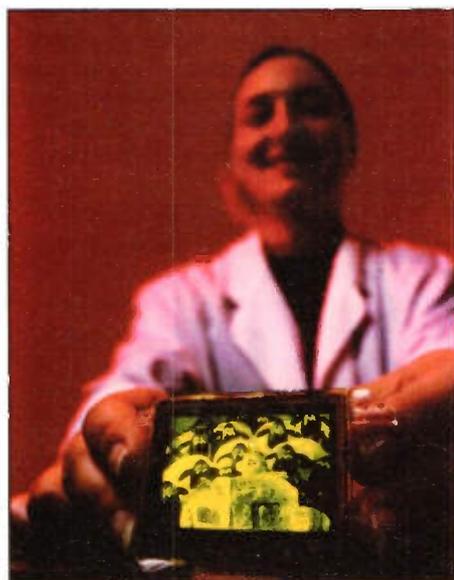
Mobile phone with experimental blue LEP screen

equivalent to that available from a LCD, but unlike LCDs and can be viewed from a 180 degree viewing angle.

The manufacturing process involves depositing individual pixels of red, green and blue polymers onto an active matrix substrate with a simple ink-jet printing process. Seiko-Epson has adapted their ink-jet technology used in conventional consumer printers to produce custom-built print heads to manage the process.

The thin layer of polymer when printed onto the silicon substrate and sandwiched between two electrodes acts as a semiconductor when a voltage is introduced. Light is produced where the charges meet so that voltages can be applied to light up individual pixels.

Processing silicon, the current semiconductor material in LCDs is complicated involving numerous vacuum and deposition processes, where as



Monochrome LEP displays

polymers can be grown from solvent and processed from solution which makes the whole process easier and cheaper.

"The use of printing simplifies the process for manufacturing displays" explains, Danny McCaughan. "By using this technology manufacturers can significantly cut their production costs. People are already talking about the video requirements of displays for the next generation of mobile phones and now we can offer a display which can make colour video on the small screen an affordable and practical reality".

The self-emissive quality of LEPs eliminates the need for a large number of components used in LCDs such as polarisers, colour filters and backlights. This not only helps to further bring down the cost of the display but also considerably reduces its overall weight and thickness. Unlike LCD's the finished device is solid state making it ideal for use in portable environments.

## History

The story behind the display started with a lab experiment in the early 1990s when Jeremy Burroughes, then a Cambridge PhD, now the company's technical director discovered that a polymer called PPV will emit light when a voltage is applied to it.

Burroughes and his PhD supervisor Richard Friend, a Cambridge Physics professor, realised that they had discovered something big and immediately took out a patent for "electroluminescent devices". In 1992 Burroughes and Friend with several of their colleagues set up CDT to exploit the potential of the glowing polymers with the knowledge that they controlled the fundamental patents for a new generation of electronics.

## Deal Brokers

The company is currently busy negotiating licensing the technology for which it holds the sole patents worldwide to leading OEM's. Seiko-Epson and Phillips who between them supply LCD screens to two

## Prototype full colour LEP display



out of three of the world's mobile phones have already signed deals with CDT, licensing the new technology.

"We will see significant volumes of LEP displays within the next two years," said McCaughan. "The market for LEP displays is huge and by 2004 we plan to capture 10 to 15 per cent of the display market below 5 inches".

The fact that a large number of the process steps are common with LCD manufacture will mean a lot of existing manufacturing plant can be used in LEP manufacture. This, CDT claims, will ease the transition between the two technologies and the adoption of LEP displays as the dominant display type in future mobile device applications.

To date licensing the technology to others has been CDT's main focus but the company is expected to participate more broadly in the display business in the future.

"Working with partners like Seiko Epson

and Phillips has been crucial to developing the technology and will remain at the heart of our business. But we have recently put a lot of investment into building our in-house materials development capabilities and are looking to participate throughout the value chain", said McCaughan.

## New facilities

CDT recently opened a new multi-million pound chemistry facility in Cambridge to house their R&D team, which will focus on extending lifetime and reliability, developing more efficient light emitting structures, designing manufacturing processes and devising effective driving schemes over the next year.

The facility was largely financed by a £10 million investment by New York private equity firms Kelso and Hillman Capital last year. With a further investment of £10 million this year, Kelso and Hillman, now have a majority stake in the company.

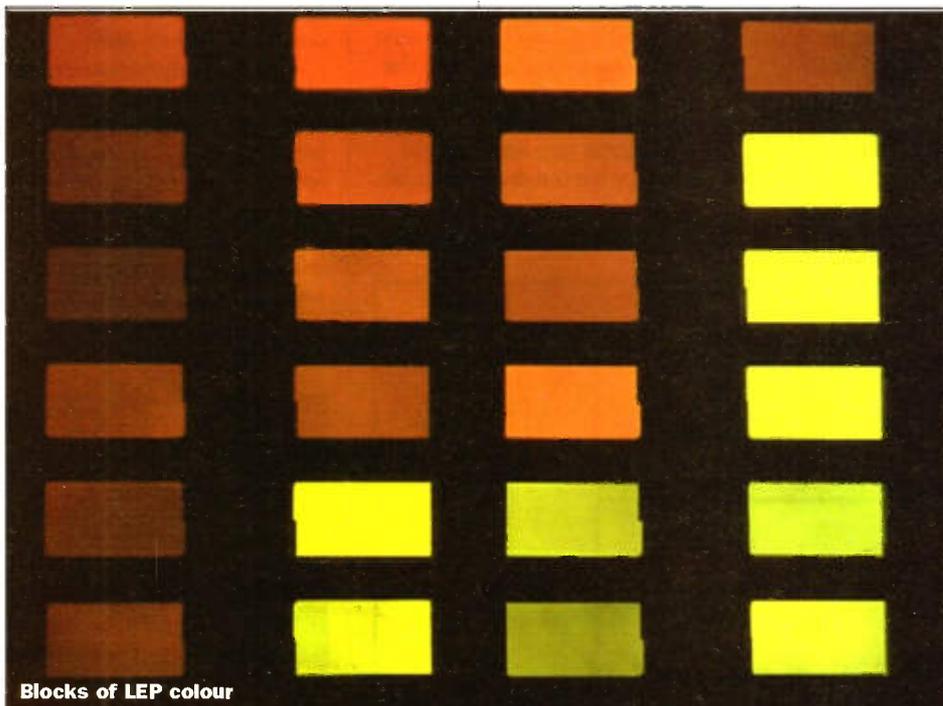
## Future Developments

Although currently CDT's prototype display only measures 64 x 64 mm, Seiko Epson has already developed the ink-jet printing techniques to manufacture larger displays printed with 40µm dots on full sized active matrix substrates.

Looking into the future, Danny McCaughan believes the company will have the capability to substitute the glass substrate currently used for plastic, to allow for formable displays. Using plastic substrates will make displays even lighter and more robust and could have a significant impact on the whole manufacturing structure even down to the casing around the product.

Mobile phones are simply a taste of what's to come claims CDT. The future could see TV screens hung up on the wall or video displays for wire-less Internet access that can be rolled up and put away in your jacket pocket.

For further information of CDT, check: <[www.cdt1td.co.uk](http://www.cdt1td.co.uk)>.



Blocks of LEP colour

Most people are familiar with the 'ordinary' aerials and antenna systems used in conventional radio and television communications from the simple wire antennas and 'whip' aerials used in the bands up to UHF (Figure 1) to the more 'exotic' Yagi-Uda array (Figure 2). The Yagi-Uda is a simple array of elements. The metal grid at one end is a reflector. It focuses intercepted television signals onto the actual aerial in front end of it, which is the driving element, and this part of the array is connected via cable to the TV. In front of the driving element and reflector, are several director elements that sharpen the aerial focus in one direction to give high sensitivity or gain. For the TV aerial this aerial pattern resembles a directional cone, which points directly at the local TV transmitter station to receive signals from it. For its relatively small size it has excellent performance if unwanted and spurious interfering signals can be avoided, usually by mounting the receiver array high up and away from reflecting surfaces.

The most common type of communications transmit antenna is the so-called Dipole and is illustrated in Figure 3. The dipole antenna is half a wavelength long and will naturally resonate at the



Figure 1. Short UHF transmitter (monopole quarter wavelength).

corresponding frequency. If we wish to make the antenna work at any other frequency we must tune it to resonate at that frequency. This involves the use of a Base Tuner and gives a very sharp resonant response. The tuned dipole is a very efficient antenna with a narrow bandwidth. Dipoles are very useful antennas in the VHF and UHF bands, but in High Frequency (HF) and

# RESEARCH

## NEWS

by Dr Chris Lavers

### Fractal Communications Antennas- Small Yet Elegant

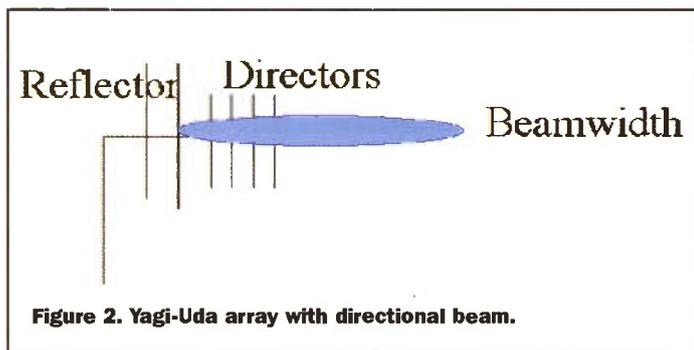


Figure 2. Yagi-Uda array with directional beam.

Medium Frequencies (MF) particularly they become impractical due to their excessive length. In these bands it is usual to use a monopole antenna which is only a quarter wavelength long, similar to that shown in Figure 1.

An interesting recent development is in the pioneering development of Fractal antennas, notably by the company Fractus led by Dr Carles Puente. Fractals are common geometric forms found in nature (Figure 4). Their mathematical basis have been used as a model in the development of innovative

applications such as image processing, the chemical industry, biotechnology and crop circle patterns. Fractal theory describes how a geometric form can be subdivided into an infinite number of parts, each of which constitutes a reduced copy of the original form. Fractal shapes are of great complexity and detail, which can be clearly seen as the observer approaches the fractal object to inspect it more closely.

Antennas may seem simple enough, but the theory behind them is so complex that antenna engineers are generally

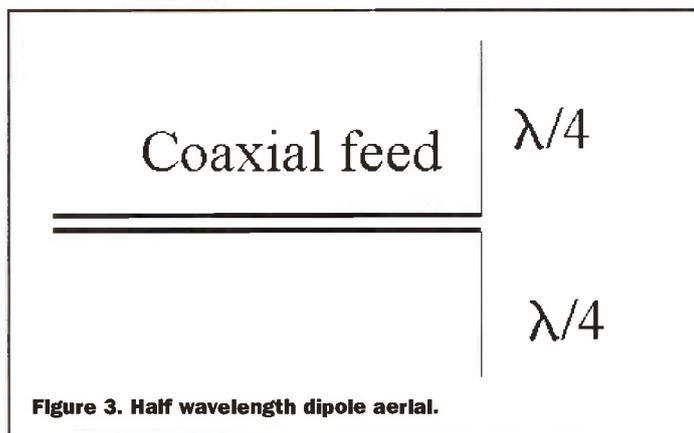


Figure 3. Half wavelength dipole aerial.



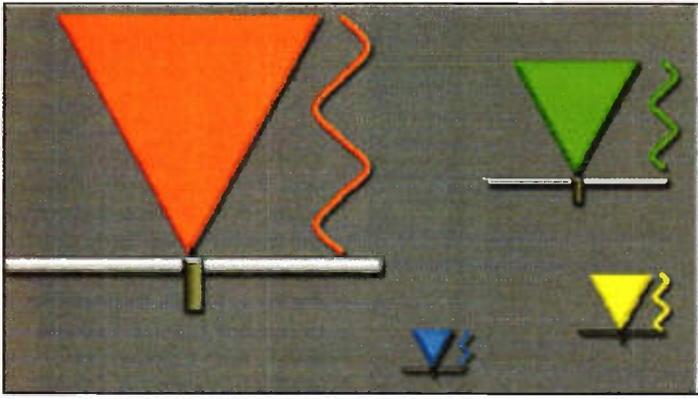
Figure 4. Coral structure. Courtesy Fractus.

reduced to trial and error in their design. A fractal antenna is composed of thousands of small antennas. Traditionally the individual antennas are either randomly scattered or regularly spaced. But a fractal arrangement can combine the robustness of a random array and the efficiency of a regular array with a quarter of the number of elements, acting as a partially filled regular array. Dr Nathan Cohen a radio astronomer at Boston University has experimented with wires bent into fractal shapes known as Koch curves, fashioned into so-called Sierpinski triangles (Figure 5). Not only can crinkling an antenna pack the same length into a sixth of the area, but the jagged shape also generates 'free' electrical capacitance and inductance, thereby eliminating the need for external components to tune the antenna or broaden the range of frequencies to which it responds. Cohen, like Carlos Puente at Fractus, has recently founded Fractal Antenna systems in 1995, and is now working with T&M Antennas, which makes cellular phone antennas for Motorola.

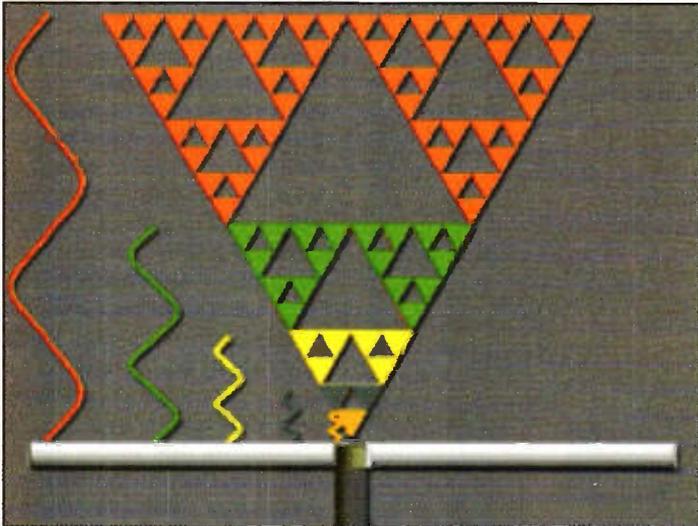
Recent challenges in telecommunications services require a major integration of actual and future systems (e.g. 3G, CDMA, GSM etc.) and full mobility (terminal size and weight reduction is required, low power consumption (for longer battery life as well as



Figure 5. Sierpinski triangles.



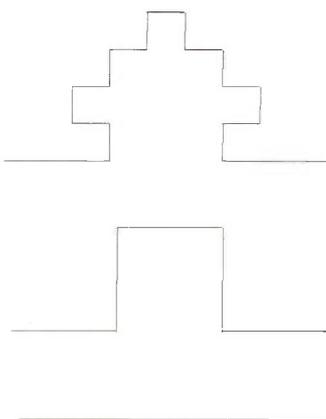
**Figure 6. (a) Individual antennas (b) combined together to form a composite antenna. Courtesy Fractus.**



reduced radiation hazards), and wide footprint coverage. These trends need improved antenna multiband behaviour and antenna size reduction. In conventional antennas narrowband antennas can only be used to send one signal at a time. To avoid this limiting bottleneck it is possible to create a broadband antenna with a wide bandwidth capable of sending several signals simultaneously. Tuned circuits,

such as antennas, have a property known as their selectivity or Quality factor  $Q$ . This can be used to determine the Bandwidth  $B$  of the circuit from  $B=f_0/Q$  where  $f_0$  is the tuned centre frequency. Resonant circuits have a very high  $Q$  factor, and therefore, produce narrow bandwidths. The  $Q$  factor of an antenna is a function of its height to width ratio and short, fat antennas will generally have a low  $Q$  factor

Fractal structure generating a larger overall size antenna within a small area



**Generator N=2**  
**L=6 units**

**Generator N=1**  
**L=5 units**

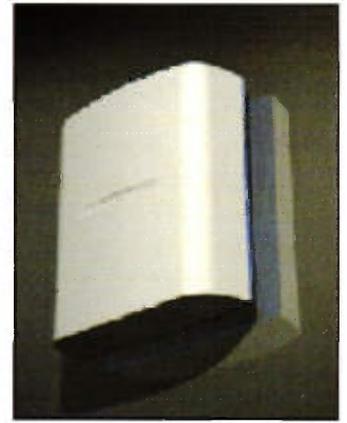
**Initiator N=0**  
**Length L= 3 units**

**Figure 7. Generating a Fractal pattern.**

and therefore give a wide bandwidth. This gives the clue to the solution for an ordinary conventional antenna, i.e. that in practice dipoles and monopoles can be made into broadband antennas by simply folding them somewhere in the middle. These broadband folded antennas have a much lower efficiency than a resonant antenna, but do not need tuning over a frequency ratio of about 3:1 (e.g. 3-9MHz). Broadband antennas can also be used to send or receive several signals at the same time, but nonetheless are still very large at HF and MF frequencies.

However for a fixed antenna size, even if it is a multiband or broad bandwidth system, the main antenna parameters: gain, input impedance, pattern shape and secondary sidelobe levels and distribution will suffer strong variations when changing the operating frequency. For instance if transmitted frequency is halved, the wavelength is doubled and the way the antenna spreads power into space will change significantly. Both the radiated beamwidth ( $\alpha=60\lambda/D$  where  $\alpha$  is the beamwidth,  $\lambda$  the wavelength, and  $D$  the effective size of the complete antenna) will change, as will the distribution of incompletely cancelled radiation in other unwanted sidelobe directions. At a particular frequency the antenna must be a minimum size, typically  $\lambda/4$  for a monopole. This well-known result has constrained for decades antenna performance in modern telecommunications systems.

Fractal design can help deal with this problem by introducing a large variety of possible geometrical shapes with some interesting and astonishing properties. Today every separate communications application requires a different conventional antenna. Fractal design appears an attractively superior solution. A fractal or self-similar antenna should work well at several widely different wavelengths replacing several antennas with a single composite structure (Figure 6a and 6b). The antenna will keep similar radiation patterns across several bands. Fractal shaped small antennas may also better take advantage of a small available space. In Figure 7 you



**Figure 8. Dual-band Base Station. Courtesy Fractus.**

can see the effect of taking a simple straight wire, and then bending it into a number of equal sections. Further repeat sequences of the same initiated pattern will consequently increase the overall length of the antenna whilst at the same time creating a proportionately smaller increase in the deployed area of the antenna system.

Fractus Products already available include Fractal Antennas®, a new generation of multiband antennas for wireless communications. They aim to integrate 3G services (UMTS) with GSM 900 and a GSM 1800 onto a single antenna. Currently products provide dual-band Base Station antennas with a single Fractus® antenna (Figure 8). Telecommunications operators can thus obtain enhanced capacity whilst reducing the cost and minimising environmental impact by reducing the size of any unsightly communications antennas.

## Large Space Antennas Having High Resolution

Clearly there will be considerable interest in the applications of Fractal Communications antennas, particularly at the low frequency (long wavelength) end of the market in order to minimise the physical size of the antennas used. At the other extreme end of the array and antenna zone, you may remember that we reported on the deployment of a new Very Long Base Interferometry Space system over a year ago in Electronics and Beyond. Recent results were presented by astronomers gathered in Japan presenting the most detailed



**Figure 9. Deployed VLBI system. Courtesy NASA.**

images of quasars ever seen, produced with data from the Very Long Base Interferometry Space Observatory Program. Space VLBI, as it is known, is a new type of astronomy mission that uses a combination of satellite- and Earth-based radio antennas to create a super-large telescope more than two-and-a-half times the Earth diameter wide, creating an incredibly narrow received beamwidth in the radioastronomy bands of the electromagnetic spectrum (Figure 9). As effectively the

largest astronomical instrument yet built, Space VLBI gives astronomers an incredibly sharp view of the known universe.

New radio images presented at Japan's Institute of Space and Astronomical Science (ISAS) near Tokyo earlier this year depict quasars whose radio emission has travelled billions of light years to reach Earth.

According to Dr. Robert Preston, U.S. Space VLBI project scientist at NASA's Jet Propulsion Laboratory (JPL), Pasadena, California. "These

powerful objects exist at the centre of many galaxies, including our own familiar Milky Way, which contains a very weak version of a quasar."

Launched successfully in February, 1997 by Japan's ISAS, Space VLBI uses a technique called interferometry that electronically links widely separated telescopes so that they work together as a single instrument with extraordinarily sharp "vision" or resolving power. By taking this technique into space for the first time,

astronomers have approximately tripled the resolving power previously available with only ground-based telescopes. "The Space VLBI satellite system has more than 100 times greater resolving power in radio frequencies than the Hubble Space Telescope has at optical wavelengths," said Preston. "In fact, its resolving power is equivalent to being able to read a newspaper headline in Tokyo all the way from Los Angeles."

Quasars are enormously bright point-like optical objects, shining with an intensity hundreds of times brighter than that of an entire galaxy. However, they are so distant that they appear only as very faint points of light to optical telescopes on Earth. Scientists believe that quasars are powered by gases such as remnants of stars spiralling into black holes at the centre of galaxies such as our own. Black holes are so massive that no light or matter can escape from their immensely strong gravitational field and, in the case of quasars, they can have masses that millions or billions of times that of our own sun. Although most in-rushing matter is captured forever by the black hole, some of the material is ejected at enormous speeds to form the observed narrow radio-emitting jets. By studying these jets, which are usually visible only at radio frequencies, astronomers hope to learn more about the black holes themselves.

Key results from Space VLBI include clearly resolved individual components in the observed quasars' jets. Perhaps the most significant single result of the Space VLBI mission so far is the detection of a number of radio sources associated with quasars that are brighter than theory predicts from a stationary source. A strange prediction of Einstein's theory of relativity is that radiation from an object moving at near light speed will be beamed in the direction of motion, analogous to the higher Doppler shifted frequencies of a moving source of radio waves towards an observer, consequently a source of rapidly moving plasma away from the observer will generate a dimmer source of waves than predicted from theory.

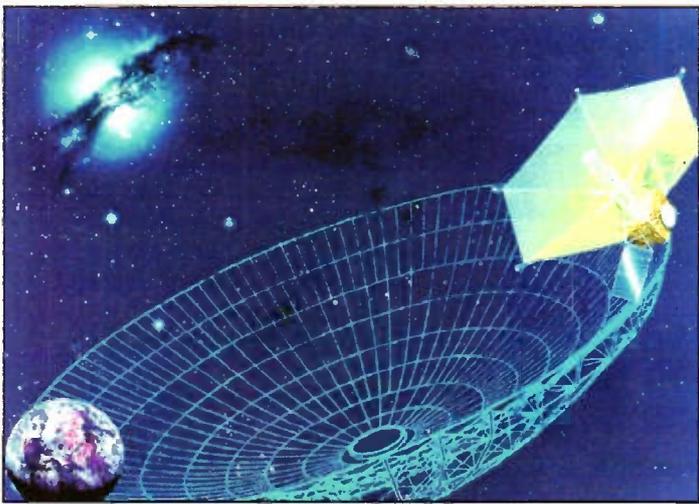


Figure 10. Quasar X-ray emissions. Courtesy NASA.

Therefore, rather than looking equally bright from all directions (like a light bulb), the source looks much brighter if it is moving rapidly toward us (like looking into a flashlight). This effect allows some sources to appear much brighter than they really are, solving the conflict between the observed and theoretically allowed brightness of the radio-emitting quasars. As a consequence, recent observations imply that the radio-emitting plasma in these sources is actually moving

toward us at nearly the speed of light in accordance with Einstein's prediction.

Fine details revealed by Space VLBI images have also been combined with observations of the same objects in other parts of the electromagnetic spectrum (such as: infrared, optical, ultraviolet, X-ray, and gamma ray regions). For example, the recently launched Chandra (Chandrasekhar) X-ray telescope detected bright X-ray emission from the core of a distant quasar named PKS 0637-

752, as well as a very unexpected source of X-ray emission coming from part of the quasar's radio jet (Figure 10). Space VLBI observations show the intricate radio structure in the core of this quasar with a thousand times finer detail, and measure the speed of material in the radio jet by comparing images made at different times. Knowing the speed of the jet allows astronomers to better define the fundamental physical processes responsible for generating such intense X-ray emission.

Not all space VLBI observations have been of very distant objects. Space VLBI observations have also helped determine the size and shape of an extremely bright radio source in a nearby star-forming region of the constellation Orion. These observations indicate that the intense, narrow-band, radio emission come from trapped water molecules in the star-forming region comes from within areas contained within strong magnetic fields. The new radio images and related images are available at:

<http://www.jpl.nasa.gov/pic>

[tures/spacevlbi/](http://www.jpl.nasa.gov/pictures/spacevlbi/).

Additional information about the U.S. Space VLBI mission is available at:

<http://us-spacevlbi.jpl.nasa.gov/>.

Space VLBI is part of a major international undertaking. Led by Japan's ISAS, the VLBI Space Observatory Program enables about 40 Earth-based radio telescopes from more than 15 countries to co-observe with the space VLBI satellite. The network spans the globe, in the northern hemisphere from the United States to Europe to Asia, and in the southern hemisphere from eastern Australia to South Africa.

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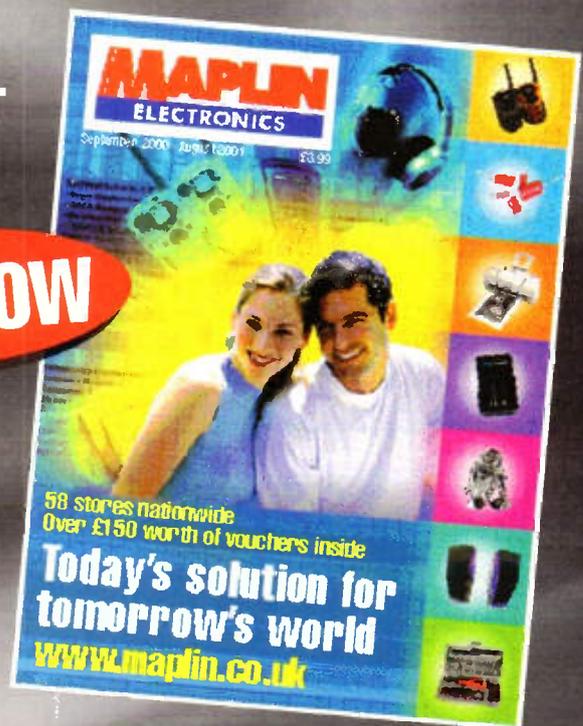
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# Happy Birthday

# LITTLE M

By Gregg Grant

## The French Yard

The metre has recently had its 125th birthday: on the 20th of May in fact. Its gestation however was a lengthy business, having begun in 1791, in a France in turmoil. The French revolution was the catalyst for toppling a number of ancient encumbrances, quite apart from the monarchy, one obvious candidate being the chaotic mess that passed for the country's system of measurement.

Metrology at this time could be said to be a body-contact activity, if not exactly a sport and indeed had been for millennia past. Consequently it wasn't simply the French who'd experienced problems with standardisation in measurement. Non-standardisation - in the shape of the human frame - had been built into the system since the beginning. The French however were the first to attempt to do something about it.

## Anciens Régimes

Probably the oldest unit of measurement known is the Cubit, from the Latin cubitum, meaning elbow. Used by the Egyptians as early as 3,000 BC, this measurement was the length of the forearm from the elbow to the finger tip.

Naturally, this distance varies from person to person, although the Egyptians made a stab at standardisation with their Royal Cubit, which was approximately equal to 524 millimetres (mm), or 20.62 inches (in). A Royal Master Cubit of black granite was used as the standard, against which all other cubit sticks in Egypt were - supposedly - checked periodically.

The cubit of course could be sub-divided,

as table one illustrates, and even the digit could also be reduced further.

The 14th digit on a cubit stick for example was marked off into 16 parts, the next into 15 parts and so on until - at the 28th digit - the division had become exactly half. Just as the electronic calculator has by no means banished the abacus, so the latest measuring techniques haven't ended the cubit's place in metrology. As I've seen over the years, it's still used occasionally in construction in the Arabian Gulf and in the building of fishing junks in Hong Kong and southern China.

The United Kingdom, the UK, is also a country with every bit as aged a metrology system as the French. Its equivalent of the cubit was the Yard, related to the Old Saxon word *Gerdia*. This measurement dates from roughly the 10th century and by the early years of Henry the First's reign, it was decided that the distance a yard should represent should be that between the tip of the King's nose and the end of his outstretched thumb, as shown below.

There was no standardisation of measurement at this time: that didn't come in until 1196, when the Assizes of Measures decreed that - throughout England - the yard should be identical in size and be manufactured from iron. By the time of Magna Carta in 1215, measurement was getting completely out of hand, and so the charter had a clause correcting abuses of the measurements then current, which was widespread.

Edward the First, in his turn, decided to standardise the yard and its sub-

units. This curious arrangement is shown in table two.

An ancient Saxon measurement the perch, or rod, is still in use today. Its original distance was - perhaps - the apogee of the 'body contact' system as it was the total length of the left feet of the first 16 men to leave a church on a Sunday morning! Acre comes from another old Saxon word, this time *Aecer*, meaning Open Country or Untenanted Land. It was this definition that Edward standardised in perches.

Measuring matters in England remained much as the Hammer of the Scots had left them until the Armada year, 1588. Despite this local difficulty, Elizabeth I found time to issue a new standard yard. Despite further national upheavals and wars - foreign and civil - the Armada yard would last almost as long as Edward's had done, it only being repealed by an act of Parliament in 1824!

## The Revolutionary Yard

In 1791, the French National Assembly ordered the Academy of Sciences to sort out the old system of measures. The Academy swiftly concluded that whatever system replaced the old one, it would be based on a natural physical measurement, so as to avoid conflict and ensure immutability, in so far as was possible.

Eventually, they settled on the length of 1/10,000,000 of a quadrant of a great circle of the Earth, measured around the poles of the meridian passing through Paris. Consequently two engineers - Jean Delambre and Pierre Méchain - were directed by King Louis XVI, by now in a prison cell awaiting his fate, to survey the distance decreed by the Academy.

Over the next six years the two engineer-surveyors determined the arc of the meridian from Barcelona to Dunkirk. Their task was an expedition in itself, a roller-coaster of delay, local suspicion - they were arrested as spies on a few occasions! - civil war and, more dangerously still, the likelihood of war with Spain.

Royal Cubit:	Equal to 524 mm or 20.62 in.
Basic sub-unit:	The Digit. A finger's breadth.
4 digits	= 1 palm.
5 digits	= 1 hand.
12 digits or 3 palms	= 1 small span.
14 digits or 0.5 cubits	= 1 large span.
16 digits or 4 palms	= 1 r'ser.
24 digits or 6 palms	= 1 small cubit.
28 digits	= 1 Royal Cubit.

Table 1. The Cubit and Its Sub-Divisions

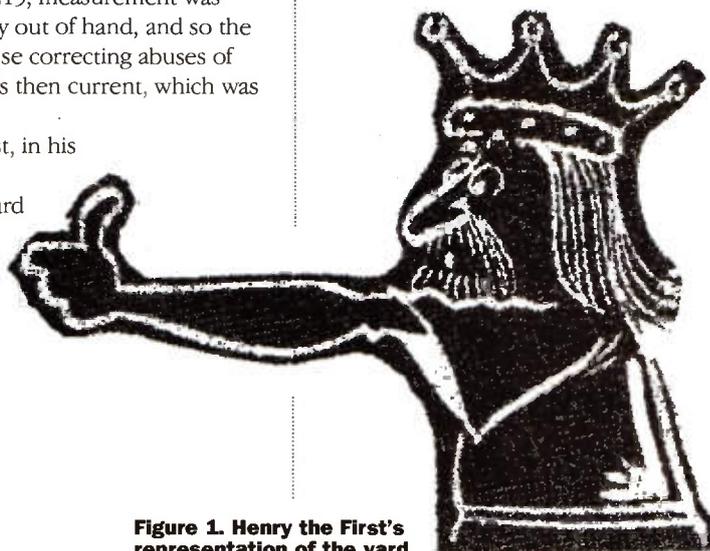


Figure 1. Henry the First's representation of the yard

Yard (or Ulna):	Equal to 3 feet.
3 Barley Grains	= 1 inch.
12 inches	= 1 foot.
5.5 Ulna ( or 16.5 feet)	= 1 Perch or Rod.
40 Perches (long)	
x 4 Perches (wide)	= 1 acre.
1 Furlong (a furrow in length)	= 660 feet.
1 Perch also defined as 16.5 feet.	

**Table 2. The Yard and Its Sub-Divisions**

Delambre and Mèchain finally came up with a figure of 39.37008 inches for their new unit, which they termed a Metre, from the Greek Metron, meaning to measure. Eight years after the National Assembly's instructions to the Academy of Sciences, what was termed the Metre and Kilogram of the Archives - in effect platinum representations of the new units - were declared the legal standards throughout France. Although the system's creators hoped that their new derivations would be accepted throughout the world, another 76 years would pass before any attempt was made to spread the French system even in Europe, let alone elsewhere in the world.

In 1875 an international conference, held in Paris, established an International Bureau of Weights and Measures and signed the Treaty of the Metre which - among other things - created a permanent laboratory at Sèvres, outside Paris, where research is carried out into metrology. It's here that the international standards are kept and national standards checked and measured. All the other metric units were derived from the metre, which is why its birthday is important.

In 1889 several bars of platinum-iridium - a metre in length - were manufactured, the bar designated number six replacing the Metre des Archives. This was termed the International Prototype Metre. The other bars were distributed among the signatories of the 1875 Convention, the selection being made by drawing lots. The UK ended up with bar number 16.

The fact the British were given a bar at all was something of a surprise because - as at present where further integration with continental Europe still divides the nation - they hedged their bets. It was 1884 before the UK signed the Convention and on its own particular terms! The British refused to implement the clause calling for the signatories to introduce the metric system in their homelands. Another 13 years would pass before the metric system of weights and measures became legal in UK business

SI Nomenclature	Abbreviation	Quantity
Metre	m	Length
Kilogram	kg	Mass
Second	s	Time
Kelvin	K	Temperature
Ampere	A	Electrical current
Candela	cd	Luminous intensity
Mole	mol	Amount of substance

**Table 3. The Basic SI Units**

and commerce generally.

## Little m Grows Up

That the Academy had been on the right track with their insistence on using a natural physical measurement, was borne out by subsequent developments in metrology. The International Prototype Metre's stability and

ready verification meant that it soon replaced the original meridian definition throughout the world. Nevertheless, scientists, engineers and others were still impressed by the fact that this measure was based on a 'natural' one.

Soon, metrologists were advocating the wavelength of light as a basis for determining a truly natural standard for length. Quite apart from an accuracy point of view, the idea had another clear advantage: once established, the measurement could be re-created - and therefore verified - in any, properly-equipped laboratory.

In 1892 the first measurement of the metre in terms of the wavelength of light was made. Between 1932 and 1935, two further measurements were made at the National Physical Laboratory, the NPL. By 1940, some nine measurements of the metre in terms of the wavelength of light had been made and the mean value of these experiments were used to re-define the metre as the length equal to 1,650,763.73 wavelengths in a vacuum of the radiation ... of krypton-86. This remained the definition of the metre until 1960.

If the 1960s are famous for anything it's the cult of youthful rebellion, flower power and ear-drum shattering music. They are less well-known for the profound change made to the way we measure things, in particular the *Système International d'Unités*, or SI system, created by the 11th General Conference on Weights and Measures.

This gathering endorsed the Italian physicist Professor Giovanni Giorgi's Metre-Kilogram-Second, or MKS, system of 1901 and decided to base the SI system on it. Seven basic units were adopted, as shown in table three.

Of the seven, only the kilogram is represented by a physical object, namely a cylinder of platinum-iridium

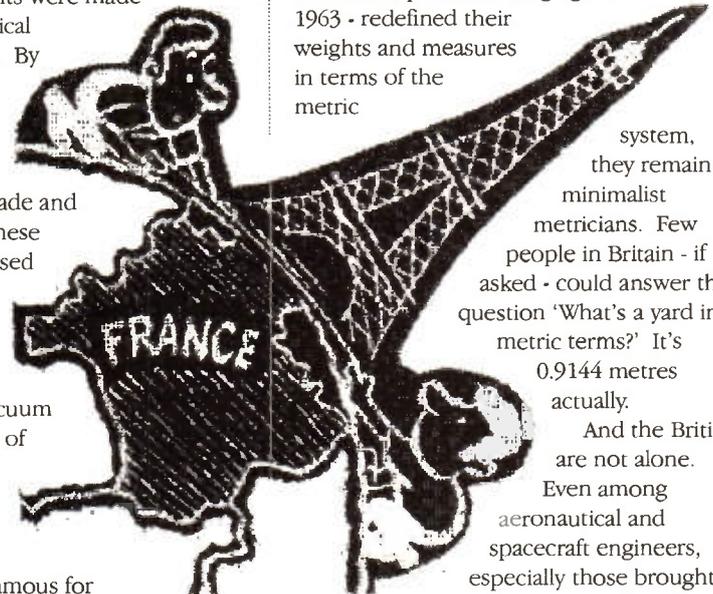
kept at Sèvres. The representation of the others indicates the enormous strides scientific technology has made throughout the 20th century.

In 1960, the American physicist Theodore Maiman built the first laser, based on ruby. A decade later, these devices were being used to establish metrological standards, most prominently that of length. Consequently in 1983 the krypton-86 definition of this quantity was replaced by the length of the path travelled by light in a vacuum during a time interval of 1/299,792,458th of a second. This definition was created using an iodine-stabilised, helium-neon laser, which has a reproducibility better than  $\pm 3$  parts in 100,000,000,000!

The second is now defined as the duration of 9192631770 periods of the radiation corresponding to the energy-level change between the two hyperfine levels of the ground state of the caesium-133 atom.

Has the SI system, now in place for almost 40 years, led to universal acceptance of a single measuring standard? No, not quite.

Although the British - in an Act of Parliament passed as long ago as 1963 - redefined their weights and measures in terms of the metric



**Figure 2. Messrs Delambre and Mechain sorting out the French metrology system**

system, they remain minimalist metricians. Few people in Britain - if asked - could answer the question 'What's a yard in metric terms?' It's 0.9144 metres actually. And the British are not alone. Even among aeronautical and spacecraft engineers, especially those brought up on the American Customary and the

British Imperial systems, metrication can hardly be said to have taken off.

America's National Aeronautical and Space Administration, NASA, used pounds per square inch and feet per second in building the Space Shuttle and, apparently, is still doing so in its design for the multinational space station, currently edging its way towards something approaching completion.

Nevertheless Little m has grown up spectacularly, achieving what no other measurement has attempted to do: become the basis of a system embracing all the major technologies - electronics, mechanics, aeronautics and thermodynamics - in a single, cohesive metrology.

# COMPUTERS WITH

# VOICES

**If you thought 'designer babies' were a long way off, consider the population explosion of 'virtual' people being conceived now. Steve Waddington investigates.**

**T**hirty-five Stanford University students supervised by communication Professor Clifford Nass, in a course sponsored by the National Science Foundation, decided to find some of the answers last quarter by testing how 1,000 real people responded to virtual ones - especially to their voices.

Based on the assumption that virtual characters will have to be attractive to real people in order to survive in a free market, the students began the design of their experiments by reviewing research on psychology and how the brain processes speech. Nass encouraged them to ask, if something works for humans, what about for synthetic and recorded speech?

Some of the graduate/undergraduate research teams investigated people's reactions to representations of human faces on computer screens, and one team looked at responses to a computer that 'touches' its users through a joystick. The majority of the 11 teams chose to test virtual voices, or the hot new technology known as voice user interface (VUI).

VUIs range from poor-quality machine-generated voices, which many companies use on their telephone answering equipment, to high-quality human-recorded voices, which are more expensive to produce but which are beginning to crop up on commercial web sites. These voices can be employed to respond to consumer questions about investing in the stock market or how to set up the computer they just bought.

Voice interface technology has improved incredibly rapidly, so that companies like Philips and Microsoft are talking about imbedding speech into almost everything," says Nass, the co-author of *The Media Equation*, a 1996 book on people's social responses to communicating technology.

Venture capitalists, he adds, also have been funding speech interface start-up

companies with names like TellMe, BcVocal and Quack.

"Yet there has been almost no research on the psychology of design of speech interfaces," he said, which is why about six dozen US and European-based companies sent product designers or researchers to campus in June to hear the students present their sometimes surprising results.

So what will virtual people be like? First, their gender and ethnic background is not likely to be accidental or even representative of the human population. That is because designers are not likely to ignore what the students learned - that gender and ethnic stereotyping, often subconscious, is pervasive when people encounter voice interfaces.

The experimenters also found they could manipulate people's attitudes toward the

content of messages by changing the emotional tone of voice, as well as physical parameters such as pitch and speed.

The students also found that voice interfaces may not always be preferable to the text interfaces to which computer users are now accustomed.

## Stereotyping

The research subjects reacted more positively to virtual male voices than to virtual female voices in several experiments, as the researchers predicted.

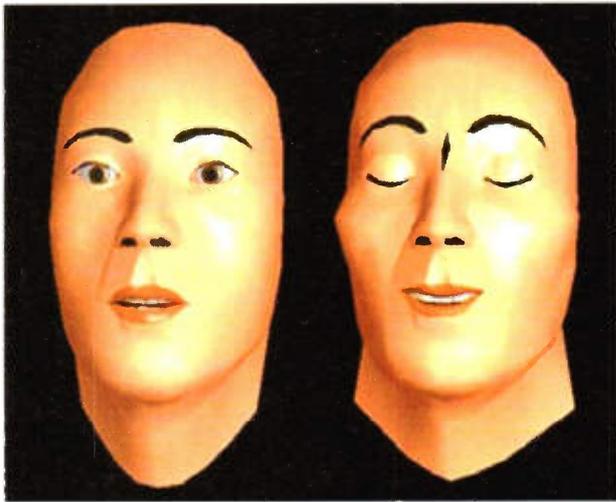
"Gender is the first social attribute people recognise in a human voice, and it triggers stereotypical reactions, so that male voices are perceived as more assertive, ambitious and persuasive," said Eun-Ju Lee, a student whose research team conducted an experiment in which they found that even obviously synthetic voices "elicited gender stereotyping and gender identification. Casting is crucial," she said.

But while male voices are more highly respected by men and women, psychologists also know from past research that human voices can generate group favoritism. Another student research team looked at what type of voice would prompt people to disclose the most personal information to a computerised interface.

They found that their American male subjects - Stanford students - were willing to disclose more personal information to user interfaces that spoke in a female, foreign-accented voice - in this case, Swedish. American females, on the other hand, revealed more personal data to an US-accented female voice than to either a male US voice or Swedish voices of either gender.

Seema Swamy, one of the researchers who conducted the experiment, concluded that men are more likely to disclose personal information to a voice that they feel socially distant from and are not likely to meet again.

The screenshot shows the Ananova website interface. At the top, there's a navigation bar with 'FOOTBALL' and 'Fixtures, results and tables'. Below that is the 'ANANOVA' logo and an 'Instant search:' field. A 'BREAKING NEWS' section reports on an evacuation. There are sections for 'Latest news by category: 00:46' and 'VIDEO REPORTS' featuring a woman's face. A 'BUY TICKETS with ananova' banner is also visible. The main content area includes articles like 'Queen Mother finishes day of celebration at the ballet' and 'Life and times of a special lady'. A 'NEWS CHOICE' sidebar lists categories like Entertainment, Funny old world, Business, and Health.



## When Voices and Faces Intimidate

In another experiment, students tried to see how much personal information they could get subjects to disclose when voices were combined with representations of faces on screens. They found that a synthetic face coupled with a human-sounding voice decreased people's willingness to respond with a yes to such invasive questions

Women may feel more comfortable sharing information with someone whom they consider more like themselves. Women said they like the speech interfaces better, but men disclosed more information, she said.

Companies could design different speech interfaces for men and women consumers, she noted, because they would have to do only two designs. Playing to people's nationality and racial stereotypes, however, would be more difficult, at least for products distributed globally.

like - Do you sometimes tell lies if you have to?

Research subjects disclosed the most to text interfaces. Apparently, the more human-like the interface, "the greater desire humans have to manage themselves," said student researcher Li Gong. "The synthetic face made people spend less time answering the questions."

Yet another team found that voices obviously generated by machine probably should not try to claim they are human. Setting up an over-the-phone auction, the researchers tested human-recorded and machine-generated voices, each offering the same items for sale with the same language, except in two styles of grammar.

## Voices Trump Content

Several experiments looked at how to manipulate people's perceptions of the content of messages. In one, researchers Kyu Hahn, Sylvia Loveda, Rob Baesman and Sandra Lui took four current events. These were stories that mingled factual and opinionated content and told listeners they were listening to either 'news' or an 'editorial' on 'NetRadio.'

For stories labeled as news, the human-recorded voice made the content seem more factual and persuasive than the machine-generated voice. For stories labeled as editorial, the reverse was true.

The results suggest that content labeling primes the audience and that listeners are seeking some sort of balance, the researchers said. News may seem 'a little boring' in the machine-generated voice, but opinion was probably perceived as less opinionated when spoken by the less human voice.

In a related experiment, another research team found that people ascribed emotions to machine voices; this influenced the credibility of the message. Research subjects liked happy news or movie reviews better when read by a happy voice and bad news and reviews better when read by a sad voice, but they gave more credibility to the report when the voice didn't match the content.

For more information on the Stanford University speech project or the National Science Foundation or the, check: [www.stanford.edu](http://www.stanford.edu) or [cs1u.cse.ogi.edu](http://cs1u.cse.ogi.edu).

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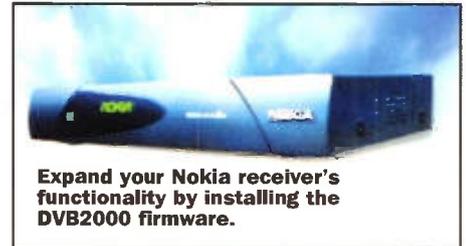
# TECHNOLOGY WATCH



## With Martin Pipe

In last month's Technology Watch, we discussed some of the interesting things that you could do with a Nokia 9200/9500/9600 digital satellite receiver. We concentrated on audio matters - getting the best from BBC radio, and even downloading MP3 files without an Internet connection were all touched upon. Making all of this possible are two pieces of software. The first, DVB2000, is a replacement operating system that resides in the receiver. One of the keys to DVB2000's flexibility is its enablement of the receiver's SCSI-2 port. Connect this to a PC with compatible interface, and you can transfer DVB (audio, video and raw data) streams to your hard disk. This brings us to the second piece of software - Vgrabber - which allows you to

A future release of Vgrabber will have another interesting feature up its sleeve. At present, you can stream a TV channel's video to your hard disk. Unfortunately, I cannot play the .mpv files with a computer-based MPEG video player, even when they've been renamed with a .mpg extension. I can imagine that there's some residual transport information that needs to be stripped out first. Even if they could play, there would be no sound. That future

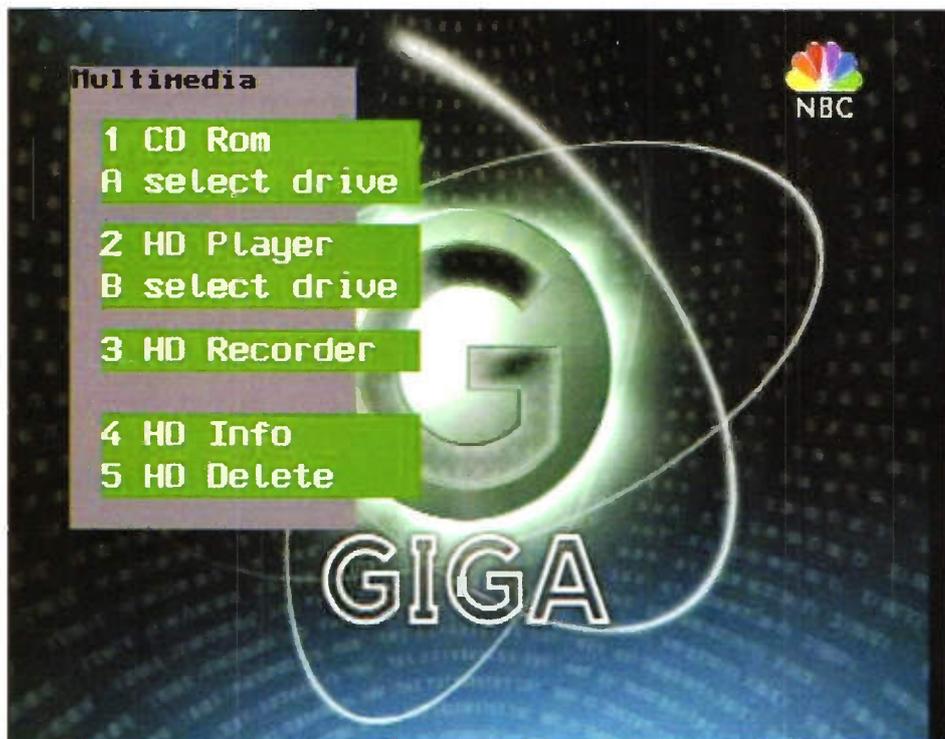


Expand your Nokia receiver's functionality by installing the DVB2000 firmware.

option, a timer, the ability to recognise multiple SCSI devices - such as hard disks and CD-ROM drives - and support for VideoCD playback.

Note that some of these features have not yet been fully debugged, although DVB2000's developers are working on them. An obvious problem with the current version of the software is that it doesn't support playback of video - even though it lets you record it in the first place! Sound recording (i.e. the capture of audio streams), and the selection of previously captured streams for playback through the receiver's MPEG decoder and audio circuitry, are however supported. In other words, a DVB2000-upgraded Nokia receiver is a powerful radio tool even without a PC connected! Archivists will appreciate that the average multi-gigabyte hard disk will store many tens of hours of radio broadcasts - and audiophiles will like the fact that there's no loss of sound quality whatsoever, because you're capturing the original broadcast datstream. Equip the receiver with an S/PDIF output, so that an external DAC can be connected, and you'll have a flexible digital radio receiver that will please the most critical of audiophiles! The modification was detailed in February 2000 issue of 'Electronics and Beyond'.

Once again, enthusiasts pooling resources on the Internet have managed to pip the



A Nokia DVB satellite receiver, reprogrammed with the DVB2000 firmware, will interface to a SCSI hard disk and CD-ROM. Timeshifting and VideoCD playback are possible - or shortly will be.

choose exactly what you want on your PC's hard disk. Audio can be grabbed from the currently selected radio or TV channel. The MP3 service described last month, R@dio.MP3, transmits MP3 audio in real-time using the space normally used for teletext information. The teletext datstream is grabbed, stored on the hard disk and processed by another program (R@dio.MP3 extractor) that discards the unwanted transport information to yield the MP3 payload.

Vgrabber release will have the ability to multiplex the audio with the video, and hopefully in a 'true' MPEG format that's compatible with hardware and software DVD playback peripherals. Interestingly enough, DVB2000 makes provision for the connection of a hard disk to its SCSI port, so that the MPEG streams pertaining to the currently-selected TV programme - with sound and vision - or radio broadcast can be stored. The relevant DVB2000 menu ('multimedia') also includes a disk format



The video inputs and outputs, as fitted to the prototype audip PC. Now it's got some pretty nifty video functionality too!

large corporates to the post. By the end of the year, Sky Digital subscribers will be able to purchase receivers with in-built hard disks, so they can timeshift programmes without the need for a VCR. This is just as well, seeing that the timeshift potential of current Digiboxes is - as we discussed last month - extremely restricted. Video recording on a PC is a practical possibility right now, though. Many vendors sell video capture cards that will capture analogue video (and sometimes audio, although most such peripherals rely on the PC's soundcard) to the hard disk. These cards employ a Motion-JPEG codec to compress the video after it has been digitised. They also have an analogue video output, so that previously captured footage can be fed to a TV or VCR. Most of these cards have been designed for non-linear video editing, but there's no reason why they can't be used as video recorders provided that your PC has sufficient hard disk space available! Matrox's G200/400-TV range of M-JPEG video-enhanced graphics cards are well suited for the task. For a start, provision has been made for a Nicam stereo TV tuner. The



**Zerex PARC researchers are striving to make dynamic sheets of electronic reusable paper no thicker than a standard transparency.**

audio capture, and are supplied with the same Windows control panel.

Amongst other things, PC-VCR Remote allows you to store and access TV channels, invoke recording/playback and customise capture parameters. Last but not least is a simple timer that makes unattended recording possible. I

recommend a resolution of 352x288 along with a capture rate of 25fps for most TV recordings. A higher resolution will capture more detail, but it's hungrier

on hard disk space. Not only that, but due to a design fault of Windows, each video capture cannot exceed 4GB in size (2GB if your hard disk isn't FAT32). In systems where the sound and video capture cards are separate; there's a danger of losing lip sync over time. Indeed, this was a real problem with early PC-based non-linear

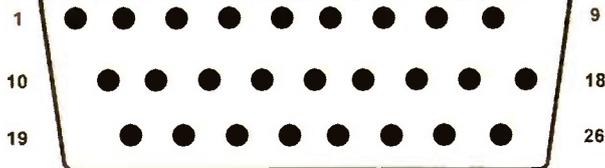
editing systems in which the only choice was an ISA soundcard. However, I have had no such problems with a PCI sound card - presumably because they're synced to the same master clock. Note that both Matrox products are supplied with a video editing program (Avid Cinema) and Ligos' excellent LSX-MPEG conversion utility. The latter will convert your capture into MPEG-1 or MPEG-2 form, and is just the thing for VideoCD creators! That said, several vendors - including MGI (Diva) and Cyberlink (PowerVCR II) - are in the process of releasing PC-based video recorder programs that are able, with suitably powerful hardware, to compress video to MPEG-2 standards in real-time! The capture card needs to be compatible, though, and lists of suitable hardware been not yet been released.

Until such time as we know more, the Matrox is an excellent choice for computer-based video recording. Hardly surprisingly, then, I specified one of the Matrox cards (in this case, an original G200-TV) for the audio PC that was described a short while back in



**The Marvel G200-TV will convert your PC into a video recorder.**

G400-TV, an AGP card, is supplied with one as standard. The previous-generation G200-TV, which is available in PCI and AGP guises, has to be upgraded with one at extra cost. Both cards rely on the PC's sound card for

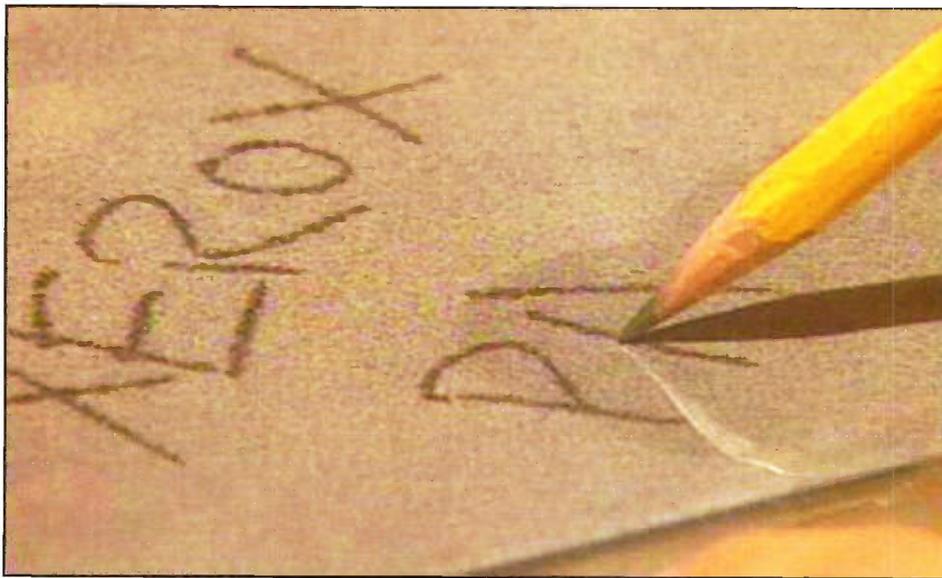


- Pin 1. S-video Y out
- Pin 2. S-video C out
- Pin 3. Ground
- Pin 4. Composite video out
- Pin 6. S-video C in
- Pin 7. Composite video in
- Pin 8. Ground
- Pin 9. S-video Y in

**Video pinout of the 26-way high-density 'D' connector, as sported by the G200-TV and G400-TV graphics cards**



**The paper pulp of the future, according to Xerox**

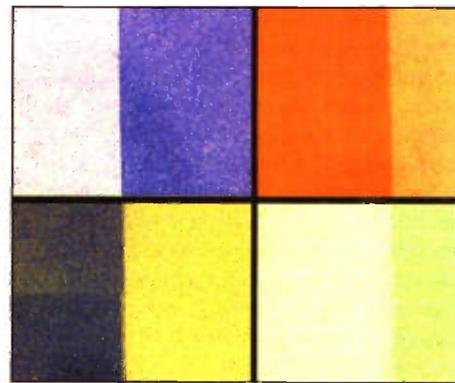


**An electronically-charged pencil rotates the bichromal beads in a sheet of Gyricon.**

'Electronics'. In addition to its graphics and video capture potential is its ability to convert the Windows desktop into a standard video output. Keep the display resolution fairly low (800 x 600 is a sensible maximum) and you can dispose of the monitor in favour of a lounge-friendlier TV set with AV inputs! All G200/400-TV video signals are brought out to an external 'breakout box', via a hefty interconnecting cable. Connections at the card end take the form of a 26-pin high-density 'D' socket. Although builders of the previously-described audio PC could cut a rear-panel hole large enough to accommodate the Matrox card's breakout box connector, I decided to fit standard composite and S-video output sockets to the rear of the case, and hard-wire them to the relevant pins of the connector. For the benefit of anybody with one of these cards, the connector's video ins and outs are given in Figure 1.

### Do journalists dream of electric paper?

Our next subject for discussion is one close to my heart. As a journalist, I receive stacks of paper every day, in the form of press releases, catalogues, magazines and so on. In fact, in the Western world, paper consumption is at an all-time high, despite the promise of paperless offices and homes. Printed magazines, junk-mail, flyers, catalogues, official literature, newspapers and so on are all flourishing despite the growth of the Internet. Most of this paper is eventually thrown away, which raises environmental problems. Although most of it can be recycled, there's still the issue of the energy expended during the processes involved. And because only a finite proportion can be recycled, trees are still being felled to meet the world's demand for paper. Hats off, then, to Xerox's Palo Alto Research Park (PARC) - yes, the same chaps that brought us the GUI, mouse, laser printing, Ethernet and much more besides. Its latest accomplishment is a unique form



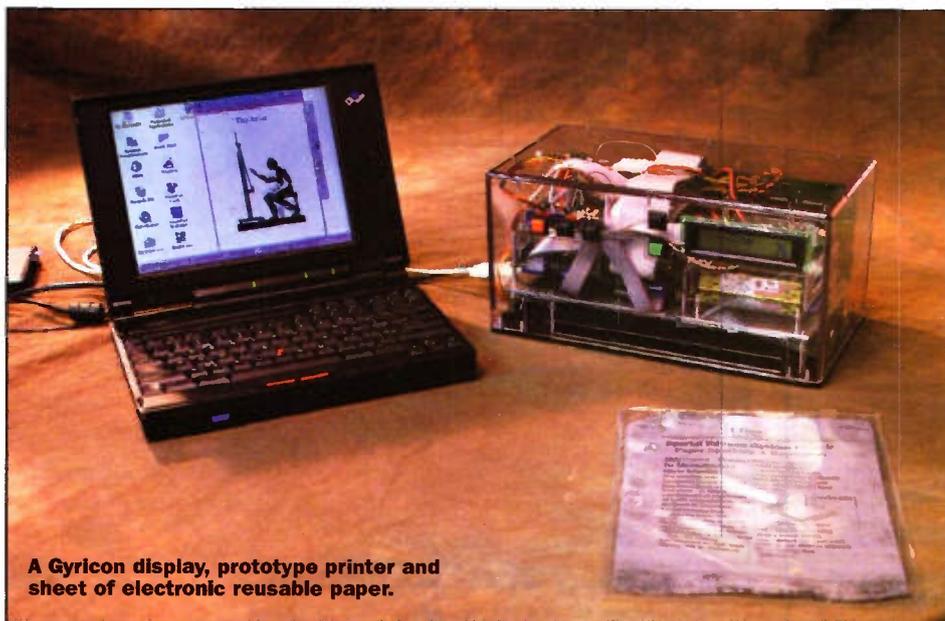
**Those tiny bichromal beads can be used to reproduce contrasting colours - not just black and white.**



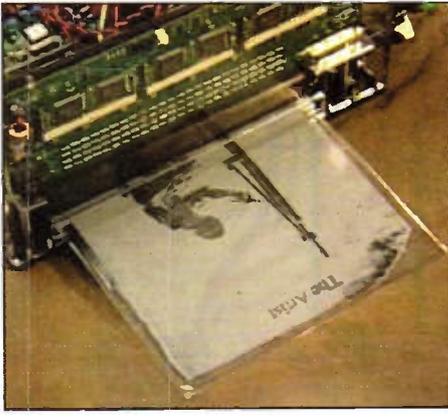
**A partnership with 3M means that Xerox's reusable paper can be manufactured in large enough quantities for commercial applications.**

of erasable 'paper', which has been christened 'Gyricon'. Although it has many of the properties of paper - Gyricon is viewed in reflective light, has a wide viewing angle, is flexible, and is relatively inexpensive - it's a completely new material.

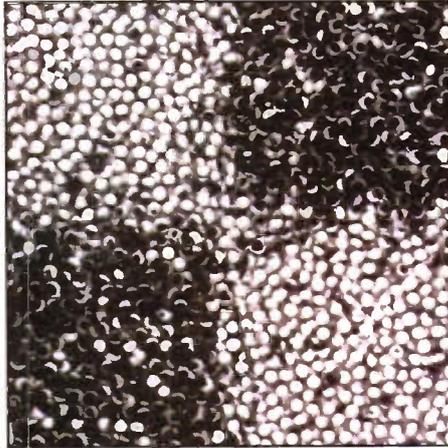
Each sheet of Gyricon is, in fact, a thin layer of transparent plastic in which millions of small beads, somewhat like the toner particles associated with photocopying and laser printing are randomly dispersed. The beads, each contained in an oil-filled cavity, are free to rotate within those cavities. They are 'bichromal', with hemispheres of two contrasting colours (e.g. black and white, red and white), and are charged so they exhibit an electrical dipole. When a voltage is applied to the surface of the sheet, the beads rotate to present one coloured side to the viewer. Voltages can be applied to the surface to create images such as text and pictures. The image will persist until new voltage patterns are applied. In other words, Gyricon is electrically writeable and



**A Gyricon display, prototype printer and sheet of electronic reusable paper.**



The Gyricon printing device could shrink sufficiently for it to fit into a purse.



Microscopic view of the bichromal beads that give Gyricon its properties

erasable! There are many ways an image can be created in electronic reusable paper. For example, sheets can be fed into printer-like devices that will erase old images and create new ones. The company reckons that Gyricon printers could be made so compact and inexpensive that you one could be carried in a purse or briefcase at all times. PARC researchers envisage a 'wand' that could be pulled by hand across a sheet of electronic reusable paper to create an



Xerox PARC researcher Matt Howard demonstrates a Gyricon sheet in the laboratory.

image. Incorporate a scanner and you have an 'all-in-one' printer, copier and computer input device.

Gyricon is also capable of being used as a traditional display, making it suitable for applications that requiring more rapid and direct electronic updating. Here, the Gyricon material might be packaged with a simple electrode structure on the surface. Because each Gyricon display 'sheet' is very thin and flexible, a number could be bound into an 'electronic book'. Electronics mounted in the spine of the book would include display management circuitry, non-volatile memory, power supply and a

computer interface. Pages could thus be stored, and the content changed at will. Imagine finishing a novel, and transferring an electronic version of the sequel (bought via the Internet, naturally) from your domestic information appliance to the 'book' ready for the next day's commuting? That assumes, of course, that we're not all working from home by the time Gyricon becomes a reality! Other applications of the material include wall-sized displays, fold-up displays and low-power portable displays. Of great relevance to the latter (and possibly the aforementioned electronic books) is the fact that Gyricon display's energy requirements are considerably lower than those associated with traditional reflective displays. It doesn't require backlighting or constant refreshing, and yet - claims Xerox - Gyricon is brighter than today's reflective displays. Although projected to cost somewhat more than a normal piece of paper, a sheet of Gyricon could be re-used thousands of times. Xerox is already working with 3M, which has the infrastructure needed to produce the material commercially.

Martin Pipe welcomes comments and ideas.

E-mail him as:

[martin@webshop.demon.co.uk](mailto:martin@webshop.demon.co.uk)

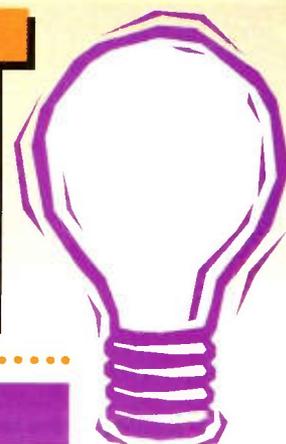
Or look out for him online! His ICQ ID is:

15482544



Nick Sheridon - Gyricon's inventor - and colleague Fereshteh Lesani show off the first roll produced by 3M.

# COMMENT



by Keith Brindley

## I have a prophecy.

Before I say what that prophecy is, though, I'll give the background. A long time ago, a young man called Bill Gates formed a company called Microsoft. Readers might have heard of it.

Microsoft came to prominence because of one very shrewd tactic. It took an already developed personal computer operating system from a personal computer manufacturer, made a few adjustments to it, and licensed the rights to use the operating system to a huge manufacturer of computers - IBM. Now, IBM being what it is - or at least was in those days - it sells millions of personal computers and so forms the basis of the personal computer we know today. Other personal computer manufacturers jump on the bandwagon also, and so the operating system - DOS - becomes used in tens of millions of personal computers worldwide. So for very little work indeed, Microsoft sees a huge financial return in the form of a royalty payment.

At this point it's worth summarising what's happened. Microsoft obtains some software that it perceives as useful, simply writes a few lines of software code to make it a Microsoft product, and makes a fortune. Note that Microsoft makes no hardware at all, so isn't lumbered with all the massive overheads that computer manufacturers themselves take for granted.

In search of new ways to increase revenue, Microsoft now reiterates this tactic over and over again to create other software products. For example, at the time DOS was so popular the next most important computer manufacturer in the world after IBM was Apple, which was developing its own operating system (known now as the Mac OS). Unlike DOS, the Mac OS is a graphical interface, far easier to use and much nicer for the user. Microsoft tries to license the Mac OS but Apple won't allow this, so Microsoft takes the graphical idea and creates its own version that it calls Windows.

Microsoft also tries to expand its product range, realising that computer operating systems represents a fixed market - usually users only have a single operating system on a computer. So it develops applications to run alongside operating systems, using the same tactic. It buys in a word processor, spreadsheet, presentation package and so on, and Microsoft Office is born. Other applications: a Web browser, an email

program, networking products, and so on, and so on, follow suit, until Microsoft has a full range of products and is selling about as many products as it can surely hope to handle. But still it wants more, and still the shrewd tactic it used from the beginning does it proud.

Until, one day, there are sufficient people who realise exactly what Microsoft's shrewd tactic is, and - more important - what it has done for the computer industry. Initially, of course, the tactic appears to be a great thing. Its initial result is the creation of solid, reliable programs and operating systems that are used by many people around the world. But the very same tactic turns into a monster if left unchecked - which, to date, it has been. You see, every time Microsoft sees a software idea that's useful and buys the product outright if the developer is willing to sell, or buys the developer if it's not willing, there is one less idea in the marketplace. In the beginning, this was all done in quite friendly and open ways. By the present time, Microsoft's dealings have become secretive and damaging - you only have to look at the evidence presented in the recent lawsuit against Microsoft to see this. Email messages between senior management from Bill Gates down, show exactly how Microsoft has targeted competitive companies to remove either their products or their companies. Statements from senior management in various computer manufacturers show how Microsoft has threatened them unless they supply only Windows with their computers. And so the evidence goes.

In effect, Microsoft's tactic has always reduced competition. By simply buying out good ideas, fewer good ideas exist. Bundling DOS or latterly Windows with a computer effectively railroads users into Microsoft products. Computer manufacturers just make the computers, while Microsoft just makes the money. And here we stand, with a large proportion of the computing world tied into Microsoft products and having little apparent alternative. The lawsuit result looks set to split Microsoft up into two distinct organisations - one for operating systems, one for applications.

But, where does that get us, and what's my prophecy? Well, I don't for one minute think that merely splitting Microsoft up into two will do any good. There'll just be two companies with the same tactic, that's all. After all, even while the lawsuit's been

proceeding Microsoft has still been buying up competitive companies or products, so why should splitting it up do any better? And besides, Microsoft's revenue naturally falls into these two main markets - operating systems, and applications - anyway. Formally splitting the company won't make a button of difference to overall revenue or how the company or companies operate.

No, what I prophesy is that Microsoft will diminish naturally, without any help from the legal system. At its current state Microsoft is as big as it can get. And when you're at the top, there's only one way to go - down. Yeah, sure, it'll take years for Microsoft's fall from grace, but fall it will. Microsoft's problem is twofold. First, the operating system battle is over. The industry has known for years that the operating system a user has on a personal computer is irrelevant. The network system merely has to cater for all personal computers (and their various operating systems), while the personal computers themselves are simply interchangeable components. And, as the ultimate networking system is the Internet anyway (which runs - always has done and always will - on non-Microsoft standards, and which caters for any computer operating system), it really doesn't matter whether a computer is a Windows one, or a Mac OS one, or a Linux one, or a Java one, or whatever.

Second, it's an industry acceptance that applications are getting cheaper and cheaper. So Microsoft's revenue from applications can only reduce as it cannot continue to charge its current overly high price while other equivalent applications are on the market at much lower prices. Currently, for example, you can buy a whole low-spec computer for less than it would take to kit it out with a full range of Microsoft software products.

While the computer industry has known these two things for several years, Microsoft, with astute marketing, has managed to keep their importance away from end users' eyes. However, the facts are slowly becoming apparent to users too. The lawsuit has highlighted them, the industry is screaming about them, and the price of Microsoft applications now finally shows Microsoft's untenable position.

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

## Free for all

The happenings centred around the free download of mp3 files recently are worthy of note. It's all to do with whether or not mp3 sound files - which have been created from audio CDs - can be freely swapped between users on the Internet.

The record industry, naturally, says not. It argues that these files are copyrighted and so it must not be legal to swap them with others. It has defended this stance with a lawsuit against Napster, one of the leading organisations that allows people to swap files. While the court case in the US has not finished at the time of writing, the current state is that the record industry has won a preliminary injunction against Napster, and the swapping of files over Napster has to be withdrawn pending the trial conclusion. Napster, meanwhile has managed to win a postponement of this injunction, to give time to the company to prepare its appeal. So, to date, Napster continues, but for how long - by the time this is published even - it continues is anybody's guess, and will be decided eventually in the US courts.

As far as the record industry is concerned, users who swap mp3 files by Napster do so illegally. But, for users who do swap mp3 files by Napster, any subsequent closure of Napster is in itself wrong. Napster and its users argue that copyright law allows anyone to allow friends to listen to CDs they own - letting a friend borrow a CD, say, is not illegal. Napster merely extends this, and allows users to swap with any other 'friends' who also use Napster. The fact that there are quite literally millions of Napster 'friends' is irrelevant according to Napster.

In fairness, the record industry is protecting its own assets. Of course, it says it is doing so on behalf of the artists who make the music in the first place, and there may be a grain of truth in this, however this would be more arguable if more of the costs of the CDs went to the artists themselves. As it is, the lion's share of the sales costs of CDs goes straight to the coffers of the record companies not the artists. And perhaps this is why users of systems like Napster actually do use them. They see that very little of any money they spend buying CDs goes to the artists, so don't actually view the swapping of files as anything wrong. Since systems like Napster have started, CD sales - far from declining, they have actually increased. Users would say that this is because by downloading mp3 files of CD tracks, they get a sample of what's available and so are far more likely to go out and buy the CD. This way, they make sure they get the value added extras that can't be downloaded - lyrics, photographs, sleeve notes and so on. With an estimated 20 million Napster users, there could be more than just a grain of truth in this.

Where the record companies need to take stock though, is that Napster is an easy target. Napster's servers hold the information about files and availability, and it's the servers that users log onto when they want to swap mp3 files. Users log onto a server (the client software on the users computer takes care of all this, automatically choosing the best server to connect to) to perform the swaps. So, take the servers out by legal means and the source of file swapping is ended. Or is it?

Where the record companies are making their error is that Napster's only one method of downloading mp3 files. By

plugging a thumb into the Internet dyke, they may have held back the inrush of mp3 files - for the moment. The Internet, though, is one huge dyke, and there are many other holes forming. Despite being a powerful group, the record companies simply don't have enough thumbs to go round. More important, the record industry doesn't yet seem to understand what it's up against.

Two other systems of swapping mp3 files are important, and will become targets of the record industry in due course. Unlike Napster, which is a fixed target due to the necessity of its servers for the Napster system to work, these other systems are effectively moving holes in the dyke and aren't so easy to plug up. This is because they are based on completely new methods of file transfer which, like FTP and HTTP, are generic methods in their own right. Napster on the other hand is specific to mp3 downloads.

The first we'll look at - Gnutella - allows users to connect directly to each other over the Internet, so no servers are required - in computer speak, it's a decentralised peer-to-peer system where each user's computer is simply a node on the network. There are Gnutella client programs (actually called - just to confuse us - servants) available for most computer platforms. Gnutella was originally developed by AOL for use in the AOL system, but was shelved when AOL realised the problems it could cause. However, several third-party developers have been working on it since, and it is now a usable - though little-known as of yet - system. Unlike Napster, Gnutella's generic, decentralised peer-to-peer system allows searching of servant computers for all file types - not just mp3s. The consequence being that video files could be just as easily downloaded - a fact which will eventually make the movie industry hot under the collar too.

The other new system that must make the record industry worry enough to quake in its boots is Freenet. This, like Gnutella, is a decentralised peer-to-peer file transfer method, but is rather more clever. Freenet employs intelligent routing and caching, which means that it learns to route requests more efficiently, it automatically mirrors popular data, it makes network flooding almost impossible, and it moves data to where it is in greatest demand. As such, it becomes virtually impossible to forcibly remove a piece of information from Freenet, as information is distributed throughout the Freenet network in such a way that it is difficult to determine where it is being stored. Also, both authors and readers of information stored may remain anonymous if they wish. Otherwise, Freenet - while in its infancy at the moment - will have all the same features of Gnutella, including the ability to search for and download any type of file.

There's no doubt, whatever the record industry thinks it's gaining by blocking a hole in the Internet dyke by shutting down Napster, the dyke is about to collapse upon it. Shutting down Napster is only an attempt to put off the time when it occurs and indeed, only brings forward the time when other systems emerge which cannot be shut down. Perhaps the industry should be putting more time and effort in looking at how to ride the wave when the dyke collapses, rather than vainly use its legal muscle trying to maintain its gross margins.

## RealNames Clears Path Through the Internet



RealNames at [www.realnames.com](http://www.realnames.com) is providing navigation to company and product names, quickly and accurately through Internet Keywords.

Internet Keywords allow people to use brand names, familiar words or phrases to easily find the information they are looking for on the Web. Users looking for companies, products and services on the Internet need only type in the name to get to the place.

Based on open standards, Internet Keywords is a universal naming system that uses everyday language in English and many other languages.

RealNames technology has been integrated into Microsoft's Internet Explorer browser, as well as by leading portal, directory and search services such as AltaVista, Dogpile, Infoseek, MSN, UKMax and Voila.

## Demon Tops Customer Satisfaction Study

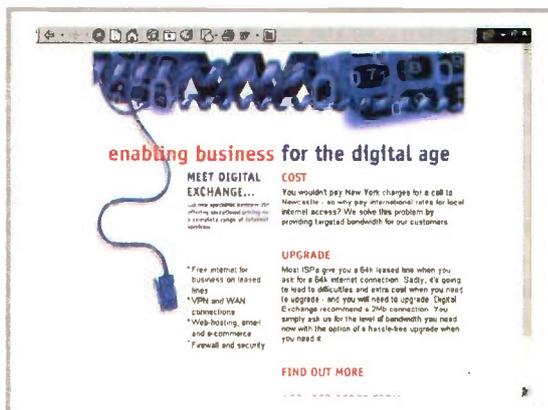


Demon at [www.let-it-be-thus.com](http://www.let-it-be-thus.com) topped the J.D. Power and Associates 2000 UK Residential Internet Service Provider Customer Satisfaction study, conducted by the US-based global marketing information firm. Other ISPs included in the study were LineOne, VirginNet, Freeserve, BT Internet and AOL, among others.

More than 1,800 households containing Internet users were questioned on the performance of their ISP in order to get the study results.

According to the study, Demon's strength is in its connection speed/access to the Internet, the top driver of customer satisfaction. Demon also excels in customer service and e-mail services.

## To Dot-Com or Not to Dot-Com?



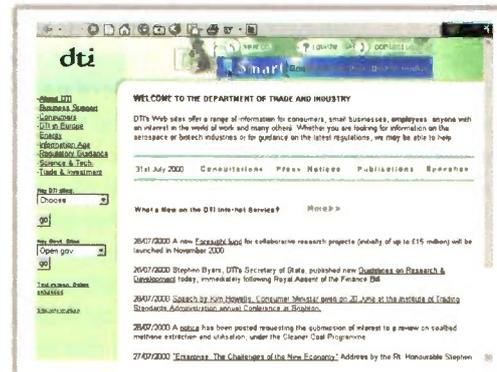
Small businesses risk losing huge investment in dot-comming their businesses without proper consideration. Digital Exchange is warning companies there are ten issues to address before thinking about buying new systems or paying for new staff and facilities.

In response to concerns, the ISP for the small-to-medium business market has published a new guide for SMEs thinking of going online. The report aims to address business and technology issues for a company considering a Web presence before they make any kind of investment.

The guide looks at issues such as bandwidth requirements, future personnel needs and investment in systems, depending on legacy applications and present capability.

The guide for businesses thinking of moving online is available from Digital Exchange at [www.digitalexchange.co.uk](http://www.digitalexchange.co.uk).

## E-Signatures Legal in UK



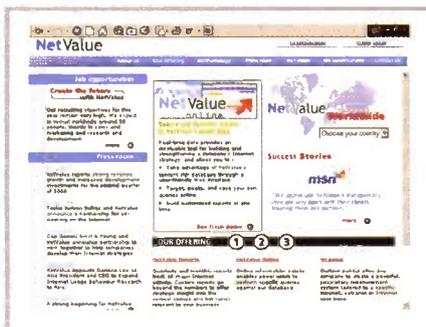
From the end of July an electronic signature is legally admissible as evidence in court in the same way as a hand-written signature according to the Department of Trade and Industry at [www.dti.gov.uk](http://www.dti.gov.uk).

This legal milestone brings the UK a step closer to its aim of becoming the best place in the world for e-commerce. Electronic signatures are essential if contracts are to be concluded over the Internet.

Businesses and people using the Web can now feel more confident knowing that e-signatures will be admissible as evidence in a court of law should a dispute arise.

Under the terms of the Electronic Communications Act 2000, electronic signatures and any certificate which supports them can be used as evidence in court in much the same way as a hand-written signature. The UK is one of the first countries in the world to pass legislation in this area.

## Women Clambering Online Across Europe



Data issued by Internet analyst Netvalue at [www.netvalue.com](http://www.netvalue.com) shows that the number of home Internet users in the UK now stands at 10.1 million, an increase of more than a quarter of a million new users since May. However, the most dramatic change is the split by gender: in June, a staggering 43.5% of Internet users were women. The number of women currently logging on to the Internet at home now stands at over 4 million in the UK.

## Goblet Makes E-Commerce History for Amazon



Amazon.com at [www.amazon.com](http://www.amazon.com) made e-commerce history on Saturday 15 June by delivering 250,000 copies worldwide of the latest Harry Potter book. The feat marks the largest distribution of one item in a single day. Amazon gave its first 250,000 orders a free upgrade to Saturday delivery, while the customers paid for standard shipping, which usually takes from three days to a week. The offer saved customers around £5 on shipping, and Amazon also took 40% off the book's list price.

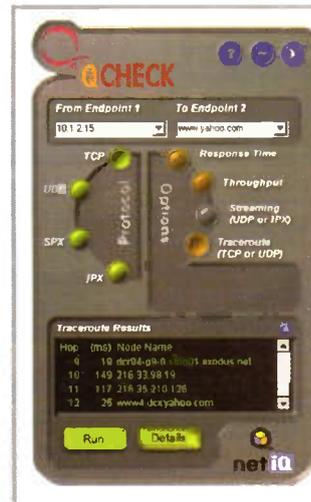
## Most Popular E-commerce Site

In the UK, the number of women visiting e-commerce sites in June was 2.8m users, a growth of over 400,000 users on the previous month. Women going on to make a secure connection on an e-commerce site grew by 56%, from 1.5m in May to 2.3m in June. Perhaps unsurprisingly for the holiday season, top sites are books and travel related. StreetsOnline remains the number one e-commerce Web site for both women and all Internet users, whilst expedia.co.uk re-enters the top 10 e-commerce rankings for the first time since March.

Ranking	Site	Unique visitors in June	Reach
1	Streetsonline.co.uk	823,820	18.6%
2	Amazon.co.uk	514,720	11.6%
3	Lastminute.com	334,670	7.6%
4	Egg.com	323,740	7.3%
5	Amazon.com	308,370	7.0%
6	Bol.com	220,460	5.0%
7	Expedia.co.uk	181,230	4.1%
8	Barclays.co.uk	179,850	4.1%
9	Nwob.co.uk	168,460	3.8%
10	Tesco.co.uk	165,740	3.7%

Figure: Top 10 e-commerce Web sites

## NetIQ Upgrades Free Network Performance Utility



NetIQ has upgraded Qcheck, its network performance utility for testing network response time, throughput and connectivity. Qcheck is a valuable troubleshooting tool for network engineers and help desk personnel who need to quickly determine whether the network is causing a performance problem. It is available for free at [www.qcheck.net](http://www.qcheck.net).

The new version, Qcheck 1.3, can now run traceroute tests between any two computers in a network, regardless of their locations. Traceroute will allow the operator to see the exact path network traffic is taking as it moves from one computer to another. To access a whitepaper on techniques for measuring network performance using Qcheck, visit [www.qcheck.net/qcheckpaper.pdf](http://www.qcheck.net/qcheckpaper.pdf).

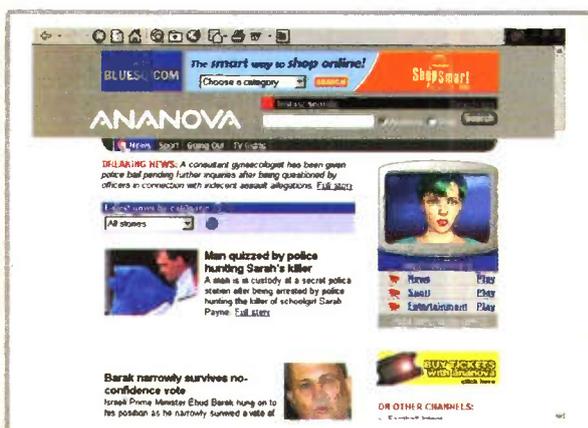
## Euro 2000 Effect

One conclusion that can perhaps be drawn is that, whilst Europe's top strikers were finding the net on the pitch, European women were surfing the Net off it.

This trend in the rapid growth of women online in June occurred across Europe, and suggests that as men were watching football, more women were going online.

In France, the number of female Internet users has grown by 358,000 new users in the period to 2.2m, whilst in Germany, female users now account for 37% of users.

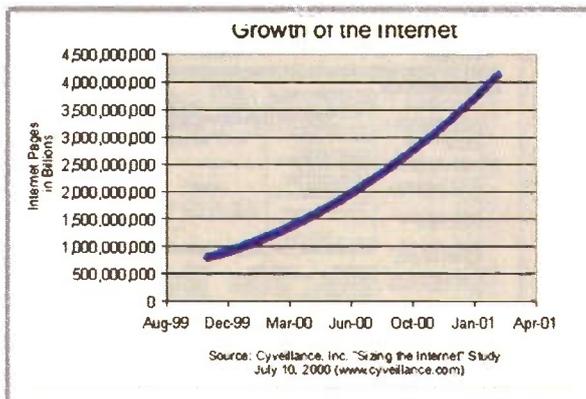
## Orange Acquires Internet Babe for £95 Million



Orange at [www.orange.co.uk](http://www.orange.co.uk) has acquired Ananova, formerly PA New Media, the interactive division of the Press Association at [www.pa.press.net](http://www.pa.press.net) for £95 million in cash. Ananova is the world's first digitally-rendered, fully-animated internet newscaster and information provider, exploiting sophisticated text-to-speech technology, and providing advanced search capabilities based on Web spidering, as well as personalisation and alerting capabilities.

Ananova provides access to innovative, digital news and entertainment services, and the company's considerable news gathering and generation capabilities.

## Internet Exceeds Two Billion Pages



Cyveillance has announced the release of a study, Sizing the Internet, which reveals that 2.1 billion unique, publicly available pages exist on the Internet.

The study also found that the Internet is growing at an explosive rate of more than 7 million pages each day, indicating that it will double in size by early 2001. Cyveillance further projects that the Internet's highest rate of growth is still to come.

Cyveillance used its NetSapien Technology, an artificial intelligence-based search-and-analysis technology, to model the Internet for this study.

The dynamic modeling technique used by NetSapien Technology is based on a continuum, so it can monitor actual growth and estimate the rate of acceleration or deceleration on an ongoing basis.

A white paper detailing the methodology of Cyveillance's Sizing the Internet study is available at [www.cyveillance.com](http://www.cyveillance.com). A real-time Web page counter displaying the most current tally is also available on the Cyveillance home page.

## Search Engine is Traffic Boost for Sites



WebSeed.com at [www.webseed.com](http://www.webseed.com) has introduced its fifth-generation search engine placement service consisting of a suite of new technologies and processes that help Web sites to achieve and maintain a prominent search engine presence.

The service is targeted at organisations that wish to improve their ability to be found through the major search engines and directories.

High search engine rankings are considered very valuable by on-line businesses. As a result, competition is stiff for popular search terms like 'MP3' or 'travel.' Higher rankings are achieved through a process of page modification and site

popularity enhancement that has, over the last year, become increasingly complex.

Just three years ago, pages were indexed by search engines based largely on their keywords, titles and meta tags, but today search engines consider at least nine attributes to determine relevancy. Services like WebSeed specialise in helping on-line companies maximise those nine attributes for their relevant search phrases.

After a site is re-engineered to maximise its relevancy scores, it is publicised to the search engines through a submitting process. WebSeed avoids using automated submitting software or services, in part because services like MSN Search have banned the use of such tools.

Once a site is fully spidered by the search engines - which can take up to 12 weeks - it usually experiences a significant increase in ranking positions. These results, however, depend in part on the keyword phrases being targeted by the site. Very popular search terms like 'travel' are extremely difficult to rank while more specific terms such as 'London Eye' are easier.

## Web is Strong Channel for Radio



Radio stations are increasingly broadcasting over the Internet as more consumers begin using their PCs to listen to the radio. Web radio is credited with a large part of this streaming audio and video use.

Yahoo at [www.yahoo.com](http://www.yahoo.com) and others such as GlobalMedia.com at [www.globalmedia.com](http://www.globalmedia.com), GetMedia at [www.getmedia.com](http://www.getmedia.com), RadioWave.com at [www.radiowave.com](http://www.radiowave.com), and WebRadio.com at [www.webradio.com](http://www.webradio.com) provide services that help radio stations broadcast and earn money online.

For radio stations, the main reason for moving online is to reach a new audience of overseas listeners or listeners at work that might otherwise not have access to a traditional radio.

## Apple Unveils HomePage iTool



Apple has released a more powerful and easier-to-use HomePage, which lets users almost instantly create their own personal Web site with no programming.

The new HomePage, one of Apple's four Internet iTools available free of charge for Mac users at [www.apple.com](http://www.apple.com), features a simpler user interface, allows greater personalisation of pages with more design templates and includes a rich image library.

## WAP Based Quizzes and Jokes Take Stress Out of Holiday Travel

Just in time for the summer holidays a novel way of using WAP mobile phones to chill-out during long journeys.

The new QuizGata and GataJoke services have now been launched. Parents can dial up a range of quizzes and jokes to keep holiday travellers entertained. It's also an ideal time filler for the stranded commuter.

Information about WapGata, QuizGata, GataJoke and the other GataGames can be found on the Web at [www.wapgata.com](http://www.wapgata.com) and on WAP at [wap.wapgata.com](http://wap.wapgata.com).

## European Internet Access Industry Continues to Reinvent Itself



According to the latest research from IDC at [www.idc.com](http://www.idc.com), the European Internet access market continues to grow rapidly, driven by sustained growth in new users, the success of subscription-free and unmetered access services, the emergence of broadband access technologies, and continuing price erosion.

Total user spending on Internet access services is forecast to increase at a 28% compound annual growth rate from 1999 to 2004, with great variation between countries and access technologies.

## UK Lacks Confidence in Buying Online

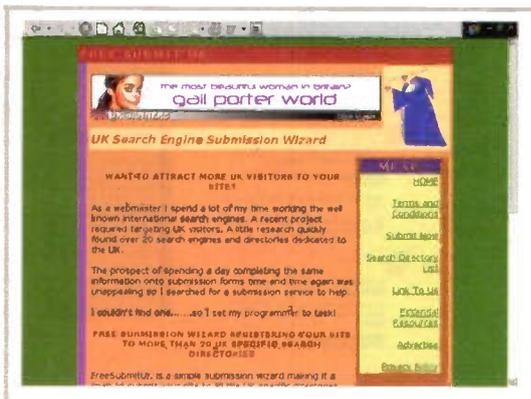
Zoom at [www.zoom.co.uk](http://www.zoom.co.uk) reckons that 1 in 4 UK Internet users who buy goods online are still concerned about security. And females remain cautious, as 1 in 3 are worried compared to 1 in 5 males.

In a recent survey conducted by zoom.co.uk only 13% of consumers aged 16+ interviewed for the survey have bought online - consumers need to be aware that there are steps they can take to surf and shop safely.

BBC Watchdog outlined its top ten tips last month on how online shoppers can take to protect themselves when buying online:

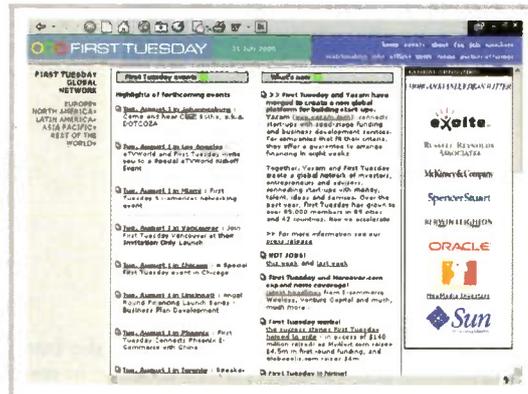
1. Pay by credit card. Only use debit cards when you are dealing with shops you know you can trust. When giving out these details, always make sure you are using a secure site.
2. Do some real-world research as well as internet research to compare prices. Net prices may not always be the cheapest.
3. Print out your order and keep any terms and conditions in a safe place along with the company's postal address and telephone number.
4. Don't let your common sense and shopping skills desert you when shopping online. The same principles apply.
5. Buy at your own speed, and get recommendations about sites from friends.
6. Check the company's policy on returning goods. If you have bought the item from a site abroad, you may find returning it costly.
7. Look out for loyalty schemes and email alerts where shops will contact you with bargains or new deals.
8. Be careful about spending too long surfing for a bargain - it can be addictive and costly.
9. Avoid early evening and lunchtime congestion when the US wakes up and logs on the Internet. Learn to keep any site you vaguely like in your 'favourites' so you can return to it quickly.
10. Be suspicious of deals that sound too good to be true

## UK Web Site Promotion with Freesubmituk



FreeSubmitUK at [www.freesubmituk.com](http://www.freesubmituk.com) provides Web site promoters a quick and easy system which enables them to submit their site to all UK specific search engines. Although there are thousands of submission tools catering for worldwide search engines, FreeSubmitUK is the only system that focuses purely on UK search titles

## First Tuesday Merges with Yazam

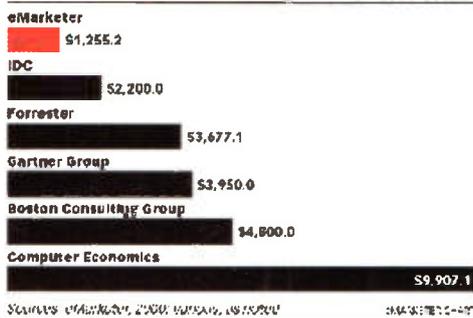


First Tuesday at [www.firsttuesday.com](http://www.firsttuesday.com), the global marketplace for entrepreneurs, and Yazam, a leader in international seed-stage investing and business development, have merged.

First Tuesday will maintain its brand and will operate as a wholly owned subsidiary of Yazam. Yazam's expertise in evaluating, investing and building early stage Internet companies worldwide will be complemented by First Tuesday's community, global network and marketplace.

## Worldwide Business-to-Business e-Commerce to Reach £750 Billion by 2003

### Comparative Estimates: Worldwide B2B e-Commerce Revenues, 2003 (in Billions)



A report issued by eMarketer at [www.emarketer.com](http://www.emarketer.com), one of the world's leading provider of internet statistics, projects B2B e-commerce will rise to £750 million by 2003. The newly-released 'eCommerce:B2B Report' is the first comprehensive look at the numbers behind B2B e-commerce, aggregating statistics and information from the leading internet research firms.

Following Forrester's headline-making prediction in August 1999 that worldwide B2B e-commerce would reach £1,000 billion by 2003, several research firms have come forward with disparate projections for the potential size of B2B e-commerce. In turn, eMarketer offers a relatively conservative estimate.

## enotate Receives 'Cool Stuff' Award from SearchPalm.com



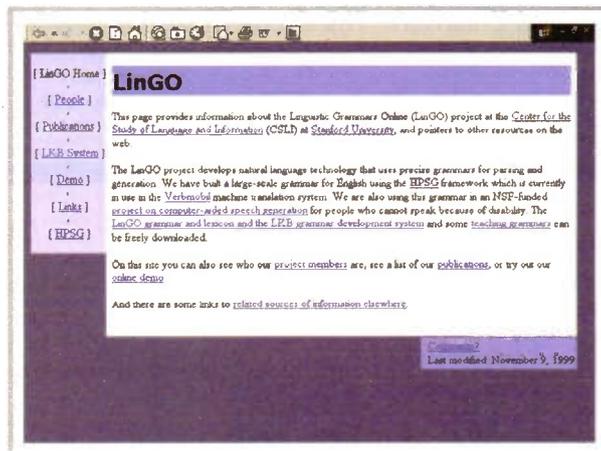
Informal Software's debut product, enotate, has received a 'Cool Stuff' award from SearchPalm.com at [www.searchpalm.com](http://www.searchpalm.com), the resource-oriented Web site that provides a variety of product information and links to software for Palm users.

The award is granted by SearchPalm.com staff, who select innovative, high quality hardware or software products that expand the functionality of the Palm organiser beyond basic applications.

enotate turns a stylus-based device, such as the Palm connected organiser, into an indispensable tool for everyday computing by transforming it into a direct, real-time extension to the PC.

With enotate, Informal Software allows users to have a digital napkin to annotate text, sketch ideas and draw directly onto their PC just as they would with traditional pen and paper.

# Linguistic Theory to be Basis for Intelligent E-Mail Response



Stanford University's Centre for the Study of Language and Information (CSLI) has announced the first commercial application of its LinGO technology.

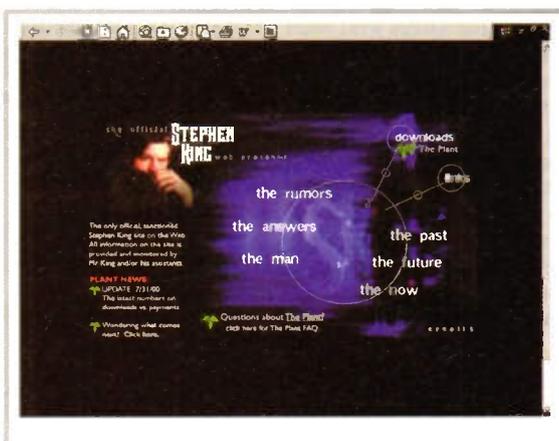
CSLI's research efforts in theoretical and computational linguistics have been adopted as the basis for an intelligent e-mail response system developed by YY Software. YY at <[yy.com](http://yy.com)> has incorporated technology freely available from CSLI at <[lingo.stanford.edu](http://lingo.stanford.edu)> into a suite of software products.

CSLI's LinGO Project is developing natural language technology that uses precise grammars for parsing and generating spoken or written phrases.

LinGO researchers have built a large-scale grammar for English using a framework known as Head-driven Phrase Structure Grammar (HPSG), which was invented at CSLI in the 1980s and has been refined over the years by an international research community.

HPSG theory derives its name from the fundamental notion that many natural language phrases are built around a single word whose dictionary entry specifies detailed information that determines the crucial grammatical properties of the phrase.

# King Trusts Online Readers



Horror writer Stephen King has now used his Web site at <[www.stephenking.com](http://www.stephenking.com)> to post the first two chapters of his new novel *The Plant*, which is about a vampire plant that takes over a publishing company.

*The Plant* will be posted as Adobe PDF files, and readers will be trusted to pay the author a dollar (60 pence) to download it. If King receives payment for at least 75% of the downloads, he will continue with his plans to post the remainder of the book on the Web.

# How the Cookie Crumbles



Microsoft at <[www.microsoft.com](http://www.microsoft.com)> is about to begin testing new software to provide Internet Explorer users alerts when there is an attempt to place cookies on their hard disks by Web sites they visit.

Cookies are used by many sites to follow the travels of Web surfers in order to provide them with personalised content and/or targeted advertising.

The new browser, which will be released in Beta before the end of the August, is also intended to give consumers an easy way to manage and delete cookies.

## Human Genetic Code - What Does it Mean for You?



Most experts believe that mapping the entire human genetic code offers almost unimaginable opportunities to better understand the human body and develop new medicines that target specific diseases.

However, according to GalaxyOnline.com at [www.galaxyonline.com](http://www.galaxyonline.com) writer Dr. Michael Fossel,

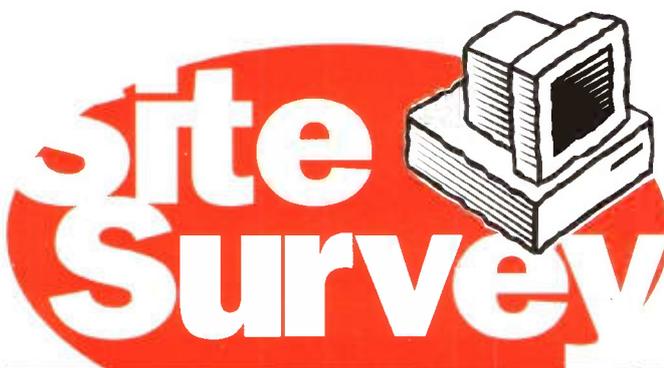
deciphering our genetic code offers at least one other significant benefit.

"When we remove the fundamental aging constraints imposed by cell aging, gene expression and the telomeres, your lifespan will increase significantly," noted Fossel in the latest installment of his four-part column. "You won't just live a few more decades, but you probably have several healthy centuries ahead of you."

Fossel, editor in chief of the 'Journal of Anti-Aging Medicine' and author of the book 'Reversing Human Aging,' has conducted exhaustive research in human life extension, and in this special investigation shares his controversial yet scientifically plausible findings.

Over the past month, this renowned researcher has offered his insights regarding extending the human lifespan in a weekly column posted at GalaxyOnline.com, the world's leading Internet supersite for science fiction and science fact information and entertainment.

"We can put a gene into a few cells here and there, but how do we put a gene into each of the estimated 100 trillion cells in your body?" asked Fossel. "What we need is a light switch ... that will let us control your aging. Once we have it, we can extend the maximum healthy human lifespan and reverse the effects of aging."



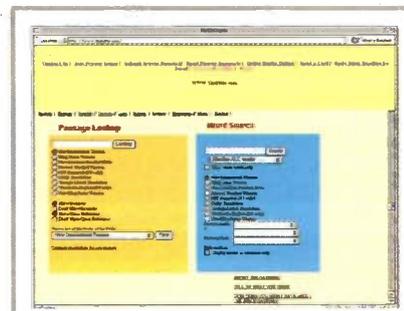
### The months destinations



The recent release of the fourth Harry Potter book created a significant stir. The series' publisher Bloomsbury has a Website that's worth a visit, at:

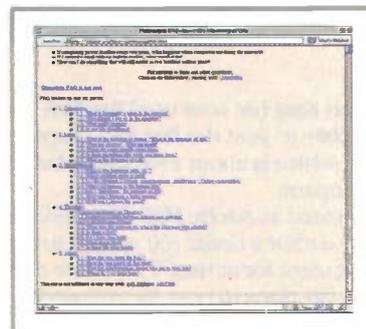
<http://www.bloomsbury.com/harrypotter/>. Here you can get a lot of Harry Potter information as well as send Howlers in email form to your friends (or enemies, if you prefer).

On a more esoteric note, here's a couple of Websites where you can find the truth. Not just any old truth, you understand, but the real truth! The Bible, at: <http://www.thebible.com/> is a valuable source of theological information, which features an extremely powerful search engine to help locate text and passages from any of the main bible translations. The Meaning



of Life FAQ, at: <http://singinst.org/tmo1-faq/meaningoflife.html>, on the other hand, is a rather more scientific coverage of why we're here.

Finally, music lovers who want to try out the systems that will take over where Napster leaves off if the record industry's legal battle against Napster succeeds should checkout <http://www.gnutella.co.uk>, where you'll find more details about Gnutella itself, and links to download software for whatever platform your computer runs on. Especially important looks to be the various Java tools such as Furi, which will (as they are written in Java) work on any Java-enabled computer. If you want to look at what will probably be the true future of downloadable music, video and other software, also checkout the main Freenet Website, at: <http://freenet.sourceforge.net>.



# Wave POWER

By Douglas Clarkson

## Introduction

As the consensus grows within the scientific community that global warming is beginning to show increasingly stronger effects on the world climate, the great challenge for the 21st century must be to aggressively cut back on production of carbon dioxide levels. In the short term the most practical approach and also the one that requires least initial investment is through recycling and energy efficiency.

The standard ISO 14001 which relates to minimising environmental impacts is a standard increasingly being sought after - especially in Europe and the Pacific Rim area - so that commerce and industry by implementing such a standard can reduce energy costs and use the good PR of such schemes in the promotion of its products.

The introduction of renewable sources of energy is at last beginning to kick in. Various countries such as Holland and Denmark have demonstrated a way forward which is both practical and economically attractive and which is not based on optimised conditions for exploitation of such resources. The development of technologies such as wind and wave power is a longer term strategy and requires more in the way of investment and is largely dependent on allowing it room in the marketplace for energy.

It is quite amusing to hear about the new renewable technologies on offer that are more 'expensive' than conventional fossil fuel technologies and that it is quite unreasonable for a market economy to shoulder these artificially high costs - especially when the competitors have plenty of tall smoke stacks. It is surely going to be the case that the cost of keeping with fossil fuels is going to be very very expensive when, for example, the real estate of Florida begins to vanish beneath the waves or the prairies turn into a dust bowl and America has to import grain at a 'market' price.

Our flirtation with wave power is only some 50 years old while that with wind power probably goes back many thousands of years. Curiously, the energy of ocean waves has in many ways determined the very appearance of the coastline of the planet but that only recently has the profile of wave energy been raised. There is still, however, very little public awareness of the existence of wave power programmes and as yet relatively few teams around the world which are developing such systems. The specific area of wave power provides a

very great challenge to the usage of what undoubtedly is a vast source of energy - considered globally to be in the order  $10^{11}$  to  $10^{12}$  W.

## Riding the Wave

The energy of wave power is of course derived from wind blowing over the surface of the oceans. Information regarding wave height for commercial shipping and more recently for oil exploration vessels in relation of wave height is now available through various satellite systems, so that data on wave height distribution is much more widely available and allows for much more detailed assessment of global energy reserves associated with wave power. This data provides, in addition, information about extreme sea and ocean conditions that a specific location is likely to experience within a given time period. A typical scenario is to describe the worst wave event likely to happen in a 100 year interval based on extended monitoring and application of statistics. It is data such as this that is used to define the structural strength and resilience of wave power structures (see Oceanor web page for wave maps).

## The World of the Wave

While it is possible to use satellite systems to indicate mean wave conditions, it is found that wave energy can vary significantly at the local level either as distributions on coasts or offshore and that factors such as sea floor height distributions and coastal topography are involved. So just as wind sites are examined by wind monitoring programmes, so too are the potential wave energy sites monitored. If anything, wave power is more 'localised' than wind energy.

The patterns of coastal erosion are also noted in relation to the variation of dissipated wave energy along the coast - with areas showing most erosion more likely to be present at wave energy 'hot spots'.

## Wave Numbers

The potential energy available in renewable energies is quite staggering. Beginning with wind power, if we calculate the kinetic energy in a cubic kilometre of atmosphere moving at a speed of 10 metres per second, then this is 50,000,000,000 Joules - assuming a density of air of approximately 1 Kg per cubic metre. This is approximately of the same order of energy taken

from the entire national grid of the UK in one second.

In relation to wave power, its value tends to be quoted in kW per metre of energy capture aperture. In mid Atlantic the average values will be around 70kW/m. The wind is a much more obliging quantity than waves, however, since wave energy is progressively lost with closer and closer approach to the shore. The spectacle of waves actually breaking on the shore is no more than the final completion of this energy degradation process. The compromise with wave energy sites therefore is to locate them in positions where there is still significant wave energy but without recourse to building structures for deep water, which are more expensive to build and maintain.

In the final analysis, however, wind energy is created by processes of natural conversion of solar energy. When comparisons are undertaken using values of watts per square metre, just below the ocean's surface the time averaged wave energy flow is typically five times denser than the wind energy flow 20 metres above the sea surface and between 10 to 30 times denser than the solar energy flow. There is in these figures an indication that wave power will be a valuable future asset to many coastal counties.

## Some Wave Power Survey Data

Figure 1 indicates a wave power with sea depth profile for South Uist who was undertaken by the Queen's University of Belfast for the Department for Trade and Industry. This shows that in relatively deep water, the value approaches 70kW/m but reduces considerably with proximity to the shore.

In the 'wave energy rich' Outer Hebrides, nearshore levels ranged from 7.3kW/m to 39.6kW/m and corresponding values for shoreline were 3.9kW/m to 34.9kW/m - indicating the necessity of good survey work as a pre-requisite for selection of potential wave power sites.

Similar wave surveys which have been undertaken by Norwegian researchers indicates off shore values in range 20kW/m to 41kW/m - showing that the seas off the

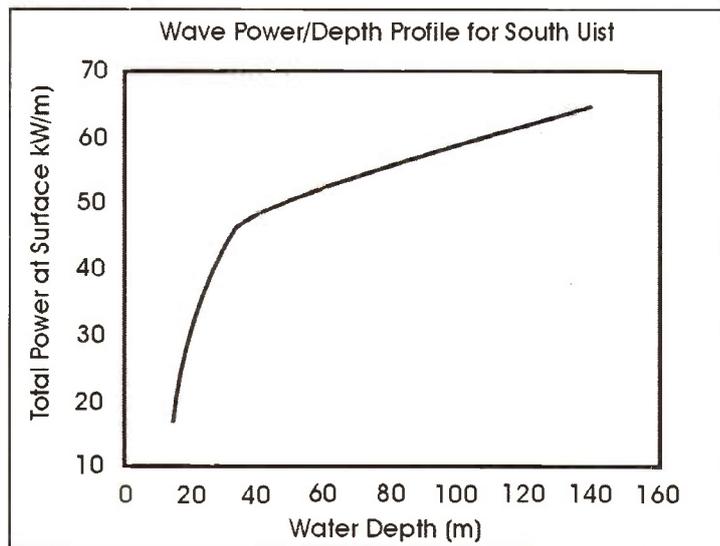
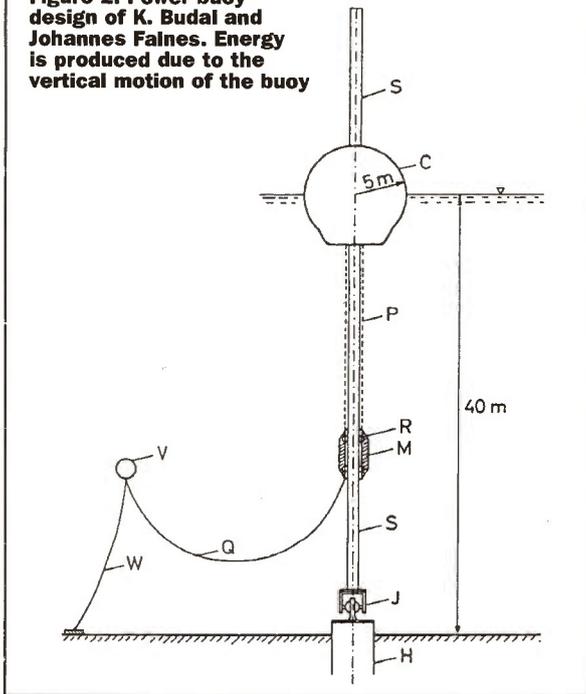


Figure 1. Wave power as a function of sea depth off South Uist

**Figure 2. Power buoy design of K. Budal and Johannes Falnes. Energy is produced due to the vertical motion of the buoy**



## Wave Energy - The Power Buoy

One system is basically related to the motion of an object floating in the water and abstracting energy from its vertical motion in the wave field. It origins can be traced to the pioneering work of the Norwegian K. Budal and with work being continued by Johannes Falnes of the Norwegian Institute of Technology at the University of Trondheim. The basic design of such a buoy is indicated in Figure 2. Useful levels of energy would be abstracted by an array of such objects on the sea/ocean surface. One of the powerful concepts behind this approach is 'small is beautiful' - of having an array of many essentially independent units rather than a few large devices.

Where the buoy moves vertically along a vertical rising support, there is a problem of coupling the kinetic energy of the floating unit to useful forms of energy. The method of power take off in this design is air pressure driven by an internal water volume. While this is a perfectly practical way of abstracting energy from the wave profile of the sea, this may be overcostly to implement.

Although based on a simple and direct concept and 1:10 scale model trials have demonstrated its effectiveness, this system has tended to remain on the drawing board, but may in the future return to favour with developments in materials science/manufacturing techniques. One comment made in relation to such a system is that while the costs of construction may be low, cost of operation and maintenance would be relatively high.

## Salter Duck

In the concept of the 'Salter Duck', initially conceived by Professor Alan Salter of Edinburgh University in the early 1970's while laid low with flu, wave energy is absorbed by 'ducks' as indicated in Figure 3.

These structures appear to 'nod' in response to the oncoming wave patterns and where this energy can be abstracted and converted into useful mechanical energy - e.g. to flow of seawater to drive a turbine, power generation is achieved. Such a system would presumably be designed to 'face' into a designated dominant wave direction. The design concepts for such devices have been extensively studied in wave tank models. If a line of such devices were installed then the wave heights behind such structures would be significantly reduced - which would be an attraction for areas facing severe coastal erosion. Is there perhaps a role here for a combined approach to sea defences and the generation of power from waves? This would be a means of making sea defences more 'affordable' if the very structures would generate electricity.

## Oscillating Water Column

Significant attention is being placed in the design of the so-called oscillating water column. The object of the system is to translate wave energy to up/down motion of air in a vertical column in which is placed a Wells turbine which in effect rotates in one direction for bi-directional flow in the column.

An early oscillating water column structure was built on the Norwegian coast at Toftestallen in 1984/85 and is shown diagrammatically in Figure 4. The structure had a concrete lower chamber and an upper air chamber with turbine/generator in a steel tower. Its rated output was 500kW. The system was tested for a period of two years during which the baseline operating performance of the design was satisfactorily confirmed. The upper steel structure, however, was swept away by a severe storm in the last week of 1988. Subsequently in 1990 and the operating company, by then Kvaerner Eureka, withdrew its commercial interest in wave power though the intention had previously been to rebuild the upper part of the system with concrete. Work in Norway, has continued at the design level of water column designs to increase efficiency of energy conversion by being able to vent

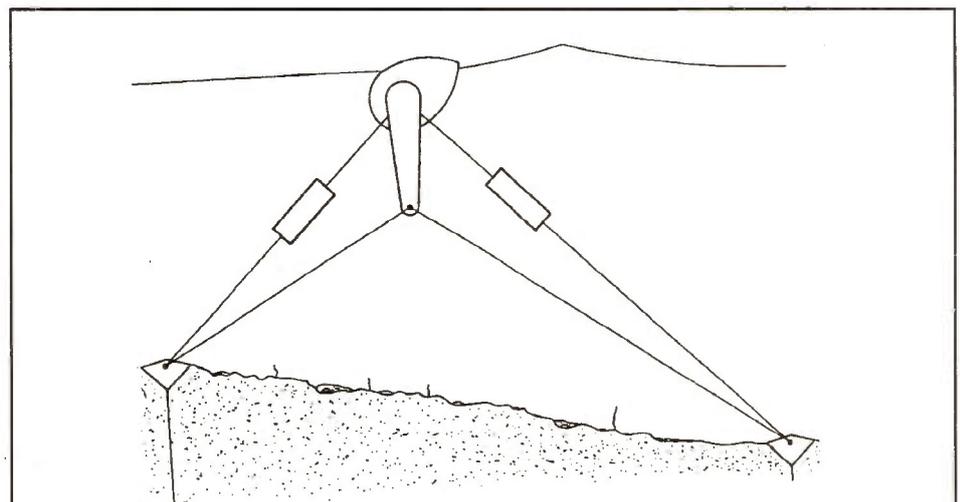
Outer Hebrides have much greater wave energies than the seas off Norway. The total available UK resource has been estimated at around 12 Gigawatts.

One curious finding, however, indicates much higher wave heights in the 1990's compared with the late 1980's. One explanation for this may be that there is less oil discharged into the sea from shipping than previously undertaken and that this is acting to allow wind energy to couple more efficiently to the sea surface.

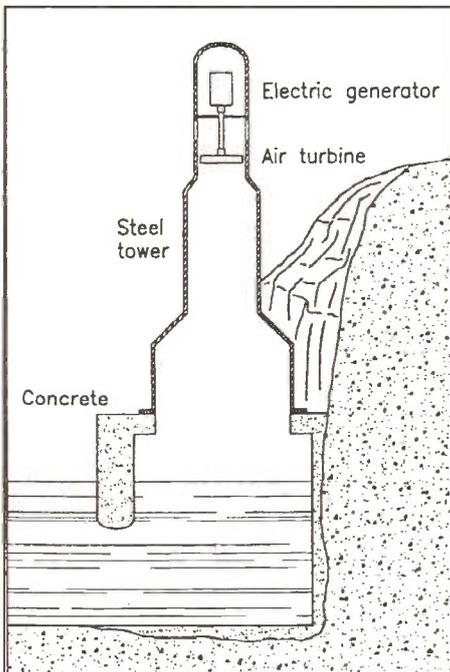
## Harnessing the Energy

The development of systems to abstract energy from ocean waves is still developing. Interest in wave power peaked at the time of the oil crisis in 1974 and passed through a crisis in 1982 when funding was withdrawn - probably at the behest of the Nuclear Power lobby in the UK. Until fairly recently funding has generally remained sparse in the extreme and projects in the UK, have largely been kept alive through EC funding. Lead Departments include those of Wave Power Group of Edinburgh University and the Department of Civil Engineering of Queens University Belfast. Within the last year, however, there has been a more 'up beat' analysis - especially with respect of developments in Scotland and Ireland and coloured with the wish to associate renewable energy with aspects of national culture and identity.

Funding of projects in Norway has probably been higher bearing in mind the relative size of the two economies through Norwegian researchers would also complain of a lack of funding. Wave power studies in Japan began with the experiments of Yoshio Masuda in the 1940's and where the use of wave power for small island communities had a specific relevance. Research has continued on through the 70's, 80's and 90's and with various developments now existing as demonstrable technology. There has also been a recent surge of interest in Australia.



**Figure 3. Basic design of the 'Salter Duck' as developed at University of Edinburgh. The structure absorbs wave energy incident upon it from a dominant wave direction**



**Figure 4. Oscillating water column constructed at Tofstallen in Norway in 1984/86**

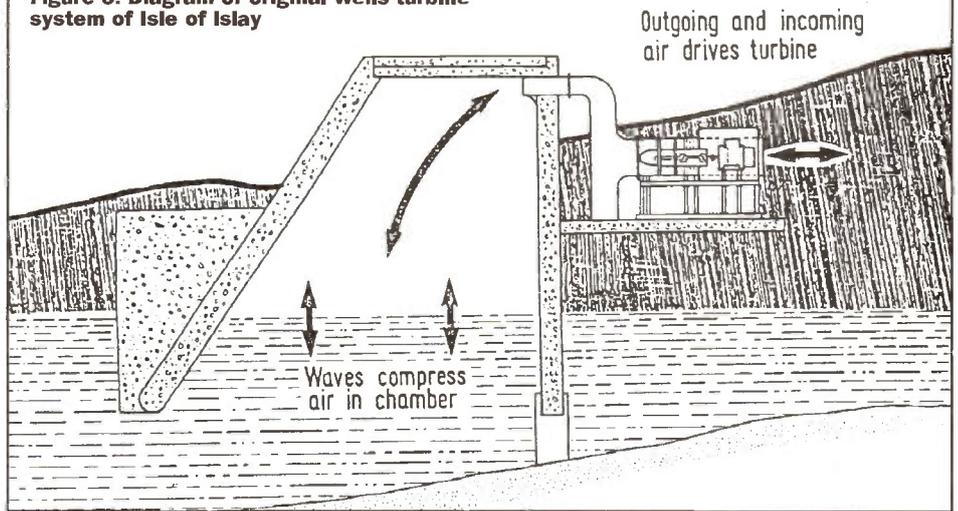
air to atmosphere or draw in air into the column system.

Extensive studies have been undertaken of a prototype Wells turbine system on the Island of Islay in the Western Isles of Scotland. The system is shown diagrammatically in Figure 5. Photo 1 shows the Wells turbine facility during construction. Photo 2 shows the main concrete construction of the enclosed concrete wave chamber and Photo 3 a view of the installation looking out to sea. This system developed by the Department of Mechanical Engineering at Queens University Belfast has been studied extensively during its successful eight-year operational life, which has just ended. The Department has secured funding to develop a larger Wells Turbine system with a rating of 500kW in the same area in association with the Scottish company WAVEGEN. This LIMPET development, created as a commercially sized plant, is being used as a demonstration site for anticipated commercial sales and is currently being commissioned.

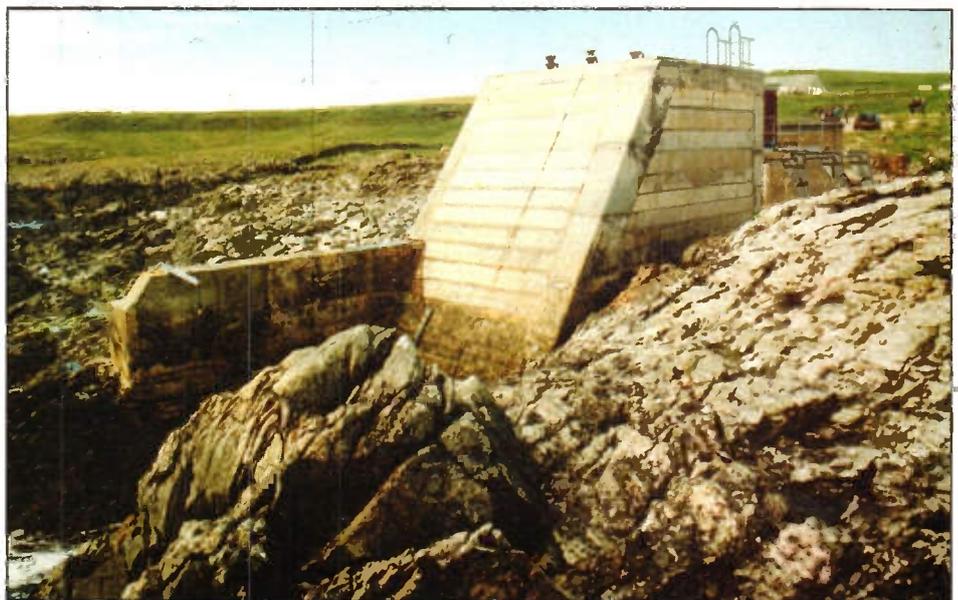
A significant development in oscillating water column technology was certainly marked by the emergence of the OSPREY (Ocean Swell Powered Renewable Energy) system shown in Photo 4 on the day of its launch on 2nd August in 1995. The system had a rated power generation capacity of 2MW. The key individual behind the development is Allan Thompson of Applied Research and Technology Ltd of Inverness. The wave power arm of the company trades under WAVEGEN. It was the practical experience of marine engineering, derived principally from offshore engineering services for the oil industries that gave the necessary practical expertise to design and develop such a structure. This demonstrates the very self evident fact that people who can survive in the tough commercial sector have plenty of good common sense to offer in matters relating to application of marine technology in new areas.

Unfortunately the OSPREY was damaged

**Figure 5. Diagram of original Wells turbine system of Isle of Islay**



**Photo 1. Original Wells turbine facility during construction on Islay (Courtesy ETSU)**



**Photo 2. Main concrete construction of the enclosed concrete wave chamber of the original Islay system. (Courtesy ETSU)**

by excessive sea action before it could be positioned securely on the seabed in the seas off the North Coast of Scotland. The experience obtained with the original OSPREY has led to the development of the OSPREY 2000 a modular low cost composite steel/concrete structure, which allows more

rapid installation. The device is designed to be operated in 15m of water depth within 1km of the shore and has a rated 2MW generating capacity. Based on the specification of the OSPREY 2000 unit, WAVEGEN have been advised by the Irish government that they were the sole



Photo 3. View of the completed installation of the original Islay system (Courtesy ETSU)



Photo 4. OSPREY on its launch on 2nd August 1995. (Courtesy WAVEGEN)



Photo 5. View of turbine waves of LIMPET 500 (Courtesy WAVEGEN)

successful bidder for the AER III (Alternative Energy Requirement III) wave energy tender and so OSPREY 2000 is likely to find its first implementation in Ireland.

## LIMPET 500

LIMPET is an acronym for Land Installed Marine Powered Energy Transformer and WAVEGEN is currently commissioning the first of these units on Islay, not far from the previous device referenced previously. The design and construction of LIMPET is very much civil engineering rather than marine engineering and will allow for reduced maintenance costs based on a totally sea based system. The rated capacity of the first phase is 500kW and with the option to add additional sections to provide further capacity. Use is made of two counter rotating Wells turbines. The photos of LIMPET under construction give an indication of the scale of the civil engineering involved. The images of the turbines also indicate how the system presents a significant increase in scale based on the original system on Islay.

The oscillating water column system is essentially a modular system, where if the design of such a system is optimised for efficiency, cost and survivability, it presents a unit of production, very much like a windmill facility. In fact schemes implementing oscillating water columns are also planning to implement wind turbines to enhance the energy efficiency of the engineering investment and to give a more uniform level of energy delivery.

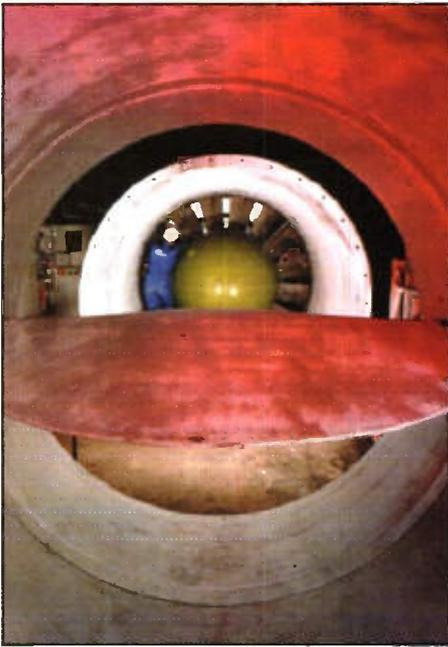
## Optimising the Oscillating Water Column Design

A single water column presents inherent limitation in abstraction of energy from the oscillating wave motion. During various periods of the oscillatory cycle, the turbine will tend to stall and energy is required to either maintain its velocity or re-initiate rotation. As part of a project largely implemented by the Department of Mechanical engineering at Edinburgh University, professor Alan Salter is developing a twin column oscillating water column device which aims to abstract energy with increased efficiency. One line of development is to be able to control the angle of attack of the Wells turbine blades with phase of the oscillatory cycle to generally improve turbine efficiency. The other development is to utilise twin columns with a rapid shutter switch to optimise cyclic flow between columns so that flow across the turbine is optimised.

Such as system is being developed on an island in the Azores and with participation from University of Cork and Libson in its development.

## A Link With Hydrogen

The best power generation areas are in deep ocean, far distant from centres of population and could, therefore, be a problem economically. One option for the utilisation of such 'energy hot spots' is to use them for the generation of hydrogen as



**Photo 6. Detail of butterfly valve designed to control flow of air across turbines of LIMPET 500 system (Courtesy WAVEGEN)**

a component for fuel for vehicles - so that such vehicles would be non-contributing to green house gas effects. After all the massive investment in Nuclear Power, however, and with the question mark over its ultimate fate, it is a little ironic that there is relatively little interest in the development of such systems.

## Tapchan (TAPered CHANNEL)

The Tapchan method would enhance the geographical topography of a coastline and focus wave energy to a given location in order to allow increased wave energy to fill locally based reservoir from which run off through a conventional hydro turbine can generate power. One such system has been implemented in Norway as a scaled down



**Photo 7. Detail of one of the turbine units of LIMPET 500 (Courtesy WAVEGEN)**

version of a more ambitious project and has been shown to operate satisfactorily within its design limit. There may well be specific coastal areas, which present attractive features for such a development. Also, such systems are easier to operate in areas with small tidal variations.

A consortium of Norwegian companies has recently won a contract to construct a tapchan wave power plant at Baron on the south coast of Java in Indonesia. The selection of the final site was based on



**Photo 8. (islay476.jpg) Detail of cliff top construction of LIMPET 500 wave power facility (Courtesy WAVEGEN).**

extensive local wave measurements and satellite data assessment.

## The PELAMIS Wave Energy Converter

A significant and interesting development within the field of wave power has been the emergence of the PELAMIS wave energy converter, which is the product of Ocean Power Delivery Ltd of Edinburgh. With the company only being established in January 1998, it has already successfully bid for a contract to install a pair of 375kW prototype devices off the coast of Islay under the 1999 Scottish Renewable Obligation (SR03). Installation is planned for early 2002. The company is highly confident of a large potential world market for its novel design.

The PELAMIS system is a semi-submerged structure, which consists of cylindrical sections linked by hinged

joints. The sections of the device respond to motion of the waves and the flexing of the joints causes high-pressure oil to be pumped through hydraulic motors which in turn generates electricity. Adjustments to the linkage tensions allow the energy uptake to be maximised for small seas or for survivability in heavy sea conditions. A given floating unit is flexibly moored to allow it to swing into incoming waves. A 750kW device will be 150 metres long and 3.5 metres in diameter. The PELAMIS design is certainly attractive since it is likely to be able to be operated in relatively deep water, which would allow it to collect higher levels of wave energy. No doubt there will be significant interest in the trials of this prototype device.

## Summary

The world of wave power has in many ways been a late starter - due very much to a lack of funds for development but there is now an emerging of a market in wave power devices which should see the beginnings of installed wave power capacity around the world.

## Points of Contact

There are many excellent internet sites relating to wave power. A selection is listed below.

[http://oblea.oceanor.no/wave\\_energy/](http://oblea.oceanor.no/wave_energy/)  
<http://www.wavegen.co.uk>  
<http://www.oceanpd.com>  
<http://www.inete.pt/ite/weratlas>  
<http://www.sopac.org.fj>  
<http://www.waveenergy.dk/>  
<http://www.jamstec.go.jp/jamstec/MTD/Whale/>

# Earth's Magnetic Field STANDS OFF SOLAR WIND

*Fleets of spacecraft are on route to space to monitor deadly electrical and magnetic fields around the earths' atmosphere. Electronics and Beyond reports.*

An unseen struggle rages in space close to the Earth. The million miles per hour solar wind, a gas comprised primarily of electrons and protons, relentlessly streams toward our planet. It is held at bay by the Earth's vast magnetic field, which deforms under the onslaught of this solar gale, like a jellyfish buffeted by water currents, or a large tent flapping in a wind storm.

## Solar Wind

The solar wind compresses the Earth's magnetic field to about 40,000 miles (64,374 kilometers) from Earth on Earth's dayside and stretches it to about 800,000 miles (1,287,000 kilometers) on the night side. This volume of space containing the Earth's magnetic field is known as the magnetosphere. Once solar wind particles have penetrated the magnetosphere, they are guided by Earth's magnetic field.

The electrically charged particles of the solar wind infiltrate Earth's magnetic realm with an intensity and impact that depends on solar conditions and direction of the magnetic field carried by the solar wind.

Cluster on launchpad



Solar detectors

Electrons and protons spiral down a funnel-like region of the magnetic field above Earth's day-side polar regions and hit the upper atmosphere, eventually creating the haunting glow that are the northern and southern lights. At the same time, these particles generate electrical currents that distort Earth's magnetic field, especially at high northern and southern latitudes.

The most severe disruptions of the magnetic field are known as geomagnetic storms, and these electric currents and energetic particles occasionally disable satellites, radio communications, and power systems. This interaction is very complex and researchers do not totally understand the effects of the solar wind on the Earth.

The magnetosphere's enormous size and complexity have made it impossible to understand with isolated spacecraft. Cluster II, a fleet of four identical spacecraft, will explore portions of this turbulent region during the summer of 2000. The space fleet is currently making its way into position having been launched in July.

## Surveying the Magnetosphere

Each Cluster II spacecraft will be positioned so that each is located at one of the four points of a pyramid. This arrangement will allow three-dimensional structures to be described, for the first time, in both the magnetosphere and solar wind. Instruments aboard Cluster II will observe the response

of Earth's magnetosphere to the ebb and flow of the solar wind in ways never before possible.

Distances between the Cluster spacecraft will be adjusted throughout the mission in order to study different regions and plasma structures. Comparison of simultaneous measurements from the different spacecraft will be combined to produce a three-dimensional picture of plasma structures.

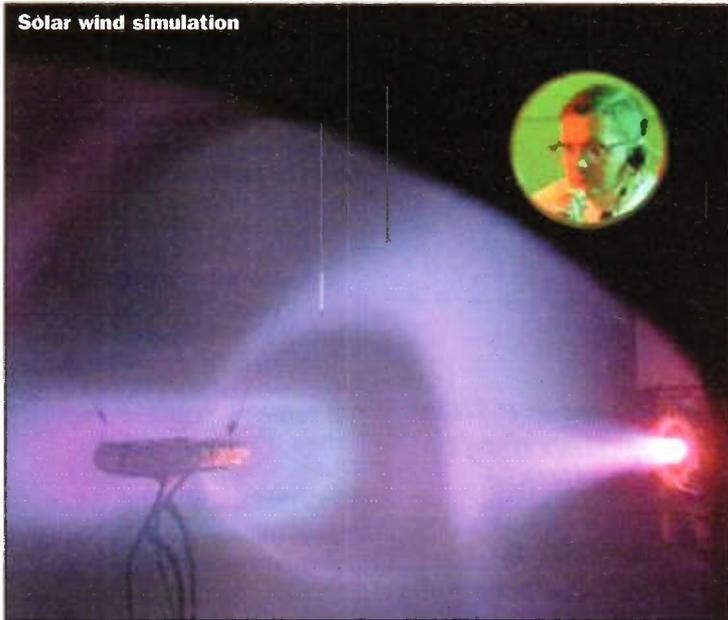
Because the separation of the four spacecraft will vary from about 400 hundred miles to more than 10,000 miles (643 to 16,093 kilometers), scientists will be able to study several of the structures, which characterize the Earth's magnetosphere.

These include the bow shock wave that stands in front of the sphere as the solar wind is deflected, polar cusp regions of the magnetic field and temporal and spatial structure of the dense plasma in the center of the tail of the magnetosphere on Earth's night side called the plasma sheet.

The Cluster II fleet was launched in pairs into a polar orbit from the Russian Aviation and Space Agency Cosmodrome, Baikonur, Kazakhstan, aboard two Soyuz-Fregat rockets. The launches, which feature a four-minute window, are scheduled for July and August 2000. The spacecrafts' intended apogee (farthest point from the Earth) will be about 74,000 miles (119,091 kilometers) and its perigee (closest point) will be about 12,000 miles (19,312 kilometers).

Each Cluster II spacecraft is cylindrically

Solar wind simulation



shaped, measuring 9.5 feet (2.9 meters) in diameter and 4.3 feet (1.3 meters) high, and weighs about 1,213 pounds (550 kilograms). An additional 1,430 pounds (649 kilograms) of fuel is included for orbital maneuvering. To maintain a stable orientation in space, each spacecraft will spin like a slow gyroscope, making one complete revolution every four seconds.

### Cluster II Science Instruments

During its initial two-year mission, the Cluster II spacecraft will conduct scientific investigations using a complement of 11 instruments and support provided by an international team of investigators.

Instruments onboard the Cluster II spacecraft include: **Active Spacecraft Potential Control (ASPOC)** This reduces the electric charge on the spacecraft, so very low-speed electrons can be measured. **Cluster Ion Spectrometry (CIS)** This measures the relative abundance of protons and helium nuclei and determines their

three-dimensional distribution in the solar wind and magnetosphere.

**Digital Wave Processor (DWP)** - provides data processing for the plasma wave instruments.

**Electron Drift Instrument (EDI)** - determines the strength and direction of the ambient electric field.

**Electric Fields and Waves (EFW)** - measures fluctuating electric fields in the plasma surrounding the spacecraft.

**Fluxgate Magnetometer (FGM)** - measures static and fluctuating magnetic fields at the spacecraft.

**Plasma Electron and Current Experiment (PEACE)** - provides three-dimensional measurements of electron distributions in the solar wind and

magnetosphere.

**Research with Adaptive Particle Imaging Detectors (RAPID)** - measures energetic ions and electrons.

**Spatio-Temporal Analysis of Field Fluctuations (STAFF)** - measures high-frequency waves in the local plasma.

**Wideband (WBD) Plasma Wave Investigation** - detects very high frequency plasma waves at very high time resolution.

**Waves of High Frequency and Sounder for Probing of Density by Relaxation (WHISPER)** - uses high-frequency plasma waves to probe surrounding plasma, determining the local density of charged particles.

Cluster II will join the Solar and Heliospheric Observatory (SOHO), which launched December 2, 1995. This is the second cooperative solar-terrestrial project between the European Space Agency (ESA) and NASA. SOHO and Cluster constitute the ESA Solar Terrestrial Science Programme, the first cornerstone mission of ESA's long-term initiative.

Each spacecraft will operate in concert with Geotail, a joint Japanese/NASA satellite, and NASA's Wind and Polar missions, to provide coordinated measurements throughout the geospace environment.

The Wind and Polar missions, along with NASA's contributions to SOHO, Cluster and Geotail, constitute the International Solar-Terrestrial Physics (ISTP) science initiative, whose purpose it is to understand how the Earth's geospace environment responds to changes in the solar wind.

For more detailed information about the Cluster II spacecraft and its science mission, visit check:

<[international.gsfc.nasa.gov](http://international.gsfc.nasa.gov)> and <[sci.esa.int/cluster](http://sci.esa.int/cluster)>.



Solar heliospheric observatory launch

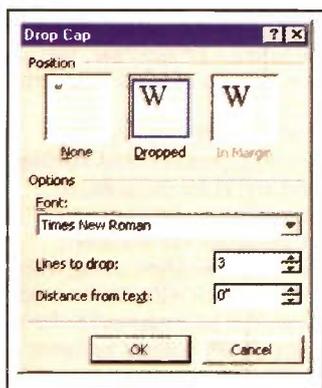


Solar heliospheric observatory on pad

**F**or the last few months I've shown you how to do various things in MS Word 97 and we're coming to the end of the topics I wanted to cover here. However, we've not looked at everything I could have included - far from it. So to conclude our treatment of Word for the moment, I thought it would be interesting to pick up on a number of interesting and little known, yet unrelated, facilities and tools.

## Drop Capitals

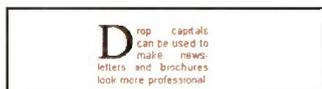
For example, did you know that Word allows you to use



drop capitals? If you're not familiar with the terminology, a drop capital is a very large initial letter as frequently used on the first paragraph of magazine and newspaper articles. You could use them, for example, to make a newsletter or a brochure look more professional.

To use a drop capital, put the cursor in the relevant paragraph and select Drop Cap... from the Format menu. The window shown here will be displayed.

You'll see that there are three options, the first of which allows you to revert to non-drop capitals and the other two of which will insert a drop capital in two different ways. You can also choose the size of the drop capital and the spacing. And having inserted the drop capital, you can even change its font or its colour but be careful not to overdo this. Here's an example of the sort of effect which you can achieve this way:



## Hyperlinks

Did you know that you can put hyperlinks in your Word documents that work in much the same way as those you'll

# Software HINTS & TIPS

by Mike Bedford

*It's a potpourri this month as we take a quick look at some of Microsoft Word's lesser known facilities.*

find in Web pages? Actually, there are two types of link - one is to external documents, perhaps on the Web, and the other is to bookmarks within your Word document.

Putting in a link to a Web page is easy. Just type in the URL and, in most cases, Word will recognise it as a reference to a Web page and will turn it into a link automatically. Just try it now by typing [www.maplin.co.uk](http://www.maplin.co.uk) into a Word document. As soon as you've finished typing it will turn blue and will be underlined to indicate that it's a hyperlink. An example is shown below. To prove that it truly is a link, log onto the Web and then click on the link. You should find yourself transported to the Maplin Web site.

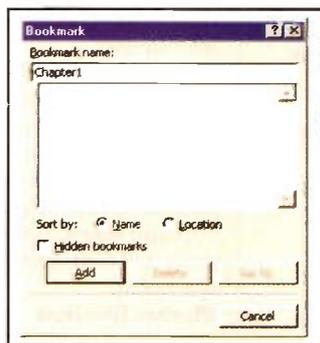
Of course there are times when you want to include a URL in a document but you don't want it to be an active



hyperlink and there are times when Word won't recognise that what you type is a URL. A growing number of URLs, for example, aren't prefixed by www and if you don't include the http:// in front of these Word won't know it's a URL. In either case, the answer is to highlight the text and then use the Hyperlink... option in the Insert menu. To turn text into a true hyperlink type the URL into the "Link to File or URL" box at the top of the window, to turn an active link to ordinary text, click on the "Remove Link" button. This facility also allows you to link to other files stored locally on your PC's disk and these don't have to be Word documents I'll leave you to figure out how to do this.

## Bookmarks

The Hyperlinks window is also used to create the other type of hyperlink - to bookmarks in the document you're working on. This could be used, for



example, to jump directly to chapters or sections in a document from a table of contents at the start. Before you can insert these links, though, you need to insert the bookmarks at the correct places. To do this, put the cursor at a place in the document that you will want to jump to. Now select Bookmark... from the Insert menu. Simply type a name for the bookmark into the "Bookmark Name" box and click on the Add button. Note that spaces and a number of other special characters such as full stops cannot be used in bookmark names. Now, to create a link from somewhere else in the document to this bookmark, go to the Hyperlink window and click on the lower of the two Browse... buttons. All you have to do now is double click on the name of the bookmark you want to create a link to.

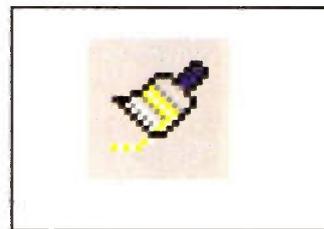
Of course you won't necessarily want all your hyperlinks to be shown in blue and underlined (or in purple once you've clicked on them). Although this is the convention for Web pages, HTML does

allow you to change the appearance of links and if you're linking to chapters within your document you may well not want it to look like a Web page. There are two options and I'll just provide brief details and allow you to try it out yourself. One option is to edit the link, removing the underlining, colouring it black and so forth. The other is to redefine the format of the links, for both the visited and the unvisited ones - take a look at Format > Style for some clues.

## Format Painter

Have you ever used the format painter? I hadn't either until recently but it can be very useful. It allows you to copy the formatting from one part of a document and apply it to another. So, for example, perhaps you've used a particular combination of font, size and colour and you want to use that same combination in another paragraph you've just typed. The quick way is to use the format painter. Select a portion of text you want to copy the formatting from and click on the following icon on the standard toolbar.

You'll notice that a paste brush will appear next to the cursor. Now simply click into the paragraph you want to copy the formatting to and it will all happen automatically.



## Over to You

It could be argued that if you've lived without a feature of Word until now you can live without it for good. I disagree. You may have managed without a particular feature but that doesn't mean that you couldn't produce better results or improve your productivity if you learn how to use the package better. So, despite the fact that we're now taking a break from hints and tips on how to use Word, I trust that you'll continue to delve into the facilities on offer and so improve your word processing skills. You don't have to buy a book, just peruse the menus, look in Help and try out those features you've not used before. It's over to you.

# The Very LONG WAVES

PART 6

George Pickworth reviews the early detectors from 1897 to 1930.

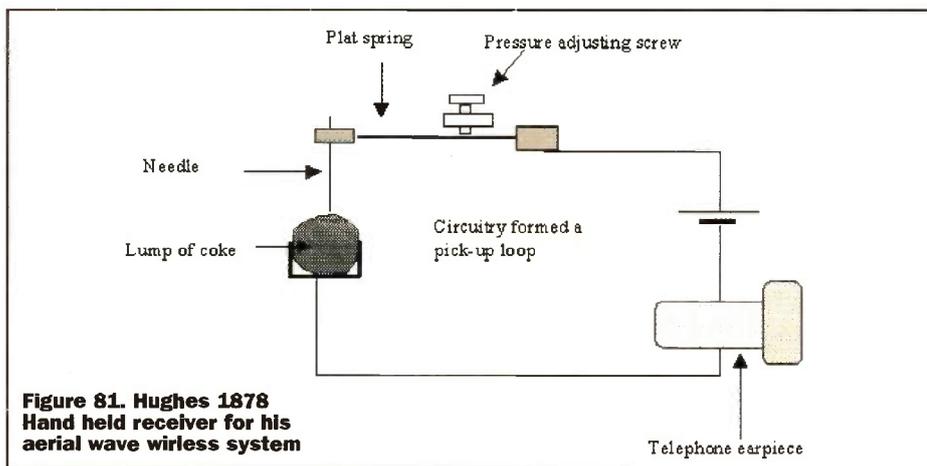


Figure 81. Hughes 1878 Hand held receiver for his aerial wave wireless system

In this final part of the study of the very long waves, we look at the evolution of radio detectors from those employed with wave train spark transmitters to continuous waves detectors employed by the very long wave, transoceanic super stations. The superstations were first to radiate continuous waves and operated from 1906 to the early 1930's when they were superseded by short wave systems.

## Misnomer

It is understandable that before the role of antennas was recognized, pioneers

believed that devices found to empirically respond to an electrical discharge were directly detecting "ether" waves. Hence the term detector was coined and although a misnomer it was nonetheless perpetuated and applied to all manner of devices most of which could be better described as demodulators. Nonetheless the common usage of the term detector is used in this study.

We now know that the spark discharge suddenly releases stored energy radiating a short train of em waves or em pulse. This induced a voltage pulse in the detector

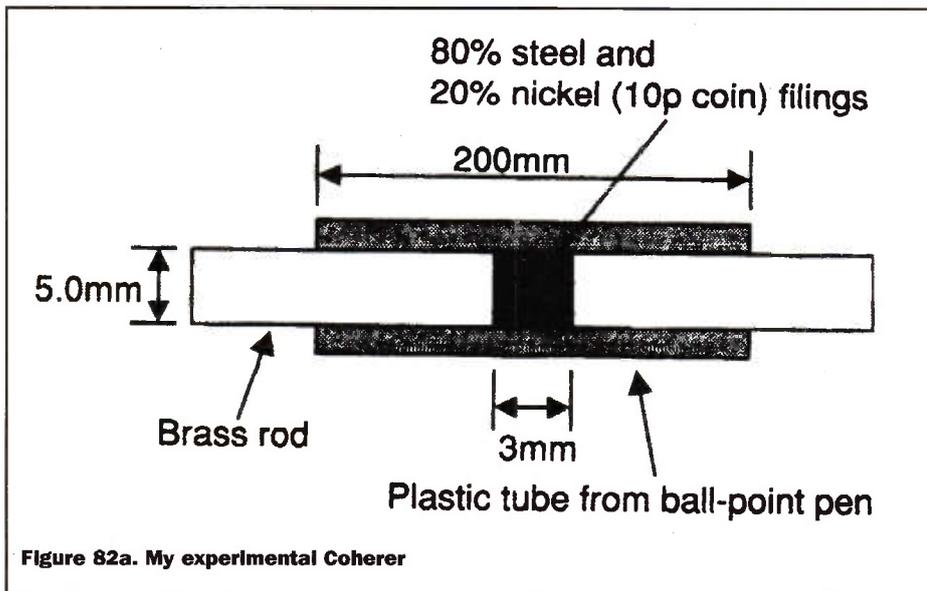


Figure 82a. My experimental Coherer

circuit and the detector actually responded to the induced pulse.

## Prof Hughes

The first detector was made by Professor Hughes in 1878 for use with his "aerial wave" wireless telegraph system; it was simply a steel point lightly resting on a small lump of coke (carbon) and connected in series with a small battery and a telephone earpiece. Ordinarily the resistance between the steel point and the coke was infinitely high and this is attributed to an oxide film perhaps only a molecule thick on the steel point. So, no current flowed through the circuit (see Figure 81).

But, when the device was exposed to an "ether wave" its resistance dropped to a very low value. Current from a local battery flowed through the device causing a click to be heard in the earpiece. More remarkably, when either an em wave or a pulse triggered the device it remained in its low resistance state until gently vibrated. It can therefore be considered as a latching relay.

Hughes incorporated his detector in a hand-held receiver, so simply by handling the device was immediately restored to its high resistance state. But as the sender continually radiated pulses the detector was continually triggered and restored thereby causing a rapid succession of clicks to be heard in the earpiece.

Hughes' devices became known as loose joint detectors but as they behaved as very sensitive relays they were actually classed as relay type detectors. There were many variations of Hughes' loose joint detectors. These included not only the metal/carbon junction but also carbon/carbon and metal/metal junctions and they all exhibited similar characteristics.

By making "ether waves" manifest, relay type detectors made early radio communication possible and I believe that Prof. Hughes should be recognized as the father of radio.

## Branly's Coherer

Branly's coherer acted similarly to Hughes's loose joint detector but differed in that it consisted of a small diameter glass tube filled with fine metal granules and with a brass plug at each end. So instead of the single point contact, the metal granules formed numerous individual metal/metal contacts (Figures 82a and 82b).

In their loose state, the granules presented almost infinitely high resistance but when subjected to a voltage pulse, resistance dropped to only a few Ohms. Moreover, like the loose joint, the coherer remained in its low resistance state until restored by gentle tapping. However, the coherer was more reliable and rugged than the loose joint and was generally adopted for early radio systems. It served as a latching relay to activate a Morse paper tape type register (Figure 83).

## Poorly understood

The reason for the fall in resistance of the loose joint and coherer is generally

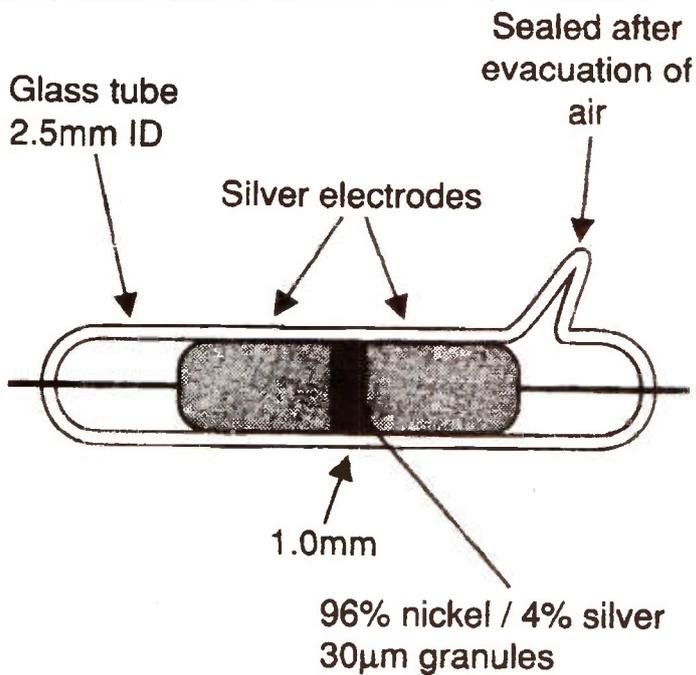


Figure 82b. The Slaby Arco Coherer

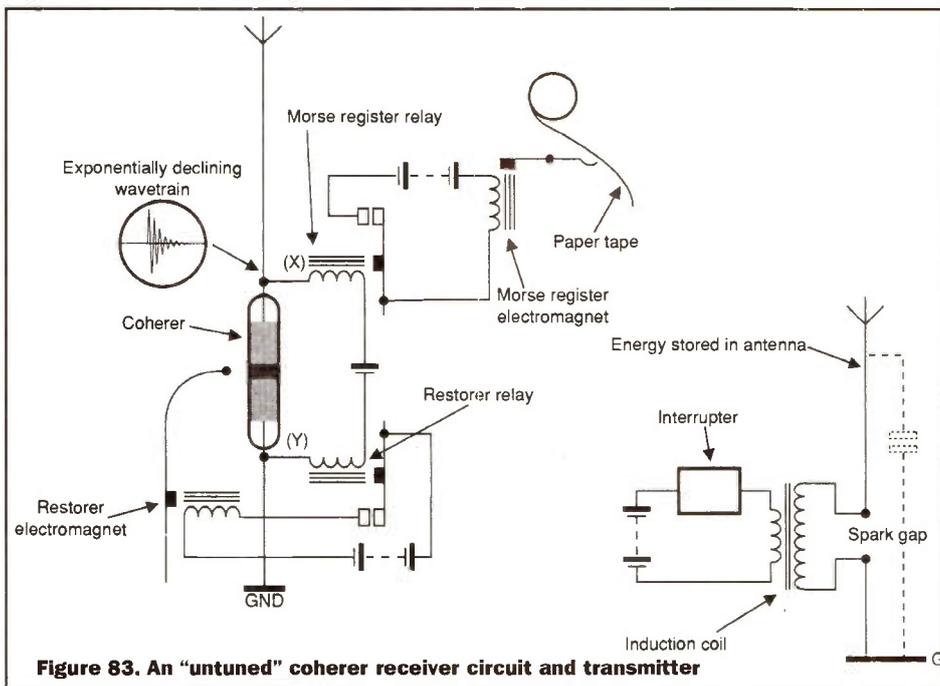


Figure 83. An "untuned" coherer receiver circuit and transmitter

voltage pulse in the receiver antenna that triggered the coherer. Current from the local battery then flowed thereby activating the Morse register. Then an automatic device similar to an electric bell gently tapped the coherer thereby restoring it to its high resistance state in readiness for next wave train.

Each wave train caused the Morse register to make a single dot on the paper tape. A succession of wave trains caused a succession of closely spaced dots on the paper tape that merged into a continuous line. So by radiating over shorter or longer periods, shorter or longer lines, corresponding to the Morse code were made on the paper. However, wave train repetition rate could not be faster than the mechanical operation of restoring the coherer would allow (Figure 83).

As the coherer was triggered by the first half wave of each train, energy present in the following waves of the train was wasted. So in order to maximize range with available power, it was logical for stations to radiate trains containing few waves with a large proportion of their energy packed into the first wave. See Oscillogram C

### Fast rise time

During my researches with reproductions of Hughes' and Branly's devices I was not surprised to find that a voltage pulse with a very fast rise time is necessary to trigger the devices. But I was surprised that the pulse's peak value had to be at least 9.0V. The first wave of a train is of course a sine wave and I believe that the 9.0 peak Volts was necessary to provide a fast rise time (Oscillogram C).

I wondered how it was possible for a spark transmitter to induce such potentials in a distant antenna circuit. I then realized that in their ready state, the resistance of both loose joint devices and the coherer were in the order of tens of MΩ thereby presenting a negligible load on the antenna.

Indeed, my miniaturized spark transmitter was quite capable of inducing such potentials at a considerable distance. Moreover, the fact that only infinitesimal power was needed to cause triggering, together with its high resistance, gave it a

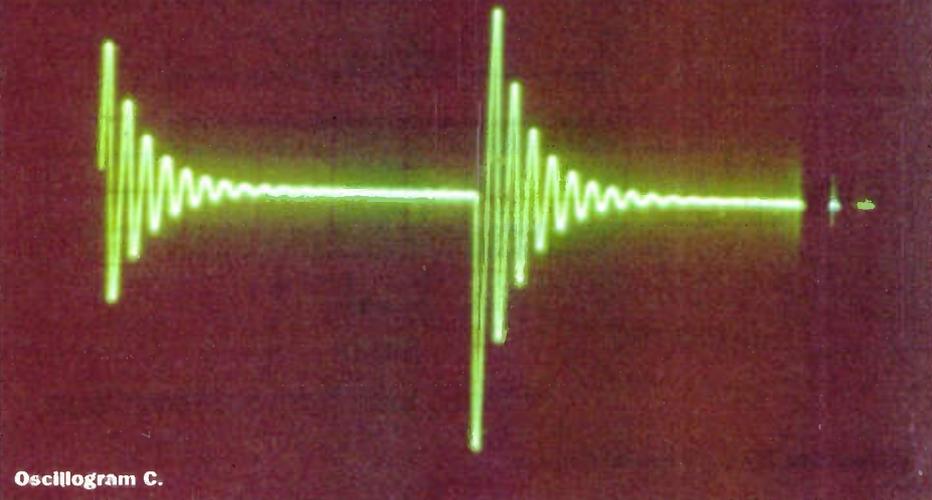
attributed to the voltage pulse breaking down the oxide film on the steel point or metal granules but this cannot explain how the same effect occurs with devices having carbon/carbon contacts. The oxides of carbon are of course gases. Moreover it is difficult to explain why the device remains in its low resistance state after the pulse.

With metal/metal contacts of both loose joints and the coherer, welding has been suggested and that the weld is broken by vibration. But welding cannot explain the effect with metal/carbon and carbon/carbon contacts. I believe that molecular attraction to be a more likely explanation.

### First half wave

Spark transmitters radiated energy in the form of wave trains and the first half wave of each train could contain an enormous amount of energy; this wave induced the

A train containing few waves of the kind radiated by early "untuned" systems. The first wave of the train contained a large amount of energy and was ideally suited to untuned coherer type systems. See figure 83.



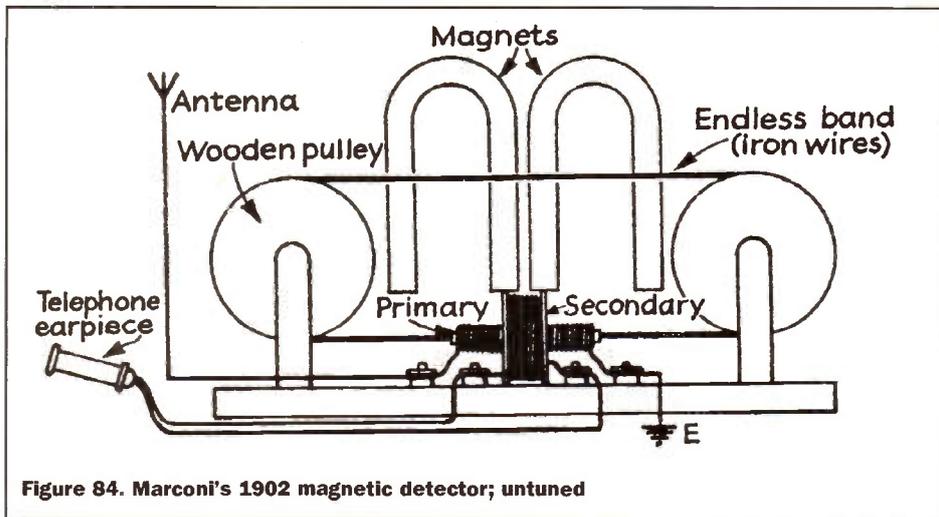


Figure 84. Marconi's 1902 magnetic detector; untuned

high degree of sensitivity and made it eminently suitable as a radio wave "detector".

## Magnetic detector

In 1902 Marconi's magnetic detector largely superseded the coherer. The advantage of the magnetic detector was that it produced an audible signal that allowed much faster working than was possible with coherers. It was simple and rugged and after initial setting generally required no further adjustment. But unlike the coherer it was a passive device and the energy that produced the sound was derived from the incoming waves (Figure 84).

In essence, the magnetic detector consists of a band of soft iron wire that moved through the primary coil at the rate of about 70mm/sec by means of a clockwork mechanism. The generally accepted explanation for its operation is that in absence of wave trains the hysteresis of the iron band prevented it from being fully magnetized by the permanent magnets. However, the hysteresis of the iron is annulled when a wave train induces an oscillatory current in the primary winding. The iron band can then become fully magnetized during the period of each wave train.

Because of the movement of the iron band, it is fully magnetized in segments and these induce a pulsating current in the secondary winding with a frequency corresponding to the repetition rate of the wave trains, typically 700/1,000Hz, thereby producing a sound in the headphones. The iron wire is re-magnetized after each revolution. Incidentally, my experiments with reproduction of the magnetic detector using ordinary magnetic tape instead of iron wire showed it was capable of demodulating AM radio stations.

## Wave Trains v Continuous Waves

The wave trains that contained few waves were efficient energy carriers and so were eminently suited to the magnetic detector and later rectifier type detectors. However, the first half wave of a train could induce a voltage pulse that also shock excited the receiver tuned circuit into oscillation at any frequency that it happened to be resonant. Selective tuning was therefore out of the

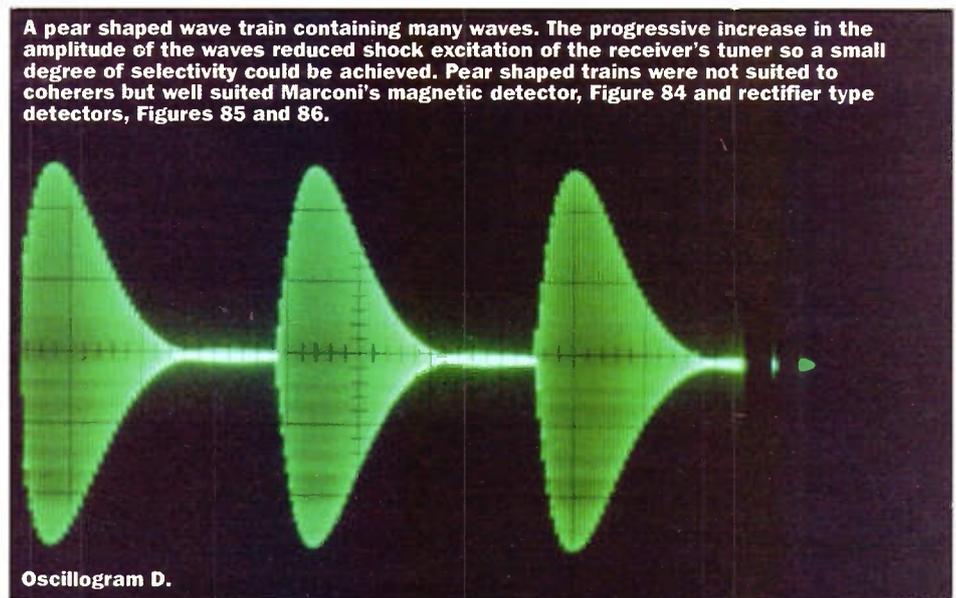
question (Oscillogram C).

Indeed, a high degree of selectivity was unnecessary when Marconi pioneered with his very long wave transatlantic telegraph service as there were very few stations occupying the VLF band. However as the number of stations increased, a high degree of selectivity became vital to prevent mutual interference but this could only be achieved with continuous waves (CW).

With CW, the amplitude of oscillations is then able to build up in the receiver's tuner thereby giving a high degree of selectivity and some voltage gain. But as we saw in previous parts of this study, the generation of CW required a completely new approach to transmitters and we now see reception required a completely new kind of receiver.

Nonetheless, wave trains still had many advantages for maritime services where a high degree of selectivity was neither necessary nor desirable. However, attempts were made to attain some degree of selectivity with maritime spark systems by radiating pear shaped trains containing a large number of waves (Oscillogram D).

The magnitude of the waves within a pear shaped train increased steadily so shock excitation of the receivers tuned circuit was greatly reduced. Obviously pear shaped wave trains were not suited to coherers but they too were well adapted to magnetic and rectifier type detectors.



## Rectifier detectors

As wave trains self-modulate the transmission with a tone, reception was possible with rectifier detectors. There were two ways of rectifying radio frequency currents, one was to dissipate the unwanted half cycles, and the other way was to block the unwanted half cycles. In either case the result is unidirectional pulses.

The DC pulses corresponding to each half wave of a wave train were integrated by a capacitor into a single unidirectional pulse embracing the whole of a wave train. Successive wave trains thereby produced a tone in the headphones with a pitch corresponding to the wave train repetition rate. The effect was similar when the carrier wave was modulated with a tone or indeed speech.

## Fessenden's Electrolytic Detector

Fessenden's electrolytic detector (circa 1905) consisted of a very fine platinum wire tipping a dilute solution of nitric acid (Figures 85a and 85b). A small DC flowed constantly from the tip of the platinum wire through to the second electrode that consisted of a globule of mercury. Positive-going half-cycles rode on the DC and were dissipated but negative-going half cycles were blocked and were forced to take the higher resistance path through the headphones. Unfortunately dissipation of positive-going half-cycles virtually short-circuited the tuning inductor thus damping oscillations in the tuning coil.

Electrolytic detectors were used on ships fitted with Fessenden equipment. They were also at his Machrihanish radio station. Oscillogram E shows a pear shaped wave after rectification by the author's reproduction of Fessenden's detector. It can also demodulate AM transmissions, indeed it was with this type of detector that Fessenden's famous 1906 Christmas message from Brant Rock, USA, was heard by operators at sea and at Machrihanish.

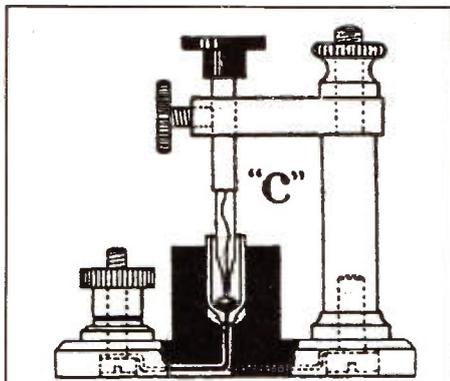


Figure 85a. Fessenden's electrolytic detector

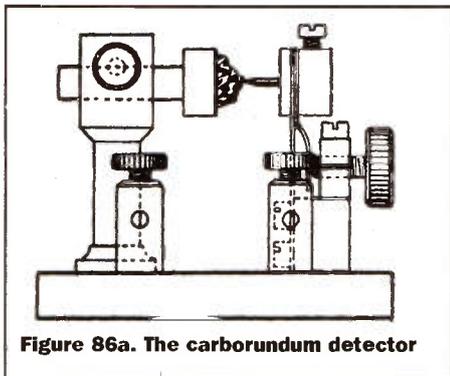


Figure 86a. The carborundum detector

## Solid state

Semi conductor detectors blocked the unwanted half cycles thereby minimizing the damping effect and the earliest solid state rectifier employed a piece of carborundum (a fusion of silica and carbon). General Dunwoodie of the US army first discovered the semi conductor properties of carborundum in 1906.

A small lump of carborundum was fixed by means of Woods metal (metal with low temp melting point) in a small metal cup so that electrical contact was over a large surface area. The top part of the crystal was then ground flat. A hardened steel point mounted on a strip of springy material that pressed against the flat area (Figure 86).

Pressure on the steel point was progressively increased by means of a screw thread until maximum sensitivity was attained. But as carborundum crystals had a resistance in the order 7,000ohms they could only be used in conjunction with high

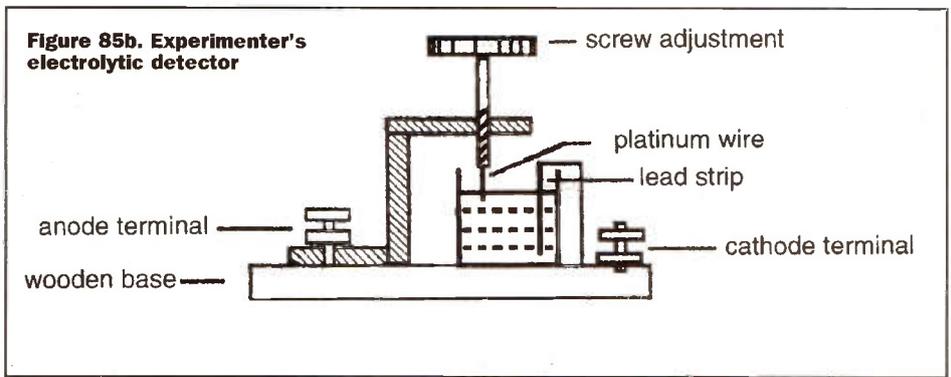


Figure 85b. Experimenter's electrolytic detector

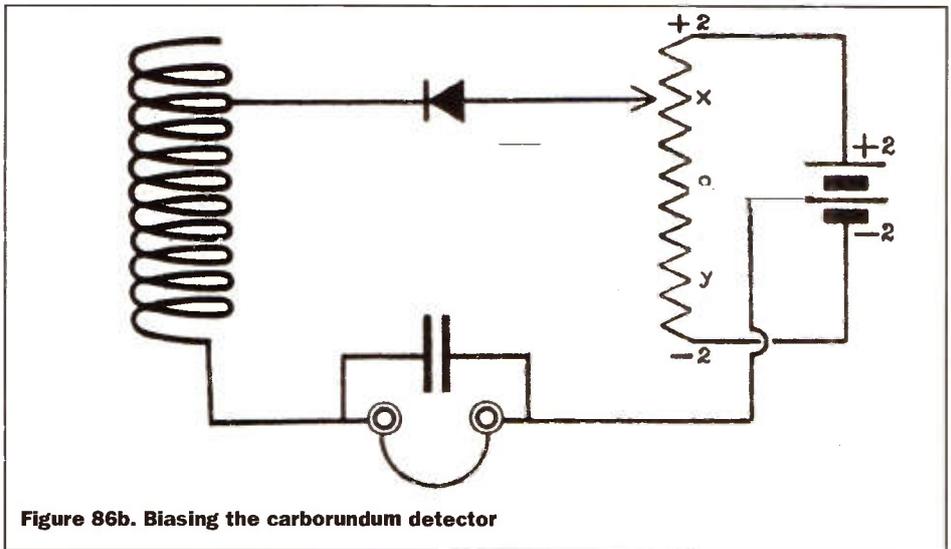


Figure 86b. Biasing the carborundum detector

resistance headphones, typically  $8,000\Omega$  ( $4,000\Omega$  for each earpiece)

Moreover, carborundum detectors required a forward potential in the order of 2.0V before becoming conductive but at long range this exceeded the potential due to the current induced in the receiver's tuning coil. So a forward bias of about 3.0V was applied via a variable resistor and the signal current then rode on the DC bias (Figure 86a).

Carborundum remained the most satisfactory solid state detector with regard to reliability and tolerance to vibration. It was also tolerant to strong signals. Carborundum detectors figured in Marconi's 1906 Clifden/Glace Bay transatlantic link where the CW transmission was modulated with a tone.

## Doping

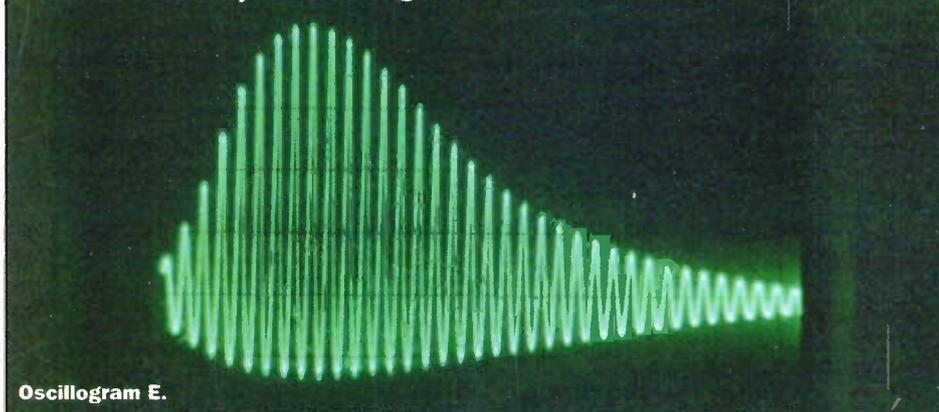
The semi conductor properties of carborundum were attributed to the presence of certain metallic salts present and not all samples performed satisfactory. So, attempts were made to improve performance by incorporating various metallic salts during fusion. Fused silicon was also employed in an arrangement similar to carborundum and here too various metallic salts were added during fusion to improve performance.

It is possible that these pioneers may have made a transistor but did not realize what they had. Indeed, amplification of an oscillatory current had yet to be conceived. Nonetheless, with "doped" silicon, point contact and applied current, all the essentials of an early transistor were present.

## Crystal types

Crystal detectors were either of the type that employed a fine wire (the cats whisker)

A pear shaped train after rectification. The capacitor integrated individual half cycles into a single pulse unidirectional pulse. Successive pulses produced an audible tone in the headphones. The Oscillogram was obtained with the author's reproduction of Fessenden's electrolytic detector. Figure 85.



Oscillogram E.

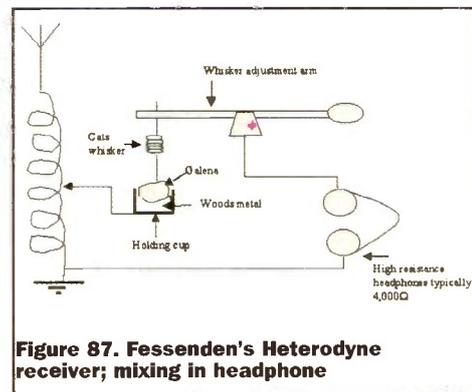


Figure 87. Fessenden's Heterodyne receiver; mixing in headphone

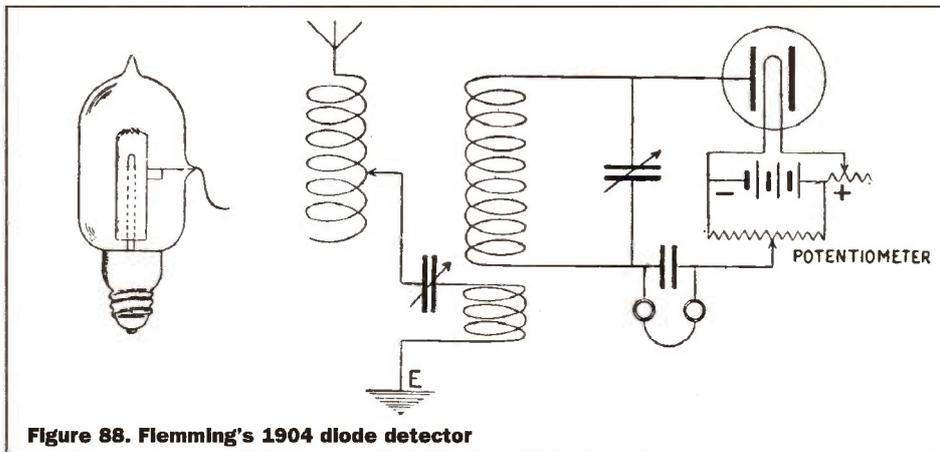


Figure 88. Fleming's 1904 diode detector

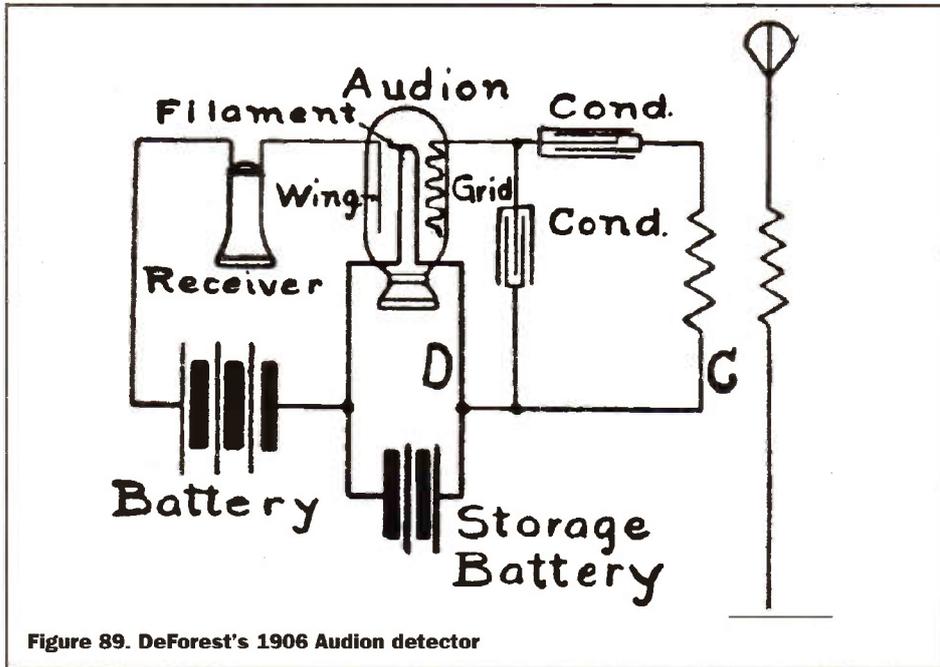


Figure 89. DeForest's 1906 Audion detector

to make contact with a crystal. Or two crystals were in contact with each other. Virtually every substance known to man was evaluated as a "crystal" for "cats whisker" type receivers during the early days of broadcasting (1920-30). However, galena (lead sulphide) or iron pyrites were most commonly used.

"Cats whisker" crystals did not require a forward bias and provided a cheap receiver for early radio broadcasts. Unfortunately it was "finicky" and upset by vibration; they were also damaged by strong signals from nearby spark transmitters and so not used commercially (Figure 87).

Another sensitive detector that was more rugged than the "cats whisker" was known as the Perikon detector; it consisted of a pair of crystals in contact with each other. Perikon detectors originally employed a zinc oxide crystal in contact with a copper sulphide crystal but other combinations were developed. Because of its high sensitivity it had some commercial application but was used principally with domestic receivers.

### Flemming's diode 1904

This detector consisted of a small electric lamp with a single hairpin filament surrounded by a copper or nickel cylinder. Rectification was by unilateral conduction between the heated filament and the

cylinder (Figure 88)

Marconi adopted the diode for maritime installations employing wave train transmissions. It was reliable and sensitivity was not impaired by strong signals. However, it does not seem to have been used with Marconi transoceanic superstations where carborundum detectors

were favoured. However, like carborundum detectors, the diode was a passive device so energy that produced the audible sound was derived from the incoming transmission.

### DeForest' Audion 1906

DeForest added a third electrode to Fleming's diode thus creating a triode which DeForest called the audion. Its significance was that unlike the diode and other passive detectors it was a voltage operated relay type detector. So there was very little damping on the tuned circuit and this enabled a high degree of selectivity to be obtained (Figure 89).

Remarkably, use of the audion seems to have been largely confined to DeForest radio systems and was not widely adopted, probably because of its short life and difficulty in production. Usually a number of audions had to be tested out before one sensitive for general use was found.

Although the audion was the precursor of amplifying triode valves it was only employed as a detector. Indeed, the amplifying potential of subsequent triode detectors was not realized until about 1912 when Armstrong employed them with his regenerative receiver.

### Unmodulated CW

Following a short initial period when wave trains were used transoceanic very long transmissions were unmodulated continuous waves. Signaling was by radiating the transmission in bursts to correspond to Morse code characters. CW maximized radiated energy and minimized bandwidth. Obviously, rectification simply produced steady DC so headphones were silent. A different type of detector had to be developed.

### The Tikker

The most successful of the early detectors for unmodulated CW was the circa 1905 Tikker that was connected in series with the resonant circuit and headphones (Figure 90).

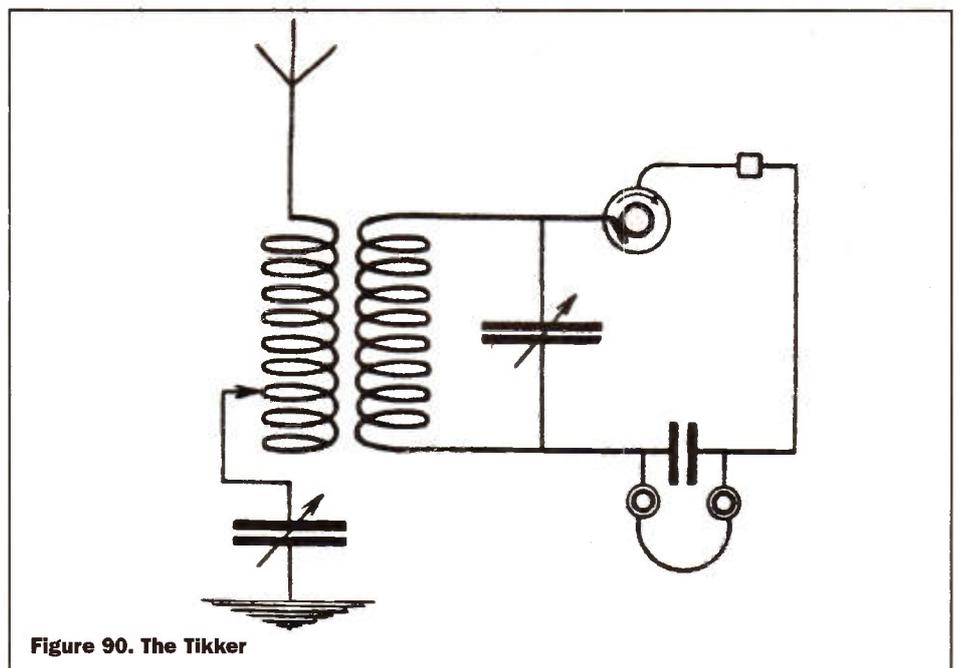


Figure 90. The Tikker

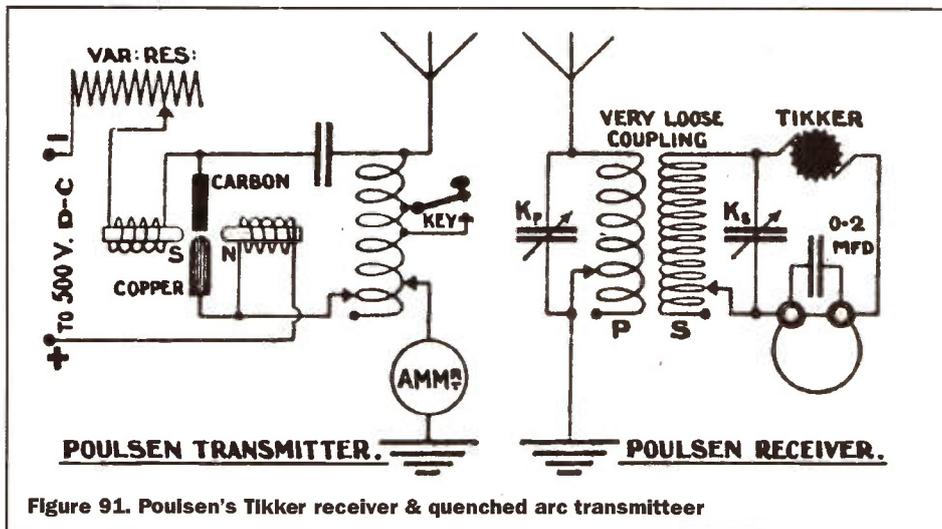


Figure 91. Poulsen's Tikker receiver & quenched arc transmitter

It consisted simply of a steel wire resting lightly on a revolving drum and made intermittent contact as the drum rotated

When the circuit was broken, oscillations built up in the resonant circuit but during the short periods when contact was established, energy was released into the headphones as bursts of pulses. This caused the headphones to emit an audible noise that persisted for the duration of a Morse code "dash" or "dot". This type of tikker was originally used for long range reception of CW transmissions from the Nauen (Germany) very long wave superstation.

Another type of tikker used originally with the Poulsen quenched arc systems employed a toothed wheel that made regular breaks with a period set by the number of teeth and the rotation speed of the wheel (Figure 91). This type of tikker was the forerunner of the Goldschmidt tone wheel so its operation was similar. But being mechanical device the tikker's upper frequency limit was only in the order of 50kHz. Nonetheless, it was well suited to reception of very long waves.

### The Goldschmidt tone wheel

The tone wheel consisted of a wheel having teeth at about 1.0mm pitch and the spaces between filled with insulating material. A copper gauze brush bore lightly on the periphery of the wheel. At a certain rotational speed, (synchronized speed) the brush made contact with a tooth during each half cycle of current thereby producing unidirectional pulses corresponding to the frequency of the transmission.

When the pulses were integrated in a small capacitor produced a steady DC was produced. So no sound was heard in the headphones (Figure 92a). However, in service the wheel was rotated slightly slower or faster than its synchronization speed so that there was alternate rectification of positive and negative-going half cycles (Figure 92b). The resultant negative and positive pulses were integrated in the capacitor to create an oscillatory current that produced a tone in the headphones.

The pitch of the tone depended upon the changeover rate from rectification of negative going to positive going half cycles. So the rotational speed of the wheel was adjusted to produce a pleasant tone. The

tone wheel was used with Goldschmidt alternators on the 45kHz Eilvese/Tuckerton transatlantic link.

### Marconi round detector.

This ingenious but little known device figured in Marconi Company systems for reception transatlantic transmissions from around 1906 until WW1 when it was phased out in favour of active-type, thermionic-valve-receivers. From a contemporaneous circuit diagram and limited information I believe the following describes its operation (Figure 93).

The device consisted of two carborundum detectors each being biased via potentiometers. During setup, the potentiometers were adjusted to apply an opposing voltage just sufficient to prevent conduction by signal currents. Then a miniature spark type oscillator of the buzzer type was brought into operation.

The role of the buzzer was to generate oscillations with a potential that alone was also insufficient to cause conduction but when added to the signal oscillations, their combined potential was sufficient to overcome the opposing potential. The detectors were therefore conductive only during the periods when signal current was present. However, the actual sound heard in the headphones was that generated by the buzzer.

### Fessenden's Heterodyne Receiver

With his original heterodyne system, Fessenden employed special headphones each earpiece having a mica diaphragm and two sets of windings. One winding was wound around an iron core secured to the headphone case and was energized by small variable frequency alternator that served as the local oscillator. The other winding was attached to the mica diaphragm but was free to slide over the iron core; this was connected to the tuned circuit (Figure 94a).

Because of the non-linear characteristics of the diaphragm, the local oscillator caused it to generate an audible beat note against the incoming transmission. However, in later versions, Fessenden employed a crystal detector as the mixer so as to allow ordinary headphones to be used (See Figure 95). Fessenden's heterodyne receiver was in its time the most sensitive available and was only improved upon by the regenerative receiver.

### Armstrong's regenerative receiver 1912

Armstrong's receiver employed the triode valve as both a rectifier and amplifier. It was the only receiver able to receive both unmodulated CW and modulated CW. After rectification, unidirectional pulses present in the anode circuit flowed through an additional coil loosely coupled to the tuning coil thereby providing positive feedback; this gave high selectivity very high amplification (Figure 95).

Feedback was increased to a level where amplification was sufficient for good reception of modulated CW.

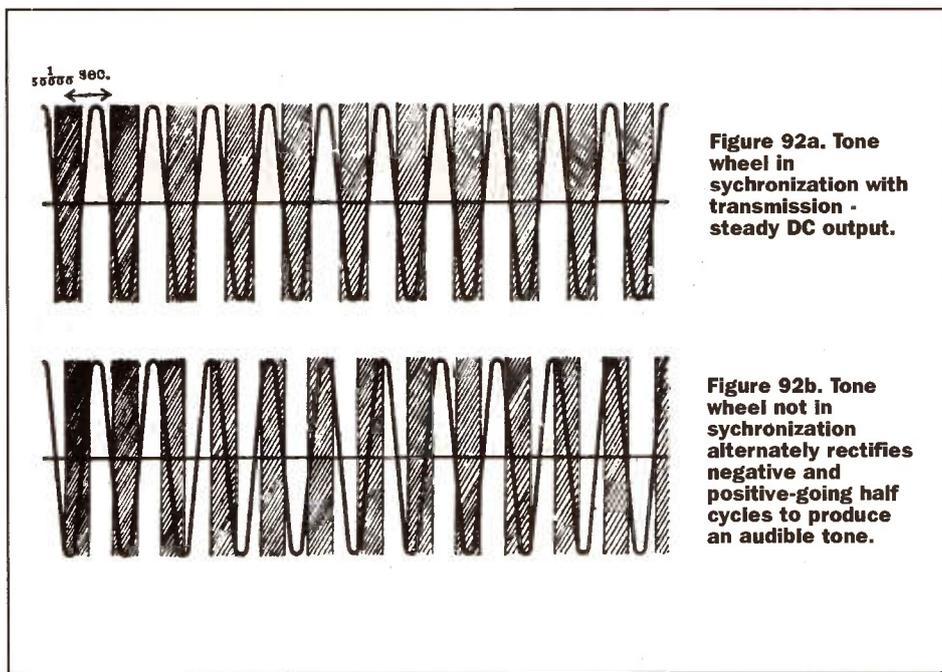


Figure 92a. Tone wheel in synchronization with transmission - steady DC output.

Figure 92b. Tone wheel not in synchronization alternately rectifies negative and positive-going half cycles to produce an audible tone.

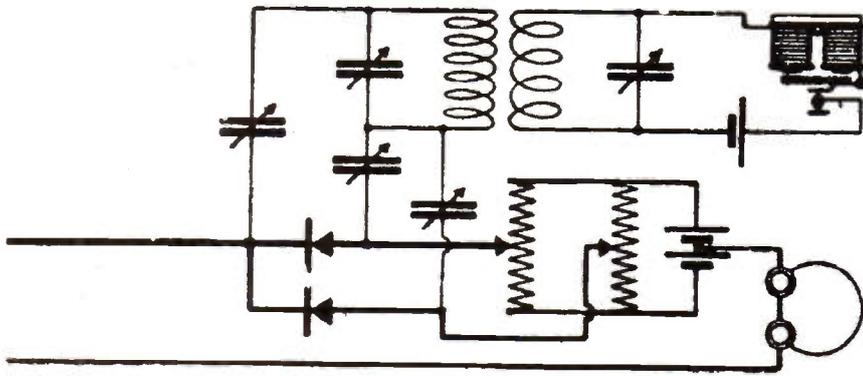


Figure 93. Marconi round receiver

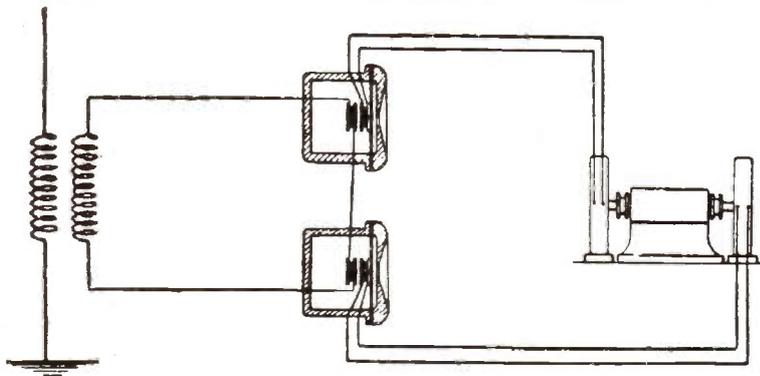


Figure 94a. Fessenden's original heterodyne receiver

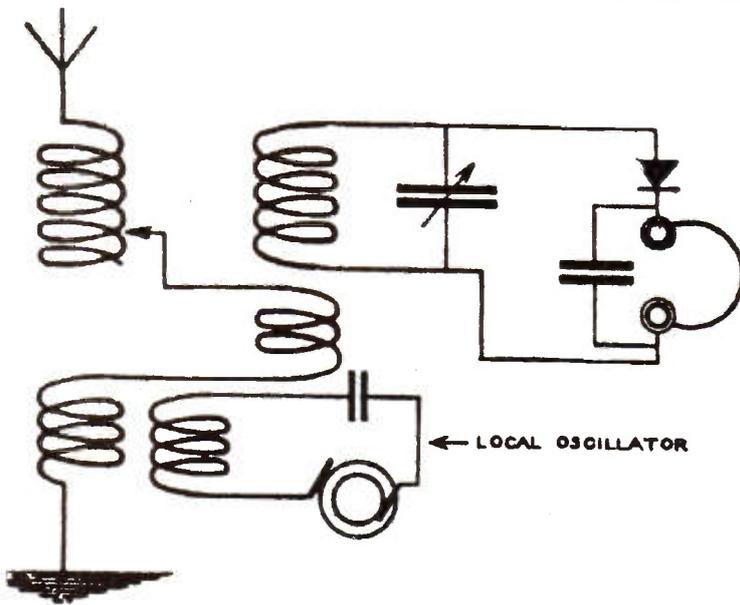


Figure 94b. Fessenden's heterodyne receiver with a crystal mixer

However, for reception of unmodulated CW signals, feedback was increased to the point of self-oscillation. Then, the receiver was slightly de-tuned so that the self-excited oscillations produced a beat note with the incoming transmission.

The receiver was theoretically capable of a voltage gain of one million; in fact it was the most sensitive receiver available prior to the development of multi-stage, multi-valve superheterodyne receivers. But by the time the superheterodyne receiver was developed the very long wave commercial superstations had been superseded by short wave systems. Indeed, it was as short wave

receiver favoured by amateurs that regenerative receiver is best known.

## Headphones

With passive receivers, receiver sensitivity depended almost entirely on the headphones. So they were made as sensitive as feasible by winding as many turns around their magnets as space within the case allowed. Therefore the coils were wound with exceedingly fine wire and this presented a high resistance.

The most sensitive headphones had a total DC resistance of 8,000Ω. (both ear-pieces in series). But, impedance with a

1.0kHz tone was in the order of 50kΩ. Their high impedance minimized damping of oscillations induced in the receivers tuning coil and this was of great significance not only with the tikker and tone wheel but also with other passive detectors.

However, headphone sensitivity was greatest at the resonant frequency of the diaphragm, typically 700 to 1.0kHz. Indeed, measurements by Duddell circa 1915 showed that 430μW were required to produce an audible sound at 300Hz but only 7.7μW at the resonant frequency of the diaphragms. It is interesting to note that the necessary displacement of the diaphragm to produce an audible sound was found to be only 0.5μm.

The amplifying triode valve and regenerative receivers eliminated the need for highly sensitive headphones, but these valves only became available during "sunset" of the commercial transoceanic superstations. Indeed, during the heyday of the very long wave superstations, reception was essentially with passive receivers.

Bearing in mind that with passive receivers the energy that produced the sound in the headphones was derived from the incoming waves and that their source could be several thousand km distant, the very fact that their signals were receivable was a truly an outstanding achievement.

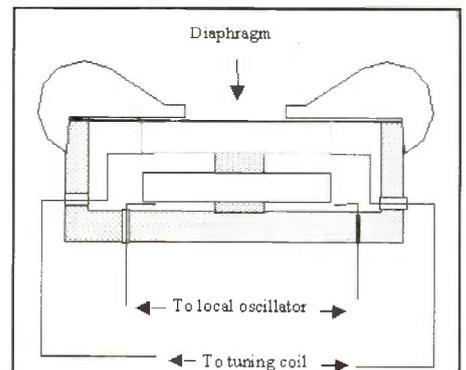


Figure 94c. Fessenden's heterodyne receiver; mixing in headphones

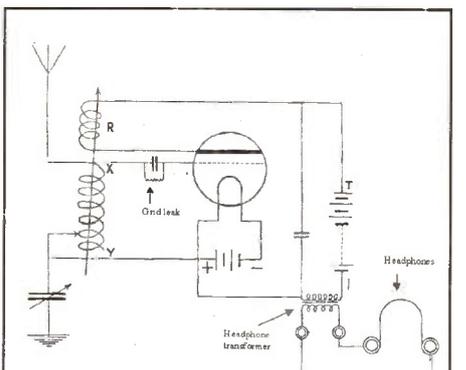


Figure 95. 1920 Schematic of a regenerative receiver

# Audio Sculpture Loudspeaker - SOMETHING SPECIAL

*John Kirk describes the design philosophy behind these distinctive loudspeakers*

Apart from the fact that they sound stunning, you may be surprised to learn that they are intended for use with computers! They are capable of causing serious competition to traditional 'high end' audiophile loudspeaker manufacturers, but it is not Audio Sculpture's intention to complete head to head with the hi-fi scene.

Originally intended for use with DVD systems, I decided a change of direction was in order well into the development project. I realised that the power and relative affordability of the new wave of technologically sophisticated PC sound cards made the need for matching speakers imperative.

The particular soundcard in question was the SoundBlaster Live! from Creative Labs. Retailing for about £100, or less,

it has D-to-A conversion properties far in excess of its small price. Creative Labs were contacted and they duly supplied their white paper and extended technical information, and we were thus able to fully exploit the sound processing powers offered.

The result was a 4.1 computer surround system, that has stunning reference qualities and as much power as your neighbours can handle!

## Design Philosophy

With so much competition within the field of electro-acoustics, it was important to make these speakers sonically different. Although very capable of traditional high fidelity reproduction, such as sound stage, linear response, stereo

separation etc., we decided to improve on one sonic performance rarely heard even in the most expensive equipment - vocal projection.

To achieve this we had to develop a new type of drive unit, which resulted in the addition of a ceramic phase plug. Vocal tones are now seamlessly smooth and are delicately projected with neutrality and linear response. The effect has been described as sitting in a jazz club. The band will fill the room in the most realistic way and the singer, or lead instrument, will be intimately 'earmarked' around your position.

## The Loudspeakers

KB1 is a 3-way design comprising two ceramic hub

bass/midrange drivers and one Audax tweeter. They provide a phenomenal sonic range by themselves, but when they form part of the full system, then the result is, quite frankly, mind blowing!

The smaller KB2 is a 2-way infinite baffle studio monitor design that provides sparkle and detailed rear augmentation in the full system. For a closed box the response is surprisingly deep.

The last component within the system is the KBS, a remote controlled 150W active sub-woofer. A 'G' class amplifier drives a composite 10in cone drive, housed in a truncated pyramid design that eliminates internal standing waves, whilst a 4.4in port allows very deep notes to be felt.

## Cabinet Design & Construction

Computer modelling was used to derive the final cabinet shape and construction using good acoustic theory and common sense as the primary programming criteria. The front baffle of the KB is 36mm thick and provides a secure mounting for the bass/midrange units. External panel bracing has been used to allow the internal vortex of air to move more freely. The bass/midrange unit displays a wide dispersion pattern so the tweeters are mounted in a formed dispersion pod. The system cabinet is made from medium-density fibreboard, which still offers superior sonic performance than any newer material.

## Crossovers

The 'liquid x-overs' employed in the KB1 and KB2 were designed by Phil Barker of 'The Audio Solution.' They use high quality,

**What makes the Audio Sculpture KB Series so special?**

*Apart from the fact that they sound absolutely stunning. You may be surprised to know that they are part of a PC based sound system.*

**Hi-Fi is boring!**

**ProPC. Audio**  
*by contrast is exciting, technically superior and 'a bit more with it!'*

**Studio Reference Quality.**

**But Computers make beeping noises don't they?**

*Today, PC sound cards have a quality of Digital to Analogue Conversion (DAC) for more advanced than the equivalent HiFi unit. Internet connection and full backward compatibility with CD and DVD. The PC is the ultimate sound source.*

**KB Series**

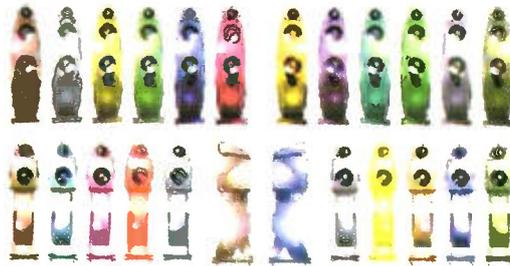


THE MOST ADVANCED SPEAKER PRODUCTS IN THE WORLD

The KB Series is available in any color.

If a specific decoration is required. The cabinets will be transported to the craftsman or artist nominated.

This option will be restricted by sonic properties and incur an extra premium.



# KB Series

now available, as it can be a tremendous experience when accompanied by the virtual reality experience of full 360° audiophile quality surround sound.

## In Conclusion..

Since the launch many high profile magazines have featured the system, and it has been quite a struggle to actually get the products to the marketplace! But when you see your 'baby' pass boxes of equipment from multinational, and go straight to the front of the review queue, then you know it has all been worth it.

We have plans to release several more designs based around our ceramic plug bass/midrange driver. A 'de'apollito' arrangement for public address purposes, which will have an output response

high voltage working polypropylene capacitors, custom wound air-core inductors and impedance matching circuitry. The electronic design is tailored specifically for the drive units employed and results in a seamless excellent response. Maplin Electronics supplied many of the components including the ICW polypropylene capacitors, which are extensively used in other high-end loudspeaker systems, and offer low loss and transparency.

## Applications

Originally intended for mastering environmental audio

extension - the method of mapping out a three-dimensional soundscape - the system has found many more applications. Due to the linear response and compatibility with the PC, recording artists consider them more favourably than conventional monitors. In the reality stakes, the final mixture of the full system as a playback option is quite obvious.

The internet is swiftly changing the way we listen to music, and the PC will soon form the musical (and video) hub in the home, namely because MP3 and CD

The single cone KBS design incorporates one 10" composite sandwich cone, powered by an on board 150W true RMS amplifier.

Just ticking the Richter scale the KBS adds an abundance of atmosphere. A very deep, lightning fast response.

The KBS has a 3 step 12db bass boost, remote control of rotary phase and active crossover point control. When part of the full surround system a very low crossover point should be set due to the comprehensive frequency range covered by the KBI.

## Down, down, deeper and down.

Why do we need bass so deep? .....Atmosphere!  
If you have ever been to a stadium gig or listened to a complete orchestra in full throttle. You may have been disappointed once or twice when you play back the CD of the same music. A lack of sub frequency is often the problem.  
A more curious situation to imagine:-  
2000 people trying to be quiet between orchestral movements actually displaces a lot of sub frequency air. So to reproduce unearthing silence requires serious bass agility.

# KB Series

The three-way KBI design incorporates two of our ceramic phase cone mid-bass drive units and one liquid cooled tweeter.

They cover a phenomenal sonic range by themselves but when part of the full system, you had better Nail the furniture down!

## Without Compromise.

The KBI uses the finest Electro-acoustic components  
Developed and tuned within cabinets that take into consideration all aspects of today's acoustic theory.  
Front baffle fire-time alignment. External bracing allowing unrestricted internal air vortex. High frequency dispersion mounting. All individually tested by the finest equipment in the world. The Ear.

# KB Series

files can be easily selected and downloaded to your PC and personal player.

DVD is now the standard specified for almost all new PCs purchased. Hook one up to this system via a SoundBlaster Live! Card and your listening room will soon be filled with the sound effects from the latest blockbuster movies.

Finally, try the most recent three-dimensional simulation titles for computers that are

similar to a 12in drive based system, but in half the space, plus a modular system that allows upgrade to a reference system via a series of interlocking tubes - and also a transmission line design.

## Contact

Sales: DesignPro@lineone.co.uk  
Technical: The audiosolution@Supanet.com

John Kirk of Audio Sculpture can be contacted at:  
Tel: 01450 860744, for sales and technical enquiries.

The '555' timer is a popular bipolar IC that is specifically designed to generate accurate and stable CR-defined timing periods, for use in various monostable 'one-shot' pulse generator and astable squarewave generator applications. The '555' IC is, however, very versatile, and this article shows a variety of ways of using it in 'special' or unusual applications.

## Schmitt Triggers.

The 555 can be used as a Schmitt trigger by shorting pins 2 (trigger) and 6 (threshold) together and applying the input signals directly to these points, as shown in the functional diagram and circuit of Figure 1. The IC's action is such that (as illustrated by the Figure 1 input and output waveforms) when the input voltage rises above  $2/3 V_{cc}$  the IC output switches low, and remains there until the input falls below  $1/3 V_{cc}$ . At this point the output switches high and remains there until the input rises above  $2/3 V_{cc}$  again. The difference between these two trigger levels is called the hysteresis value, and equals  $1/3 V_{cc}$  in this case; this large hysteresis value makes the circuit useful in noise/ripple-rejecting signal conditioning applications.

# 555 CIRCUITS

## Ray Marston shows a variety of unusual ways of using the 555 IC in applications such as Schmitt triggers, astable gadgets, alarms, and long-period timers.

Figure 2 shows the basic Schmitt circuit modified for use as a high-performance sine/square converter that can be used at input frequencies up to about 150kHz. Potential divider R1-R2 biases pins 2 and 6 to a quiescent value of  $1/2 V_{cc}$  (i.e., mid-way between the upper and lower trigger values), and the sinewave input is superimposed on this point via

C1; squarewave outputs are taken from pin 3. R3 isolates the input signal from the effects of the 555's switching actions. The diagram shows how optional RFI suppression can be obtained via C3.

Figure 3 shows the 555 used as a minimum-backlash (zero hysteresis) dark-activated relay switch, with light-dependent potential divider RV1-LDR wired

to its input terminal. The RV1 and LDR values are roughly equal at the median switching light level. This circuit acts as a fast comparator rather than as a true Schmitt trigger, since pin 6 is tied high via R1, and the light-sensing RV1-LDR potential divider is applied to pin 2 only. Note that this circuit needs good supply decoupling, which is provided via C2.

The above circuit can be made to act as a light- (rather than dark-) activated switch by transposing the RV1 and LDR positions, as shown in Figure 4(a). It can also be made to act as a temperature-activated switch by using an NTC thermistor in place of the LDR, as shown in Figures 4(b) and 4(c); in all cases the LDR or thermistor must present a resistance in the range 470R to 10k at the required turn-on level.

## Astable Gadgets

The 555 astable multivibrator is very versatile and can be used in many applications of interest to both the amateur and professional user. Figures 5 to 11 show examples of typical 555 astable gadgets. Figure 5 shows a Morse-code practice oscillator, with frequency variable from 300Hz to 3kHz via TONE control RV1. The 'phone volume is variable via RV2, and the 'phones can have any impedance from a few ohms upwards. The circuit draws zero quiescent current when the morse key is open.

Figure 6 shows a simple electronic 'door-buzzer' that feeds a monotone signal to a small speaker (25R to 80R) when SW1 is closed; C1 has a low supply-line impedance and ensures adequate output drive capacity.

Figure 7 shows a continuity tester that generates an audible tone only if the resistance between the test probes is less than a few ohms. The astable operates only if pin-4 is biased above 700mV; normally this pin is grounded via R2, so the astable is off; to operate the astable the two probes must be shorted together, connecting R2 to the output of the R3-ZD1 voltage-reference generator via RV2. In use, RV2 is trimmed so that astable operation is barely obtained under this condition, and ceases if the inter-probe

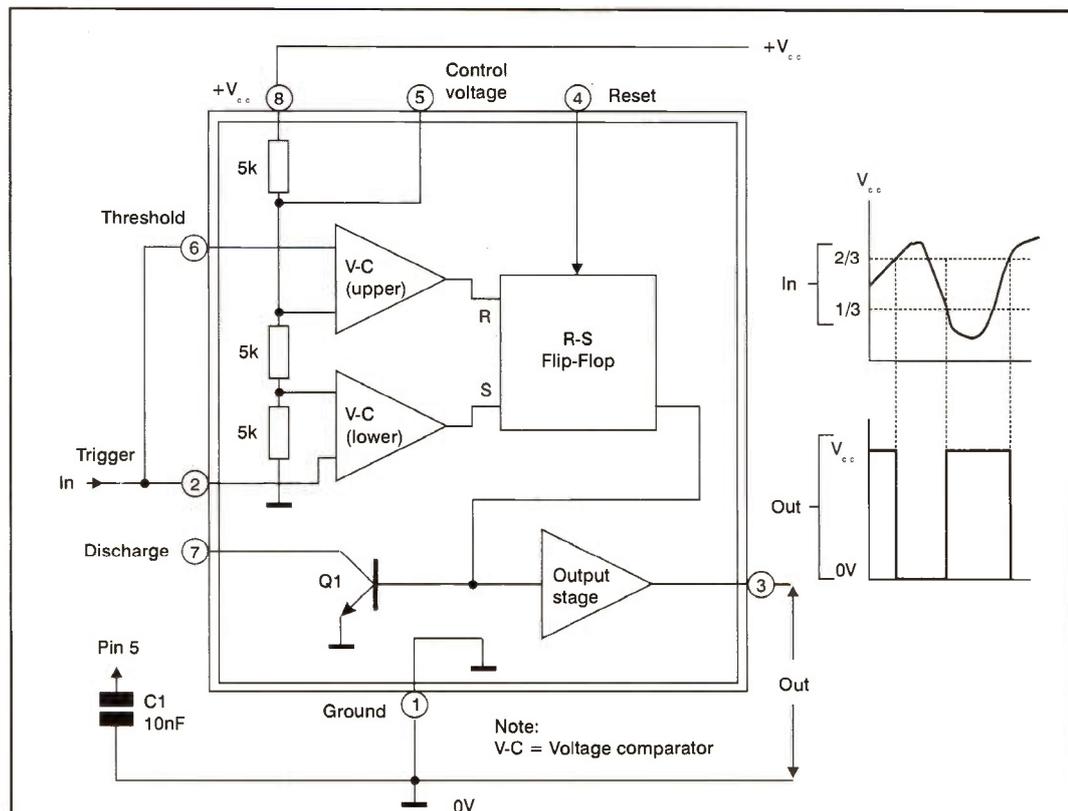
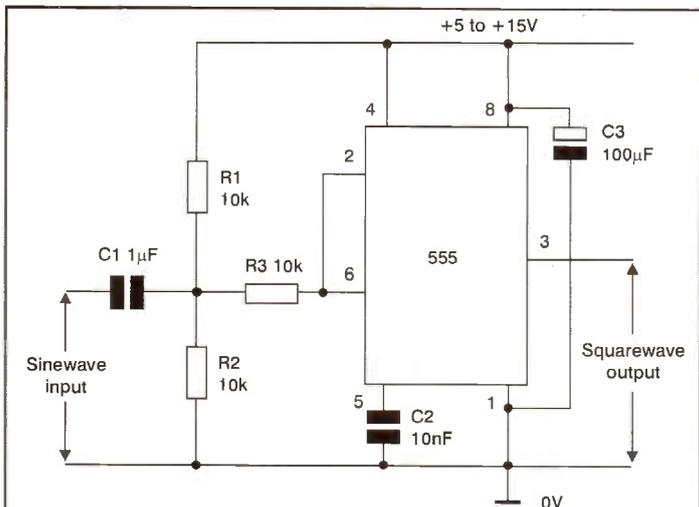
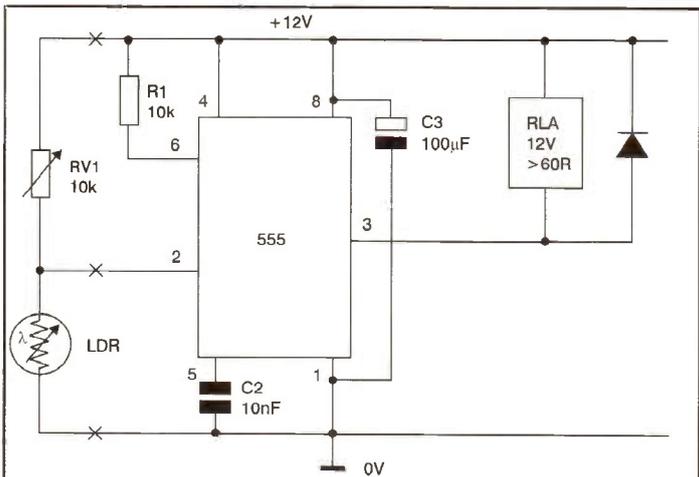


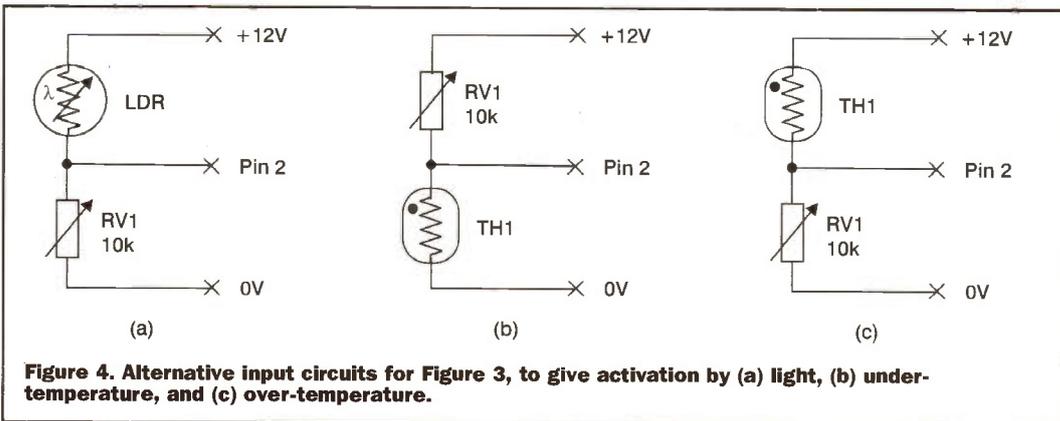
Figure 1. Functional block diagram (within the double lines) of the 555 timer IC, with external connections for use as a simple but useful Schmitt trigger.



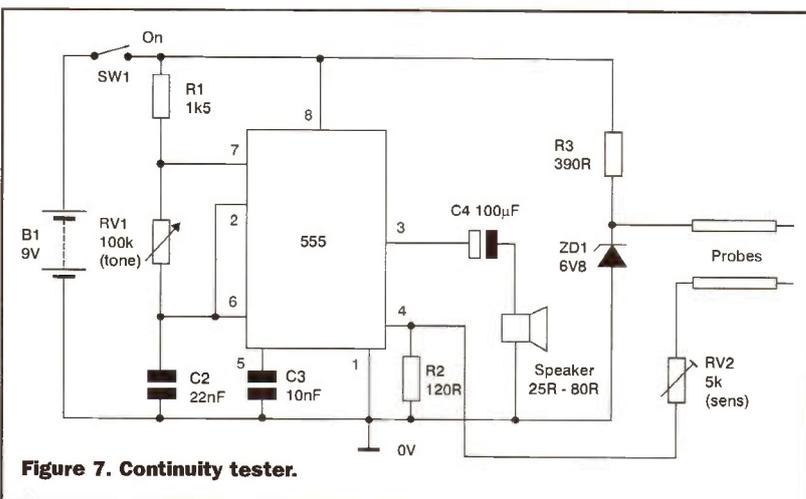
**Figure 2. 555 Schmitt sine/square converter, with optional RFI suppression via C3.**



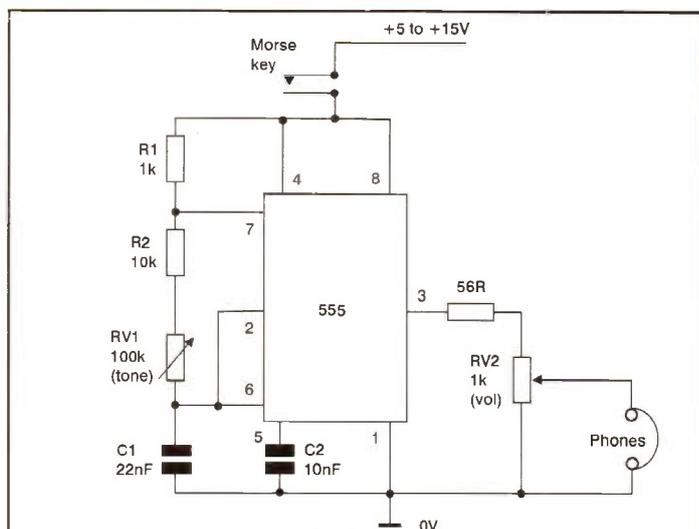
**Figure 3. Minimum-backlash dark-activated relay switch.**



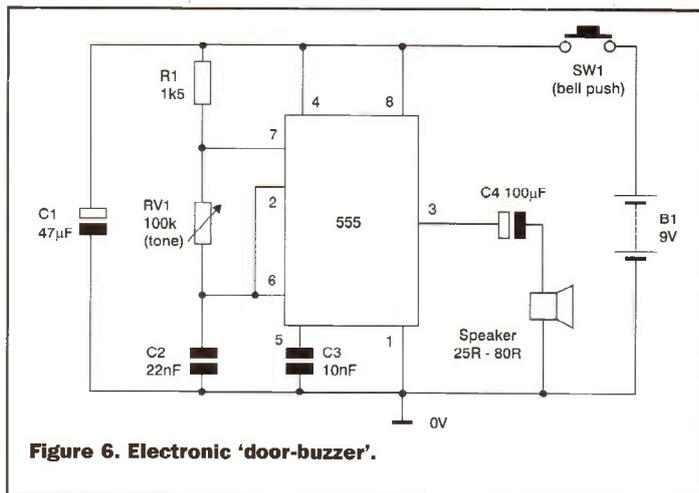
**Figure 4. Alternative input circuits for Figure 3, to give activation by (a) light, (b) under-temperature, and (c) over-temperature.**



**Figure 7. Continuity tester.**



**Figure 5. Code-practice oscillator with variable tone and volume.**



**Figure 6. Electronic 'door-buzzer'.**

resistance exceeds a few ohms. Note that the circuit consumes several mA whenever SW1 is closed, even if the probes are open circuit.

Figure 8 shows a signal injector that is useful for testing both AF and RF circuits. The astable operates at a basic frequency of a few hundred Hz when PB1 is closed; the square output waveform is very rich

in harmonics, however, and these can be detected at frequencies up to tens of MHz on a radio receiver. The signal injection level is variable via RV1.

Figure 9 shows a metronome in which the 'tick' rate is variable from 30 to 120 beats per minute via RV1, and the volume is variable via RV2. This circuit is a modified version of the standard astable, with its main timing network driven from the IC's pin-3 output. When the output switches high C1 charges rapidly via D1-R1 to generate a brief (a few ms) 'tick' pulse. When the output switches low again C1 discharges via RV1-R2, producing an 'off' period of up to 2s (= 30 beats/minute). The output pulses are fed to a small speaker via volume control RV2 and buffer Q1.

## LED Flashers and Alarms.

Figures 10 to 12 show the 555 astable used in LED flasher applications in which the LEDs

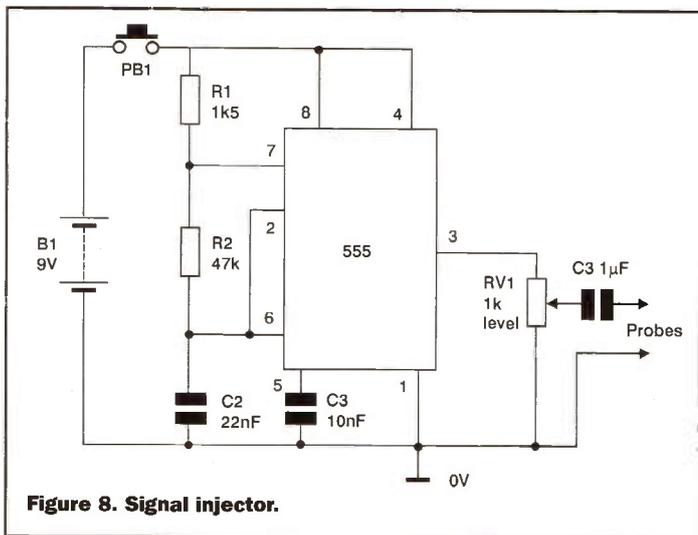


Figure 8. Signal injector.

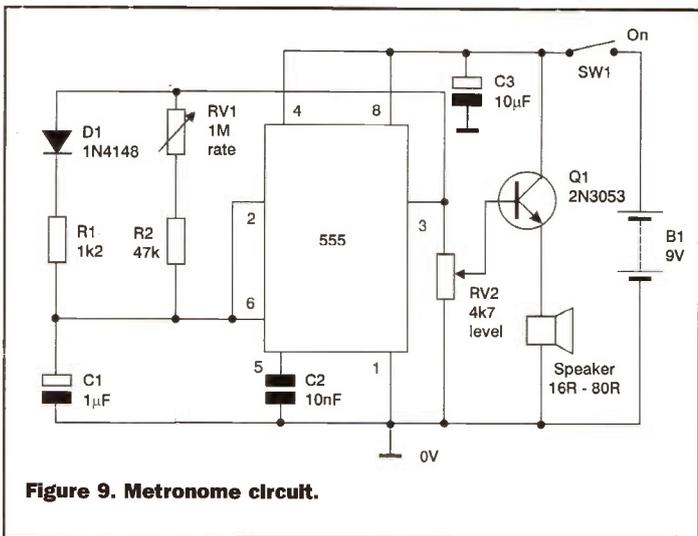


Figure 9. Metronome circuit.

have equal on and off times. With the component values shown the circuits each operate at about one flash per second.

The Figure 10 circuit has a 'single ended' output. Either a single LED or a chain of series-wired LEDs can be put between the IC's output and ground,

and all LEDs turn on or off together; R3 sets the ON current of the LEDs. Most LEDs drop about 2V when on, so several LEDs can be series-wired in a circuit that is powered from a 15V supply.

Figure 11 is similar to the above, but has a 'double-ended'

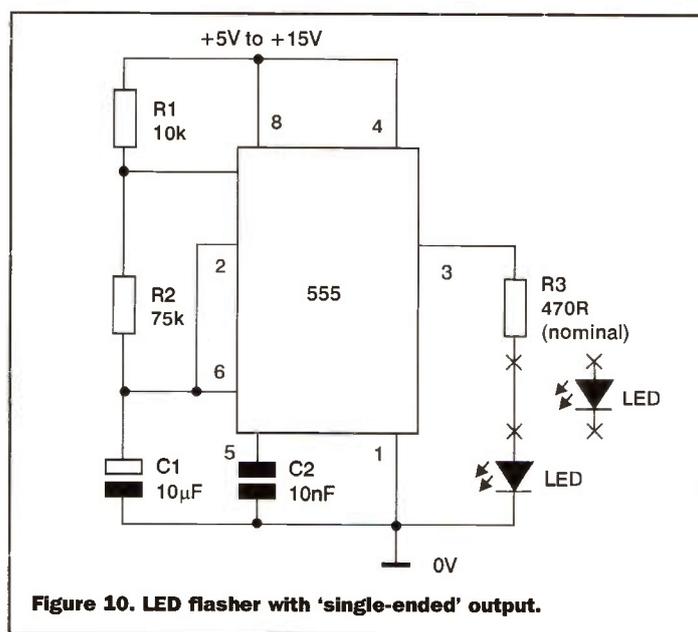


Figure 10. LED flasher with 'single-ended' output.

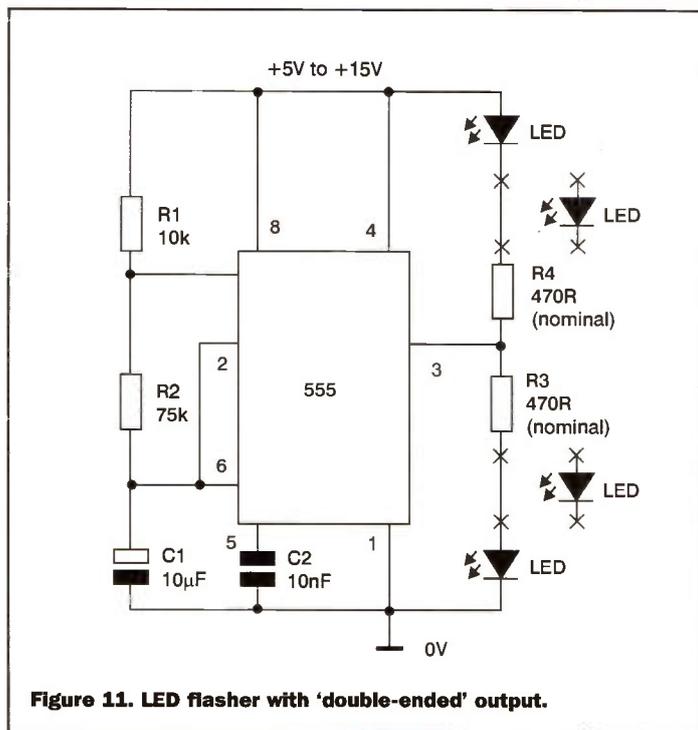


Figure 11. LED flasher with 'double-ended' output.

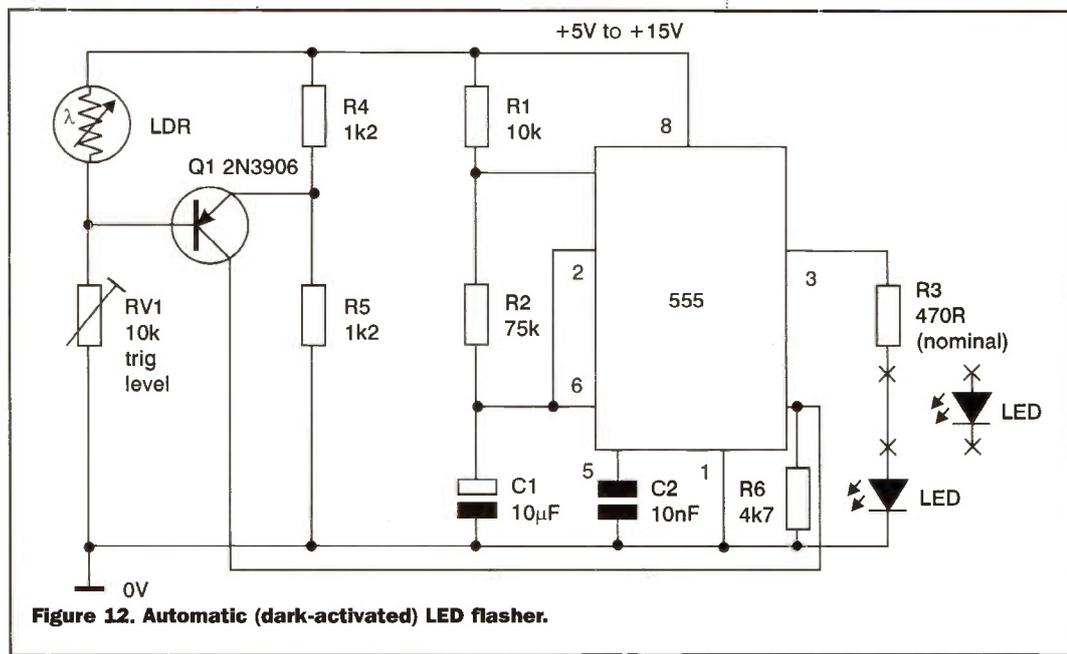


Figure 12. Automatic (dark-activated) LED flasher.

output connection in which all 'upper' LEDs are on when the 'lower' ones are off, and vice versa. R3 sets the ON currents of the lower LEDs and R4 sets that of the upper ones.

Figure 12 shows the basic Figure 10 flasher circuit modified to give automatic dark-activated operation. R4-R5-LDR and RV1 are used as a light-sensitive Wheatstone bridge that is used to activate the 555 astable via balance-detector Q1 and the pin-4 RESET pin of the IC. Under bright conditions the LDR has a low resistance, so the Q1 base-emitter junction is reverse biased and less than 700mV appears on pin-4, so the astable is off. Under dark conditions the LDR resistance is

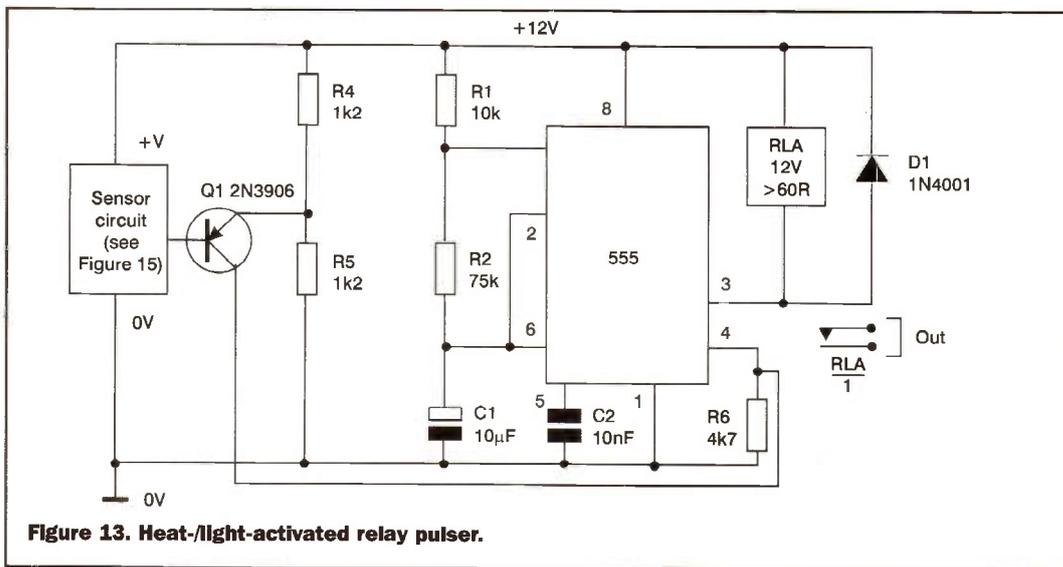


Figure 13. Heat-/light-activated relay pulser.

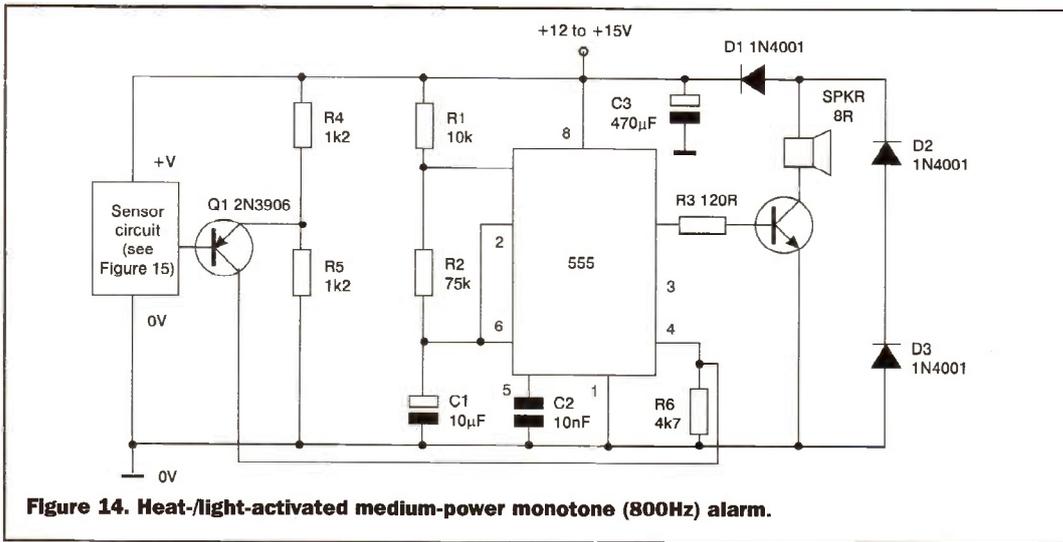


Figure 14. Heat-/light-activated medium-power monotone (800Hz) alarm.

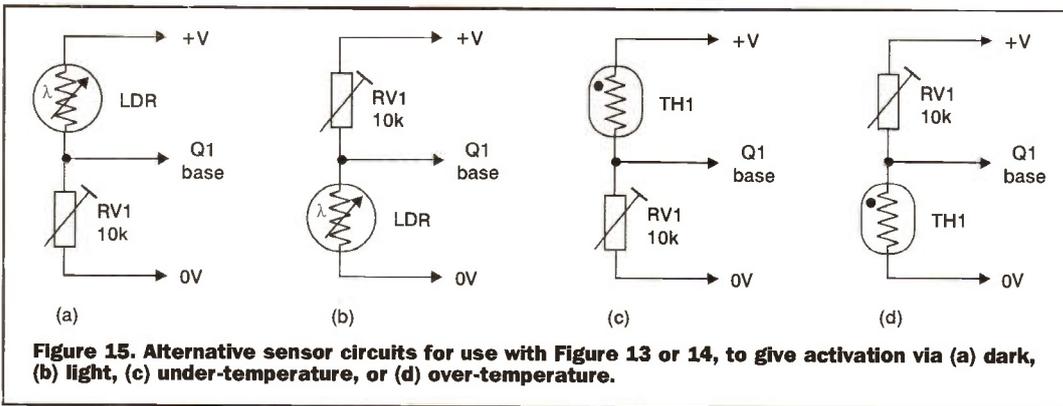


Figure 15. Alternative sensor circuits for use with Figure 13 or 14, to give activation via (a) dark, (b) light, (c) under-temperature, or (d) over-temperature.

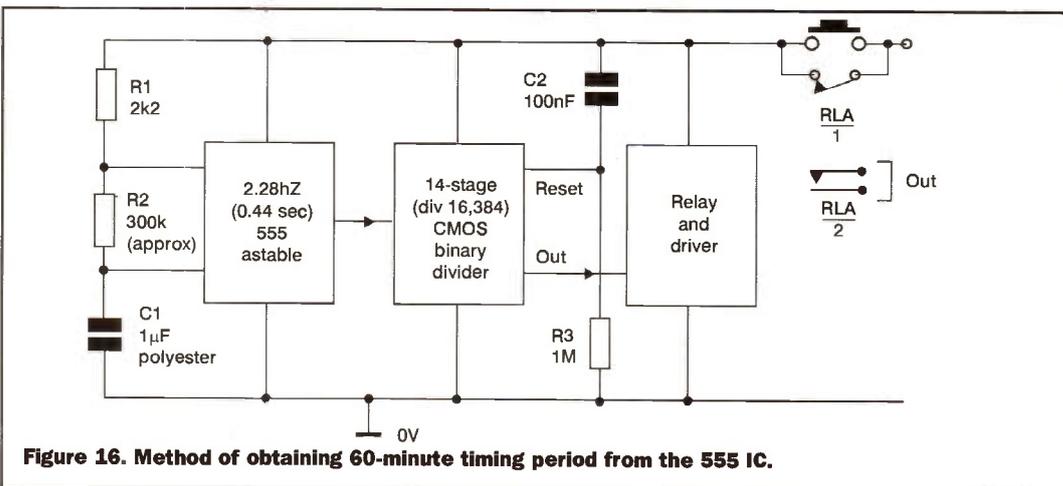


Figure 16. Method of obtaining 60-minute timing period from the 555 IC.

high and Q1 is biased on, generating more than 700mV on pin-4 and this turning the astable on. The LDR must give a resistance in the range 470R to 10k at the dark turn-on level, and RV1 is adjusted so that the astable just activates under this condition.

The above technique gives precision gating and can be used to auto-activate a variety of other 555 astable circuits, to make various audible alarms and relay pulsers, etc. By transposing the LDR and RV1 positions or replacing the LDR with an NTC thermistor these circuits can be made to auto-active when light or temperature levels go beyond pre-set limits. Figures 13 to 15 show practical examples of such circuits.

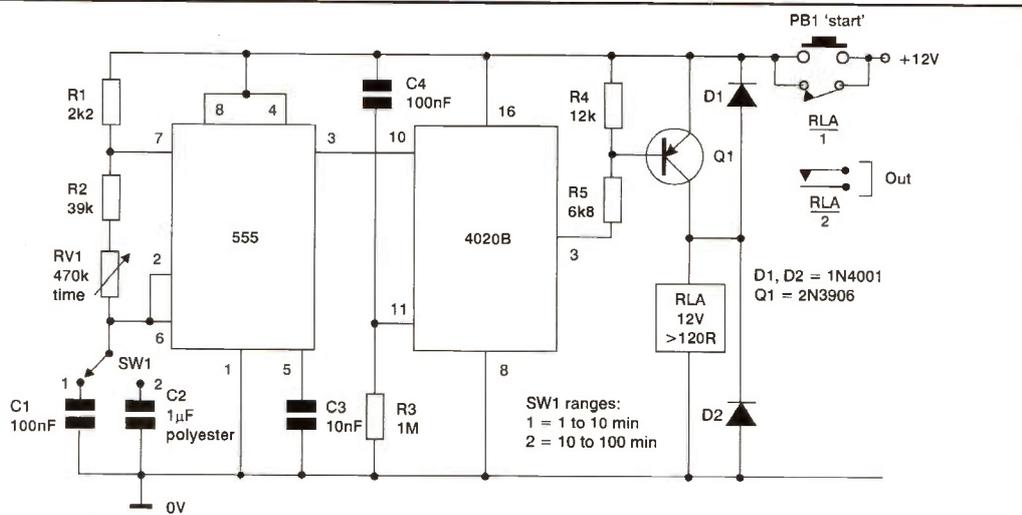
The Figure 13 circuit gives automatic heat or light activation of a relay pulser, which switches on and off at a once-per-second rate when activated. The relay can be any 12V type with a coil resistance greater than 60 ohms, and its contacts can be used to activate external electrically powered devices such as light, sirens, or alarm horns, etc.

Figure 14 gives automatic heat or light activation of a monotone alarm-call generator, which generates an 800Hz alarm tone at several watts in an 8 ohm speaker when activated. Note that the high output current of the circuit may cause modulation of the supply line, so D1 and C3 are used to protect the circuitry from ripple effects, and D2 and D3 clamp the speaker's inductive switching spikes and thus protect output transistor Q2 from damage.

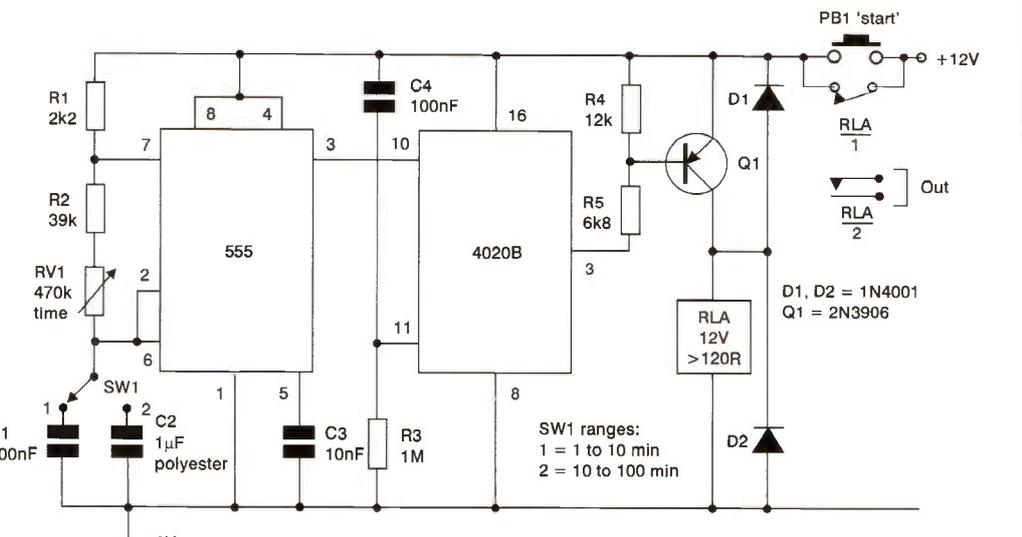
Figure 15 shows the alternative sensor circuitry that can be used to auto-activate the Figure 13 or 14 circuits. For light-sensitive operation the sensor must be an LDR; for temperature-sensitive activation it must be an NTC thermistor; in either case the sensor element must have a resistance in the 470R to 10k range at the desired trigger level

## Long-Period Timers

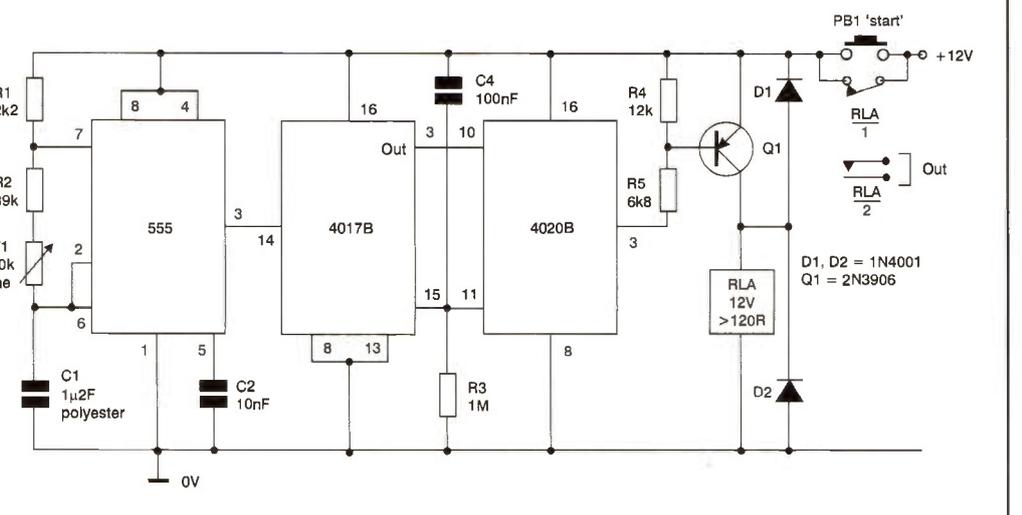
The 555 IC can be used to make an excellent manually-triggered relay-driving timer when connected in the monostable or



**Figure 16. Method of obtaining 60-minute timing period from the 555 IC.**



**Figure 17. Two-range (1-10 minute and 10-100 minute) relay-output timer.**



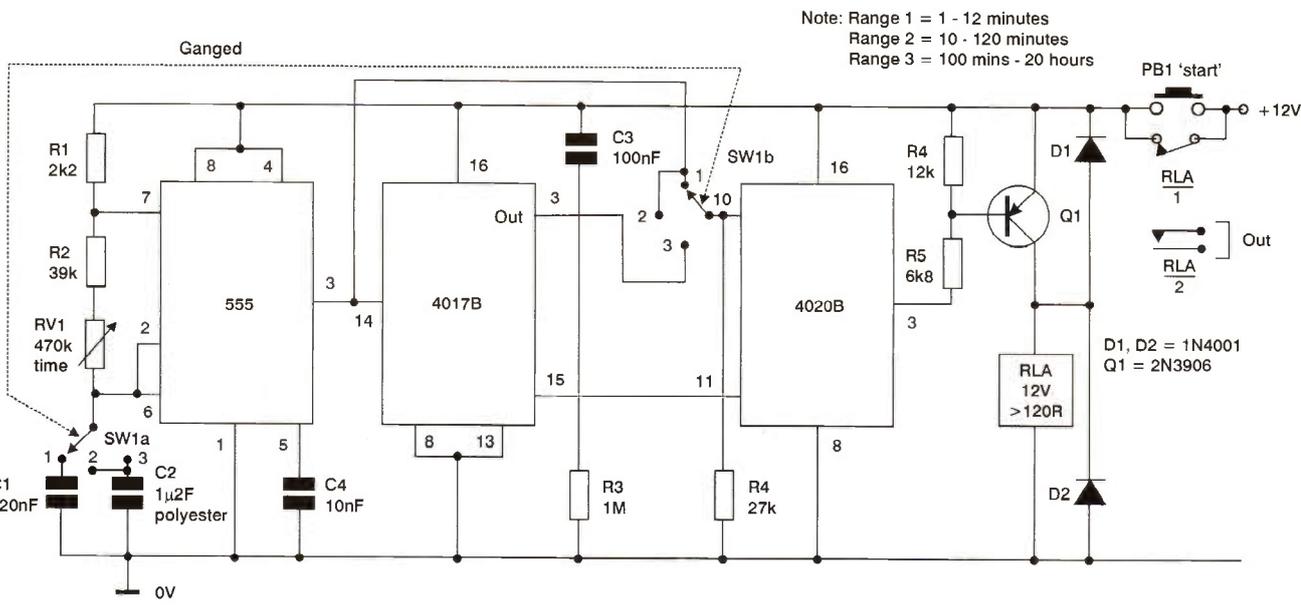
**Figure 18. Extra-long-period (100 minutes to 20 hours) relay-output timer.**

pulse-generator mode. It can not give accurate timing periods in excess of a few minutes, since it would have to use a high value electrolytic timing capacitor, and these have very wide tolerance limits (typically -50% to +100%) and large and unpredictable leakage currents.

An excellent way of getting very long but accurate timing periods is shown (in block diagram form) in Figure 16, which outlines the design of a 60-minute relay-driving timer. Here, the 555 is wired as a 2.28Hz astable that uses a stable polyester timing capacitor, and its output is fed to the relay driver via a 14-stage binary divider that gives an overall division ratio of 16,384. The divider action is such that (if its output register is set to zero at the start of the input count) its output switches high on the arrival of the 8192nd astable pulse and goes low again on the arrival of the 16,382nd pulse, thus completing the count cycle. Thus, the Figure 16 circuit operates as follows:

The timing sequence is initiated by pressing push-button switch PB1, thus connecting the circuit's supply and activating the astable, via C2 and R3. This sets the counter to 'zero count' and drives its output low and turns the relay on. As the relay turns on its RLA/1 contacts close and bypass PB1, thus maintaining the supply connection once PB1 is released. This state is maintained until the 8192nd astable pulse arrives, at which point the counter's output switches high and turns the relay off, thus opening contacts RLA/1 and breaking the circuit's supply. The operating cycle is then complete. Note that the astable operates with a period that is only 1/8192nd of the final 'timing' period, i.e., 0.44 seconds in this case, and that this period can easily be obtained without using an electrolytic timing capacitor.

Figure 17 shows the above technique used to make a practical relay-output timer that spans 1 minute to 100 minutes in two overlapping decade ranges. Here, the 555 variable-frequency two-range astable feeds clock pulses to the 4020B 14-stage divider, which in turn activates the relay via transistor



Note: Range 1 = 1 - 12 minutes  
 Range 2 = 10 - 120 minutes  
 Range 3 = 100 mins - 20 hours

Figure 19. Wide-range timer that covers 1 minute to 20 hours in three decade ranges.

Q1. The circuit uses a 12V supply, and the relay can be any 12V type with two or more sets of change-over contacts and a coil resistance of 120 ohms or greater.

Figure 18 shows how the available time delay of the

circuit can be further increased by wiring a 4017B decade divider between the output of the 555 and the input of the 4020B, to give an overall division ratio of 81,920. This provides delays in the range 100 minutes to 20 hours available

from this single-range timer. Both divider ICs are automatically reset (via C3-R3) at the moment of switch-on (PB1 closure).

Finally, Figure 19 shows the above circuit modified to make a wide-range general-purpose

timer that spans 1 minute to 20 hours in three decade-related ranges; the 4017B decade divider stage is used only on range '3'. Range switching is obtained via 2-pole 3-way switch SW1.

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