ELECTRONICS and Beyond

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...there may be trouble ahead!

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Uri Geller's Extended Reality

The development of the Egely wheel

The End of Celluloid Film?

Digital Cinema is here

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The original valves, it seems, are the best

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- Printer Head Tester
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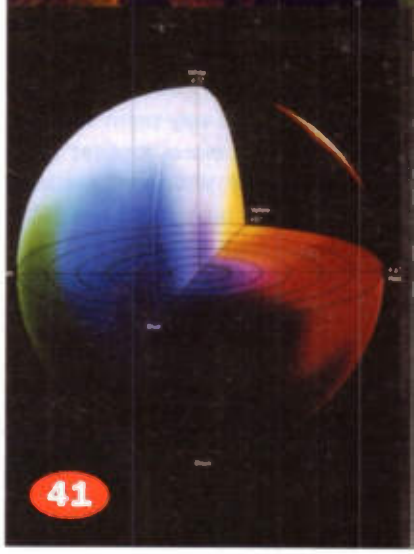
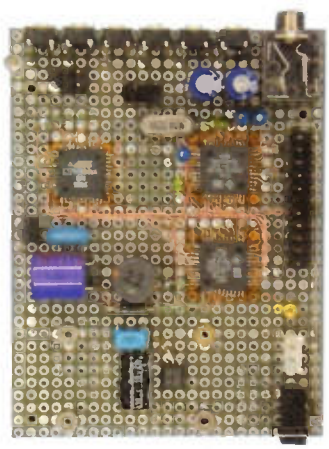




ELECTRONICS and Beyond

Now that we are in the year 2000, the Y2K 'bug' seems to have been a rather dead one. However, there is a potential problem brewing that could seriously disrupt our way of life for some considerable time - solar storms. The consequence of these storms on satellite communications could be devastating, upsetting global communications, television etc., and power distribution - and this could all be imminent. Dr. Chris Lavers discusses the implications in his article under Research News.

We have often talked in these pages about MP3 players, so for all readers who wish to try this exciting media, Martin Pipe describes such a player using PC components - this could easily be an old Pentium that you have sitting in the corner. Martin tells you how to build a dedicated MP3 player that can even be used to provide a very interesting and effective visual display/lighting effect, using the right software. This is an elaborate project, but we feel many of you will be 'hooked' on the idea. And in his series Technology Watch, Martin continues with a digital theme and looks at how a digital format is poised to replace film in the cinema.

In part three of An Electrifying Century: The Rise of Electronics 1900-2000, Gregg Grant brings us to 1950 and the arrival of the computer. Up to this half way-point developments seem to have been at a more 'modest' and steady rate with the effects of WWII perhaps increasing the pace. The last 50 years have been breathtaking - and some might argue frightening.

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT

Apple Enhances Power Mac G4 Line

Apple has enhanced its entire Power Mac G4 line to include the new Rage 128 Pro graphics card, featuring an up to 40% increase in 3D graphics performance and a digital video interface which supports Apple's new digitally-driven LCD displays.

In addition, the 350MHz configuration has been upgraded to the same architecture used in the 400MHz and 450MHz configurations, and now comes with a DVD-ROM drive, AGP graphics and support for Apple's AirPort wireless networking. The three new Power Mac G4 configurations are available immediately at the same prices as their predecessors.

Apple has also unveiled a 15in. all-digital flat panel LCD display to complement its already-announced 22in. flat panel Cinema Display. Both displays feature digital video interfaces that are compatible with all configurations of the G4 line and deliver razor-sharp, distortion-free images. The new 15in. display supports 16.7 million true colours and has a native resolution of 1024 by 768 pixels.

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

Contact: Apple, Tel: (0870) 600 6010.

Dell Introduces Webpc Designed and Built for the Internet

The new Dell Webpc, is about one-third the size of a traditional desktop tower and comes in a range of five colours with prices for a complete system, including a monitor, printer and one year of Internet service, starting around £700.

Dell's Webpc is easy to order and simple enough to go from the box to the Internet in as little as 10 minutes. Dell's Webpc was created specifically for today's cyber-psyched consumers who want an easier way to experience the richness of the Internet.

The Webpc can be purchased with an optional flat panel display. Dell's new PC is priced from £700 for a bundle that includes a Webpc with an Intel Celeron 433MHz processor, colour-matched 15in. cathode ray tube monitor, printer and one year of Dellnet Internet service.

More than 200 million people enjoy Internet access worldwide, and the number is expected to grow to more than one billion over the next 10 years, according to industry analysts.

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

Contact: Dell, Tel: (0870) 152 4699.

Quantum Ships Quietest Hard Drive

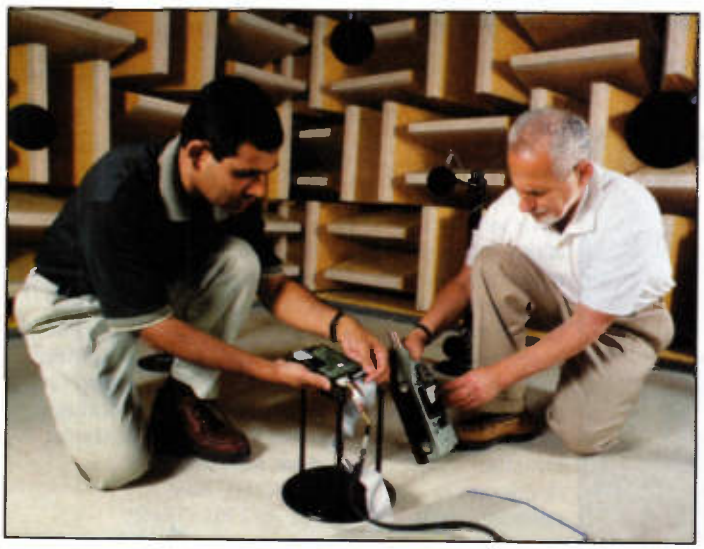
Quantum is shipping the world's quietest desktop hard drive - an accomplishment made possible by a series of innovative acoustical advancements called Quiet Drive Technology (QDT).

Quantum's QDT was pioneered through a combination of proprietary design innovations and unique drive features that enable Quantum to develop drives that emit dramatically reduced levels of noise.

Quantum introduced this technology over a year ago in its industry leading Quantum QuickView audio/video drives targeted for the noise-sensitive consumer electronics market.

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

Contact: Quantum, Tel: (01344) 353510.



AMD Expands the Embedded Processor Family

AMD, one of the few credible competitors to Intel in the PC processor market, has announced the immediate availability of four new, higher performance versions of its AMD-K6-2E embedded processor family at speeds up to 350MHz.

The new additions include: the 350MHz and 333MHz standard power processors, and the 333MHz and 300MHz low-power processors. The AMD-K6-2E embedded processors are designed to offer compelling yet cost-effective performance for embedded applications.

The AMD-K6-2E processor is a functionally compatible embedded version of AMD's sixth-generation, Microsoft Windows software-compatible AMD-K6-2 processor, which is used in many top-selling desktop and notebook PCs.

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

Contact: AMD, Tel: (01276) 803100.

NEWS BYTES

Nine Out of 10 Printer Users Prefer HP

Hewlett-Packard has announced the results of an HP-commissioned study in which nine out of 10 printer users preferred the HP DeskJet 970Cse printer over the Epson Stylus 900 printer.

According to the survey participants, the DeskJet 970Cse printer is the printer of choice based on its excellent print quality, whisper-quiet operation and overall design.

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

Contact: HP, Tel: (01344) 773100.

Free Demo Version of Internet Browser for Linux Market Announced

Access has announced that it has placed a free demonstration version of its NetFront Internet browser on its web site for evaluation by developers of Linux-based embedded applications.

Access' NetFront and Compact-NetFront browsers are very popular in Japan, where Access estimates that it has over 80% of the embedded browser market for devices such as personal digital assistants, mobile phones, digital televisions and video game consoles.

For further details, check: <www.access.co.jp/product/develop/demo/dem.html>.

Contact: Access, Tel: +81 3 3233 0200.

Mannesmann Teams With SAP to Fend Off Vodafone

German telecom group Mannesmann, in a move to fend off a hostile takeover by firm Vodafone AirTouch, is teaming up with SAP, Europe's largest software group, to develop e-commerce services. As part of its strategy to discourage the merger, Mannesmann has been touting its superior growth prospects, compared with Vodafone, in developing integrated mobile and fixed-line telephone businesses.

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

Contact: Mannesmann, Tel: +49 211 820 0.

NEWS BYTES

Credit Card Machines Confused By Year 2000

Machines manufactured by Racal Electronics and supplied to retailers by the HSBC bank were unable to recognise the year 2000 as a valid date by central computers doing four-day diagnostic checks.

As many as 20,000 credit card machines in England failed to allow merchants to swipe the cards through the machines during recent sales, forcing data to be entered manually, causing delays to shoppers.

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

Contact: Racal Electronics, Tel: (01344) 481222.

Something Old, Something New

Hewlett-Packard and STMicroelectronics are forming a R&D partnership to adapt for new uses an old microchip originally designed at Yale University in the early 1980s for use in supercomputers. The chip is called Very Long Instruction Word (VLIW), and packs instructions densely to maximise processing efficiency. The intent of the research partnership is to redesign the VLIW so that it can be embedded in low-power consumer products, such as wireless phones.

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

Contact: HP, Tel: (01344) 773100.

World Awaits Windows 2000

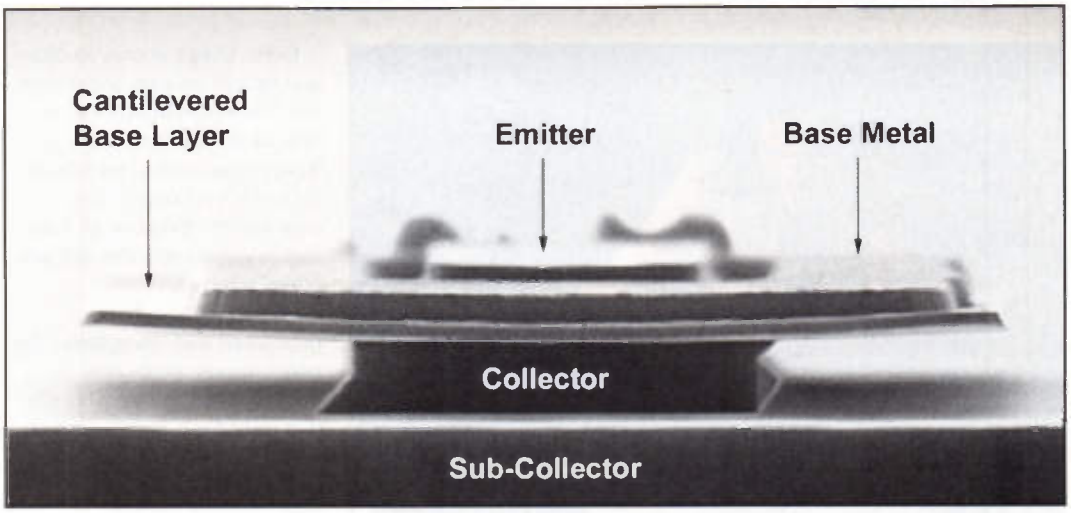
Microsoft says Windows 2000 will be released on February 17, 2000. But for months, Microsoft had been saying it was on schedule to release the program to manufacturers by the end of 1999, although the date was not fixed and could be pushed back if glitches appear.

Windows 2000 will be Microsoft's first operating system for high-end server computers, and Microsoft believes Windows 2000 will rival Unix systems in reliability and stability. The operating system is the core of Microsoft's effort to dominate the Internet computing market.

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

Contact: Microsoft, Tel: (0870) 6010100.

Indium Phosphide Technology Points to Higher Internet Speeds



TRW Space & Electronics Group, a leader in high-speed integrated circuits, has demonstrated the world's fastest digital integrated circuit: a frequency divider operating at a clock frequency of 69GHz, or 69 billion cycles per second. The chip was fabricated using indium phosphide, an advanced semiconductor material with high-speed performance superior to that of silicon or gallium arsenide.

The digital circuit was made using indium phosphide heterojunction bipolar transistors. A unique feature of these transistors is the removal of collector material beneath the base layer, resulting in a cantilevered base layer resting upon a pedestal-like collector layer. The greater the amount of cantilevering, the higher the speed of the frequency divider.

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

Contact: TRW, Tel: +1 216 291 7000.

3Com Becomes Bluetooth Promoter

3Com, Lucent Technologies, Microsoft and Motorola have all joined the five founding companies, Ericsson, Intel, IBM, Nokia and Toshiba to form the Promoter Group of the Bluetooth Special Interest Group (SIG).

The charter of the Bluetooth Promoter Group is to lead the efforts of the Bluetooth SIG by creating a forum for enhancing the Bluetooth standard and providing a vehicle for interoperability testing.

The Bluetooth wireless communications standard is expected to re-define the personal communications market by expanding the capabilities of mobile devices both in and out of the office and to make these devices work better together.

Bluetooth technology will provide an easier way for mobile communication and computing devices to communicate with one another in their immediate vicinity without the need for wires or cables, creating a wireless Personal Area Network.

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

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

Sun Previews Cross-Platform Java Development Tool

Sun has announced a JAVA development environment that allows developers to quickly and cost effectively create Java technology-based applications such as mobile phones and PDAs. Called Forte for Java, the development environment is available for free download from Sun's Web site.

The development environment is a complete, extensible tool that provides user interface, edit, compile and debug functionality and a complete, open application programming interface (API) that allows developers to create customised plug-in modules.

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

Contact: Sun, Tel: (01276) 451440.

Intel Delivers Itanium Processor-based Prototype Systems

Intel has begun delivering prototype Itanium processor-based servers and workstations, further assisting system manufacturers, operating system vendors and application providers to complete the development and testing of products targeted for Intel's Itanium processor. Production Itanium processor-based systems are scheduled to ship in the second half of 2000.

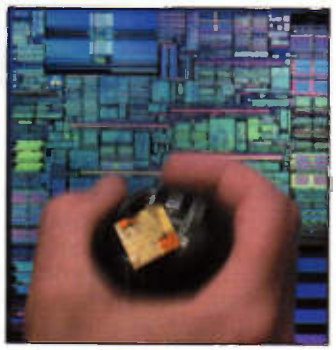
For further details, check: <www.intel.com>.
Contact: Intel,
Tel: (01793) 403000.

IBM Plans Machine 500 Times Faster Than Fastest Supercomputer

IBM is embarking on a five-year, $60 million program to create a computer called Blue Gene, designed to be 500 times faster than today's fastest supercomputer and capable of simulations that will provide insights into the basic physics and chemistry of life.

Containing a total of one million microprocessors, the machine will be six feet high and occupy a floor space 40 feet by 40 feet. Blue Gene's architecture is based on a sharply simplified instruction set and on chips that will speed processing by combining data and processor on the same microchip.

For further details, check: <www.ibm.com>.
Contact: IBM,
Tel: (0181) 818 4000.



Industry Bodies Back Anti-Ageist IT Training Initiative

Leading UK industry bodies are giving their support to a new European Social Fund-financed initiative to provide half the cost of training for engineering and construction industry professionals aged 40+ in a wide variety of IT and management skills.

Open to those who work for companies employing up to 250 people, or who are self-employed, Mature Professionals into IT (MAPIT) is aimed at improving the individual's value by training them to take on a new IT role or in helping them bring the benefit of years of industry experience to an IT-specific position.

IT skills will also extend the individual's opportunities for future employment, and the self-employed can gain valuable IT skills to transform the competitiveness of their own businesses.

The first stages of MAPIT have just been launched in London, Yorkshire/Humber, East Anglia, Hertfordshire and Bedfordshire, and training must be completed by June 2000. A consortium of local training providers is offering more than 500 courses, covering a variety of study programmes including evening, weekend and Internet courses and candidates must live in those regions.

Contact: MAPIT,
Tel: (0171) 580 6677.

Vodafone, Nortel Networks to Conduct 3G Wireless Internet Trial

Vodafone and Nortel Networks are planning a trial in London beginning early this year of W-CDMA third generation (3G) wireless radio and IP (Internet Protocol) networking technologies expected to deliver faster, more reliable and more profitable Wireless Internet services.

Nortel Networks and Panasonic, which formed an alliance in 1998 to develop 3G wireless voice and data solutions, will provide the radio equipment, core data network and terminals for the trial. A high-speed IP data connection – featuring Nortel Networks' Multiservice Passport platform – will interconnect the trial equipment to various corporate Intranets and the Internet.

Vodafone UK will be able to test a variety of innovative data and voice services using prototype terminal equipment that subscribers can instantly recognise as consumer electronics devices.

Among the devices to be tested is a mobile phone with a built-in camera and video screen which utilises the MPEG4 video codec and is capable of transmitting and receiving data at rates up to 64 kilobits per second (kbps). Other planned trial devices include lightweight, pocket-sized voice terminals, wireless modems for laptop computers, and a mobile data device with transmission speeds up to 384kbps.

The trial will feature business and consumer applications. Participants will be able to hold live video communications sessions using the mobile videophones, or view streaming media from the Internet. In addition to this trial with Vodafone UK, Nortel Networks has W-CDMA trials planned or already underway with British Telecommunications PLC, France Telecom and the North American GSM Alliance.

For further details, check: <www.vodafone.co.uk>.
Contact: Vodafone, Tel: (01635) 550000.

NEWS BYTES

ELSA Announces Wireless Networking Breakthrough

ELSA has deployed wireless networking products reaching speeds of 11Mbit, compliant with the IEEE 802.11b standard recently adopted by Institute of Electrical and Electronics Engineers (IEEE).

Complete 11Mbit products will be launched during CeBIT 2000 in Hanover at the end of February 2000. ELSA has joined WECA, the Wireless Ethernet Compatibility Alliance, an organisation of the world's leading manufacturers of wireless networking solutions.

According to research published by Frost and Sullivan, worldwide market size for wireless networking networks products will reach approximately 900 million US dollars by 2002.

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

Contact: ELSA,
Tel: (0118) 965 7755.

Logitech has New Wheel Mouse for Macintosh

Logitech is now shipping a blueberry and ice version of its Wheel Mouse. The Logitech Wheel Mouse for Macintosh fits both right and left hands. It features a scroll wheel that lets users navigate through documents or on the web without the need to locate and click on scrollbars. The scroll wheel also functions as a third mouse button.

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

Contact: Logitech,
Tel: (01306) 734 300.

£320 Million Boost for UK Scientific Research

The biggest investment in university science infrastructure for forty years has been announced by Stephen Byers, Trade and Industry Secretary and the Wellcome Trust.

A total of £320 million is to be awarded to 45 projects in 27 universities in an effort to tackle years of chronic underfunding and to help the UK maintain its position at the forefront of scientific research.

The size of the awards vary from around £30 million to a minimum of £750,000.

For further details, check: <www.dti.gov.uk>.

Contact: Department of Trade and Industry, Tel: (0171) 215 5000.

NEWS BYTES

Sharp Introduces Continuous Grain Silicon LCD

Sharp has announced its first-ever product incorporating the company's revolutionary continuous grain silicon (CG-Silicon) LCD technology - a 60in. high definition rear projection display.

Engineered to deliver superbly detailed images, the SharpVision rear projector system produces incredibly life-like and beautiful high-quality images ideal for viewing high definition broadcasts, DVD players and other digital video sources, from virtually any angle.

For further details, check: <www.sharp.co.uk>. Contact: Sharp, Tel: (0800) 262 958.

ITC Requires Ondigital to Commit to Open Standard

The ITC has said that it requires Ondigital to commit to a firm timetable for the public availability of the plug-in condition access modules that will enable their services to be received via and open-standard integration digital TV sets. The ITC will audit a set of agreed interim milestones towards a final launch date of May 2000. For further details, check: <www.itc.org.uk>. Contact: ITC, Tel: (0171) 255 3000.

High Cables with Flat Cable

Speaker cable, a little thicker than a post card and designed to run under carpets and beneath wallpaper, is now available from Acoustic Research. Called Micro-Flat, the 0.5mm thin two-strand speaker cable with 18 AWG oxygen free copper is guaranteed for a lifetime. Microflat cable comes in three pack sizes: 30ft priced £39.99; 50ft priced £59.99; and 100ft priced £99.99. For further details, check: <www.recoton-europe.com>. Contact: Acoustic Research, Tel: (0161) 702 5000.

Olympus, IBM Have Eyes on Wearable Computer

IBM and Japanese camera manufacturer Olympus unveiled a futuristic wearable computer in Tokyo. The 13oz computer consists of a screen that fits over one eye and a handle with a touchpad and two buttons to make commands. Although the wearable computer lacks a keyboard, it may be added in the future. It comes with 64MB of RAM, uses Windows, and can play audio and video.

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

Contact: IBM, Tel: (0181) 818 4000.

Quantum Electronics Doubles Capacity with £2.5 Million Expansion

Quantum Electronics, a leading UK electronic manufacturing service provider has announced the opening of a new £2.5 million facility at its Imperial Park site in Newport, Gwent and the creation of 100 skilled jobs over the next two years.

The new facility provides Quantum with a total of 60,000 square feet of manufacturing space and will enable it to double its present manufacturing capacity. The construction of the new facility cost £940,000. Quantum will spend an additional £1.6 million in capital investment over the next 2 years.

The jobs created will be split between 20% management and 80% manufacturing technicians. Quantum's expansion is being fuelled largely by its development as a virtual manufacturer to electronics start-ups under the guidance of chairman and serial entrepreneur Bob Jones.

This strategy has enabled the company to achieve year-on-year growth of 30% over the last two years and it expects to report sales of £15.6 million for 1999. Quantum's client base of electronics start-ups includes Jones' latest venture Equiinet, in addition to Flexion Systems, Imigix and Virtual Access.

For further details, check: <www,quantun-electronics.co.uk>.

Contact: Quantum Electronics, Tel: (01633) 654600

Black Silicon: a New Way to Trap Light

A new type of material, accidentally discovered in a Harvard University physics laboratory, could lead to more efficient ways of converting sunlight to electricity, communicating by light, and monitoring the environment for evidence of global warming.

The material came to light when some graduate students and their adviser, Eric Mazur, decided to treat silicon with a high-intensity laser. Silicon is the substance of which virtually all computer chips are made; without it, there would be no Internet, no cellular telephones, no electronics.

Gordon McKay Professor of Applied Physics, and his students were studying what kinds of new chemistry can occur when lasers shine on metals, like platinum. One day, they decided to put a chip of grey silicon into a vacuum chamber, add some halogen gas, and scan it with ultrashort, ultra-intense laser pulses.

Each pulse lasted a mere 100 millionths of a billionth of a second. However, the energy in a single pulse approximates to the equivalent of focusing all the sunlight hitting Earth at one time onto a space the size of a fingernail.

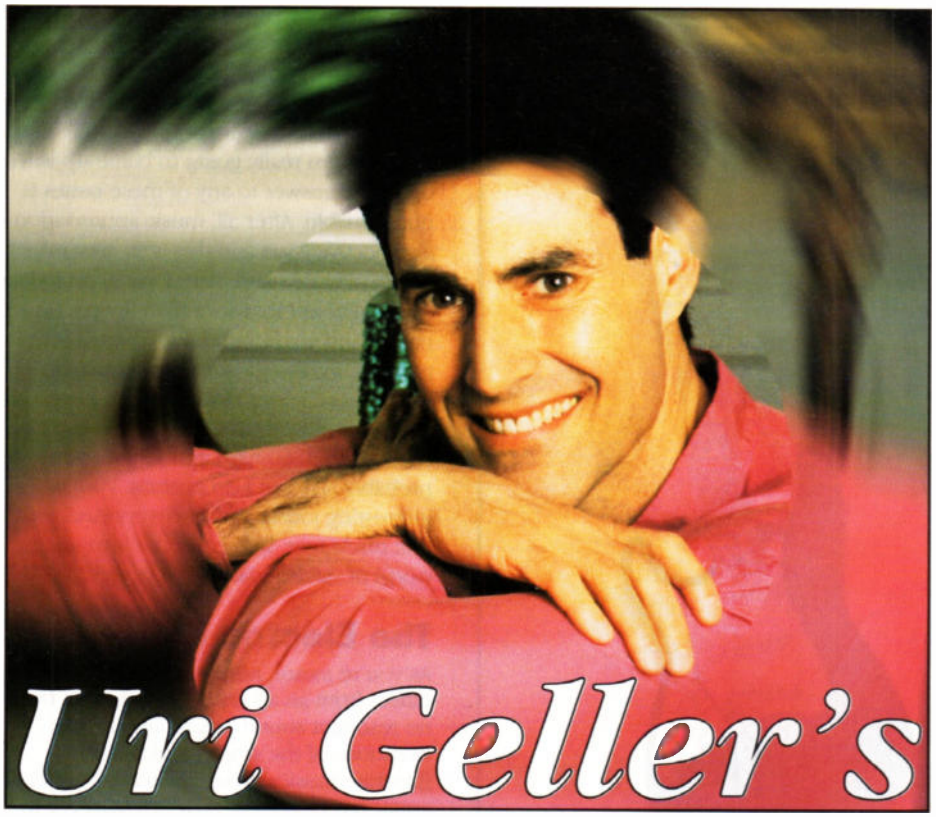
After more than 500 pulses, the silicon turned black. It wasn't burned; rather, its surface had been etched by the heat and gas into a dazzling forest of billions of minute needlelike spikes. If a light is shone on such a surface, it repeatedly bounces back and forth between the spikes in a way that most of it never comes back out again.

The Harvard team quickly realised that anything that absorbs light this well would make an excellent solar cell, converting much more sunlight into electricity than any device now on the market.

The spiky surface also absorbs infrared radiation or heat, making it an excellent detector of clouds, pollution, water vapour, and specks of dirt and liquid that change the quality of our air and influence global climate.

For further details, check: <www.harvard.edu>.

Contact: University of Harvard, Tel: +1 617 495 1000.



Uri Geller's EXTENDED REALITY

The Egely Wheel

Several years ago when I was on a visit to Budapest, I met a very pleasant young couple named George Egely and his wife Magdolna Dus. Both were well qualified scientists - Magdi had a Ph.D in mathematics while George was a graduate of the Technical University of Budapest in mechanical engineering, his speciality being energy transfer.

He won a scholarship from the International Atomic Energy Agency and spent a year and a half at the Brookhaven National Laboratory in the U.S.A. Back home, he went to work at the Central Research Institute for Physics of the Hungarian Academy of Sciences. He seemed all set for a successful and respectable career in 'real' science, as secure as Magdi's job as a teacher.

However, George had some ideas of his own about what kind of research he really wanted to do. It was probably all Magdi's fault - not long after they were married, she happened to mention that she and a group of fellow university students had done some table-tilting in their hostel - that is, making a table jump about and even leave the floor altogether just by having a group of people put their hands on it. In the mid 19th century this was a fairly normal after-dinner pastime and some very distinguished people tried it for themselves.

One of these was Alfred Russel Wallace, whom I mentioned in my January column in connection with his interest in animal mimicry, and in a future column I'll be telling you more about this much underrated pioneer in many fields, But for now, back to Budapest....

"I had to choose whether not to believe my wife or not to accept the laws of natural science," George recalls, "I was not sure which one to choose - both would have painfuland unpleasant consequences in the long run." As you might have guessed, he settled for the second choice. He was encouraged by something one of his American colleagues, a mathematician, had told him.

"Real scientists should never reject something until they are 100% sure that the subject in question is true or false. They must personally take the trouble to objectively control the facts, carry out scientific experiments and collect the data."

George began to find out all he could about what earlier researchers had discovered in the area of phenomena generally called paranormal, or inexplicable in terms of presently understood science. This was not easy to do under the Communist regime, but George had many friends in Western Europe and the U,S.A, and was able to keep up to date with progress in scientific parapsychology.

He was particularly interested in what he reckoned must be unidentified energies in the human body, and began some simple experiments with no more than a bowl of water by way of equipment. He and Magdi found they could make the water rotate just by placing their hands near it. They tested some of their friends and found that most of them could do the same, but some were much better at it than others, and the way they were feeling at the time seemed to make a difference,

They also carried out experiments in various schools, testing a total of 500 students, videotaping them as they placed their hands over dishes. About a third could not get the water rotating at all, they found, while two thirds could. George decided that there was immediately obvious explanation for this motion, and set about getting his bosses at the Academy interested in sponsoring some serious research.

He ran straight into a Communist brick wall. The eminent academic recommended by his supervisor took a brief look at the pile of research reports, photos and videos that George had brought along and told him to stop this research at once and switch to something else "that earns good money." He was unmoved by the fact that his own Academy had published George's paper Experimental Investigations of Biologically Induced Energy Transport Anomalies in 1986 (RFKI report 94/K).

"I don't believe this even if I see it with my own eyes" he declared. "The phenomenon does not exist, because it cannot, and it cannot exist because it does not."

Some might have given up at this stage, but not George. "I did not give up because my scientific curiosity did not allow me to do so," he recalled later. So it was that in 1989 he filed a patent application for what he likes to call "probably the most serious toy you'll ever have," and let me add, probably the most controversial too, namely the Egely Wheel. More about it in a future column.

Enquiries regarding the Egely Wheel in the UK should be direct to the sole importer Klara Heltay, fax no: 0181 287 1079, or email klheltay@compuserve.com.

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

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

Valves in the 21ST CENTURY

PART 3

In part 3, Mike Bedford investigates the fabled 'valve sound' and guitar and audiophile valve amplifiers

This is the third article in the series and, if you've been with us from the start, you should now know the basics of valve technology, even if you were brought up on a diet of transistors. You will also understand something about the different classes of valve amplification and these are foundations we'll be building on this month. What I haven't done, though, is to provide any justification for my assertion that there are things, even in the 21st century, which can be done with valves which would be either impossible or very expensive to do using semiconductors. And if you're a confirmed believer that valves are yesterday's technology, this month's article probably won't convince you otherwise. This month, we're going to take a look at a somewhat controversial area. Unlike some of the applications we'll look at later for which valves are the only sensible option, the area we're going to look at in this article is one which can and is served by semiconductor technology. This is an application, nevertheless, for which a vociferous minority feel that valves provide a superior result. The application in question is audio amplification and specifically in electric guitar amplifiers and in top-end 'audiophile' hi fi amplifiers. But can valves really provide superior performance to modern semiconductor amplifiers? Is there such a thing as the fabled 'valve sound?' And what of the heated debates in the valve audio industry on the best approach to valve amplification? Whether I'm really going to come up with a definitive answer to any of these issues is questionable. After all, music appreciation is a subjective issue and this is an area in which opinions and, dare I say it, prejudices seem to count for more than figures on paper. And so they should – there's little point in owning an amplifier which, on paper, has a superb frequency response and super-low distortion figures if you can't bear to listen to it. So hard and fast answers, probably not, but I do promise you an interesting journey of discovery. And with that disclaimer, let's enter the intriguing world of valve audio.

The Electric Guitar

As you're aware, no doubt, an electric guitar differs from an acoustic guitar in that there's no resonant sound box to amplify the vibrations of the strings and thereby generate musical notes. Instead, the electric guitar has electronic pick-ups adjacent to the strings which, in conjunction with an electronic amplifier, generate the music we hear. The first solid-bodied electric guitar was developed in 1940 by the American musician and inventor Les Paul but it wasn't until the 50s that electric guitars really took off. Needless to say, the amplification of these early guitars relied on valve technology – transistors didn't hit the scene until 1947 and were extremely expensive until the early 60s. Even today, to many musicians, valve amplification is an integral part of the electric guitar. Of course there are plenty of solid state guitar amplifiers on the market and there have been for decades but many of the world's top electric guitarists are thoroughly committed to valves. A flick through the pages of the Fender catalogue reveals around 50 different guitar amplifiers of which about half contain valves and a number of those which don't claim 'tube emulation'.

So what is it about valves which makes them so much superior to semiconductors according to top musicians? Some people in the music world have a rather different view but, according to many electronic engineers, guitarists have just got used to the deficiencies of the valve amplifiers of the 50s and associate this sound with the electric

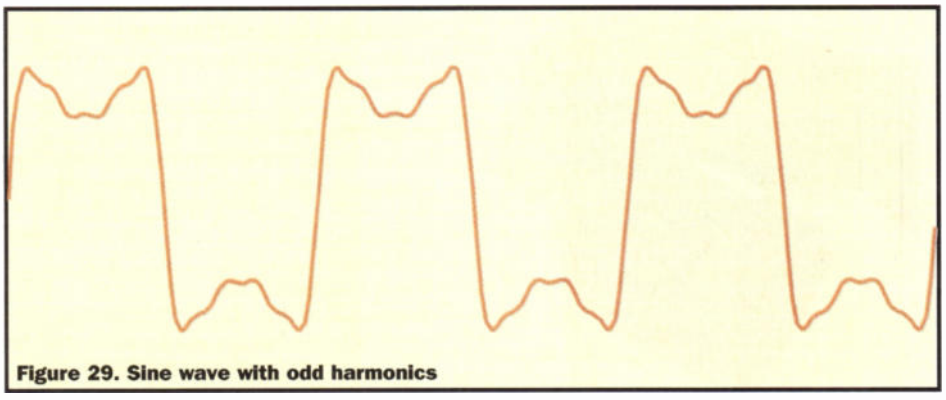


Figure 29. Sine wave with odd harmonics

guitar. Whether or not valve amplifiers of the 50s, and the copies which are made today, truly do exhibit a whole range of distortions which just happen to sound musical is a debate I'm not going to enter into. Nevertheless, the argument is a reasonable one. As we'll see later, the job of a hi fi amplifier is to amplify a sound in as linear a fashion as possible but intriguingly this isn't necessarily the case with a guitar amplifier. Unlike virtually all the instruments which preceded it, there is no 'native' electric guitar sound to be amplified and, accordingly, nobody can say whether or not the amplifier has reproduced the characteristic sound of the guitar faithfully. An electric guitar makes very little sound by itself so the amplifier is inextricably linked to the guitar. The inherent sound of an electric guitar is, therefore, dependent on the characteristics of both the guitar and the amplifier. So just as the characteristic sound of the acoustic guitar is a function of its impure waveform (which, in turn, results from the non-linear characteristics of its acoustic amplifier – the sound box) the inherent sound of the electric guitar is a function of the valve amplifier – linear or not. And as we'll see later when we look at hi fi amplifiers, valve amplifiers tend to produce even harmonics, predominantly the 2nd, whereas transistor amplifiers generate odd harmonics. A sine wave with odd harmonics added is shown as Figure 29. Although this is much exaggerated – no real amplifier would ever be as bad as this – this is the sort of waveform which would be produced by a solid state amplifier. It's typical of a woodwind instrument such as a clarinet. Figure 30 shows a sine wave with a significant amount of the 2nd harmonic and lesser amounts of the 3rd and 4th. This is typical of what might be produced by a fairly basic valve amplifier and the triangular waveform is not too dissimilar from that of a plucked string instrument such as a viola. Perhaps it's not too surprising that musicians prefer an amplifier with characteristics which make the electric guitar sound string-like than one which causes it to sound wind-like.

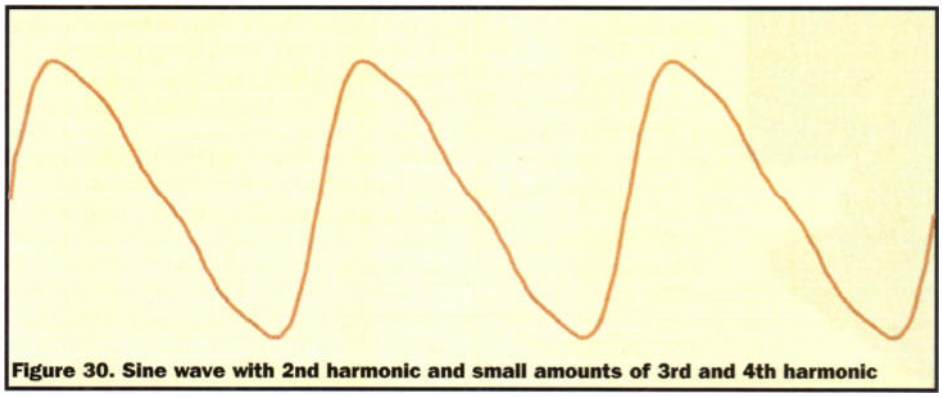


Figure 30. Sine wave with 2nd harmonic and small amounts of 3rd and 4th harmonic

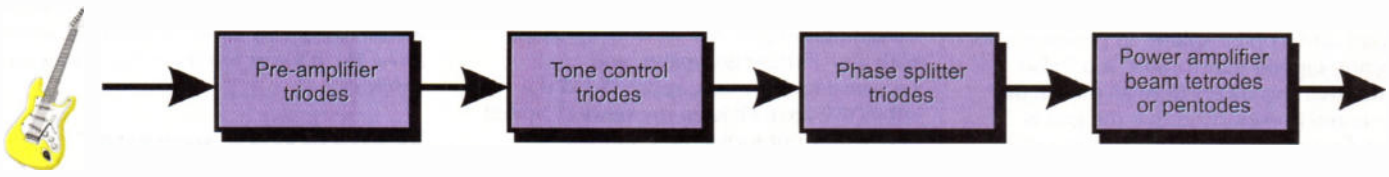


Figure 31. Block diagram of typical valve guitar amp

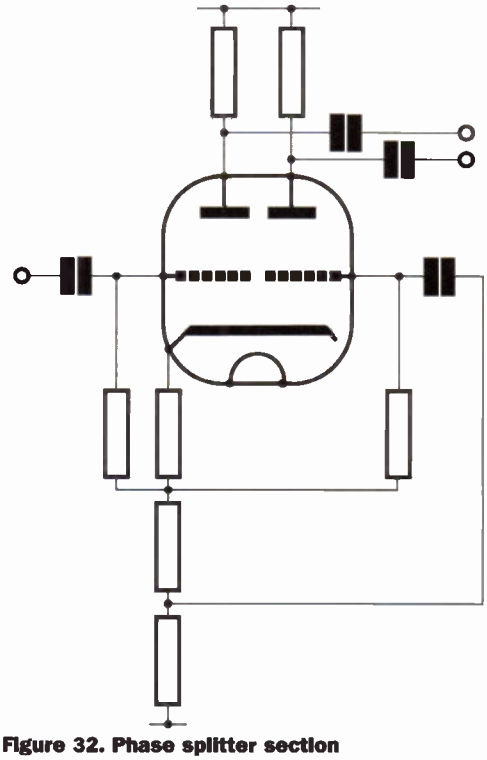


Figure 32. Phase splitter section

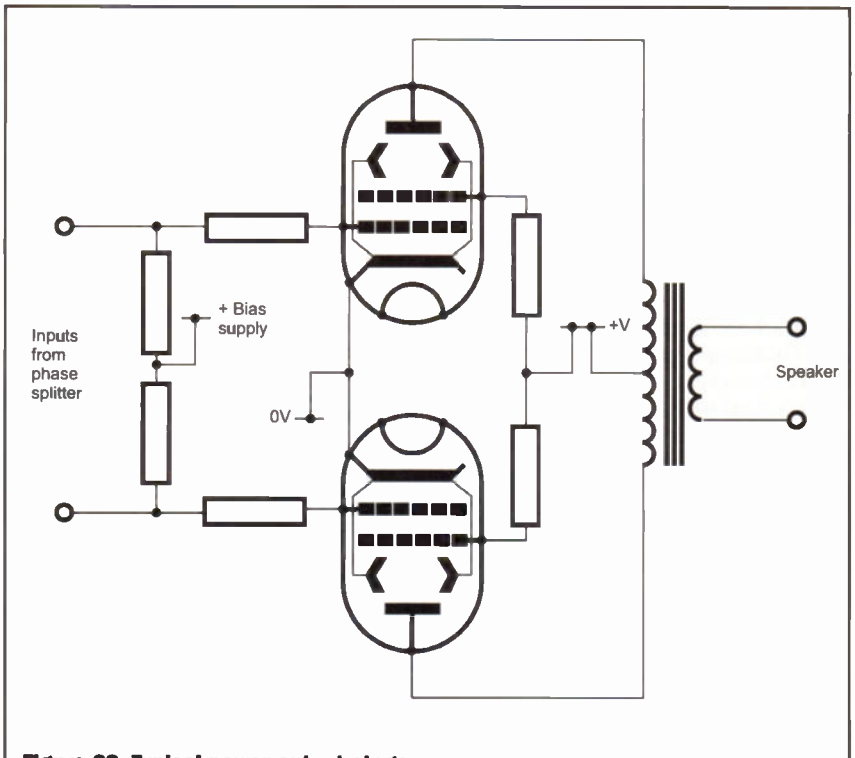


Figure 33. Typical power output stage

To conclude our look at guitar amplifiers, a typical block diagram plus circuit diagrams of the phase splitter and power amplifier are shown as Figures 31, 32 and 33 respectively. The PA is, of course, a push-pull configuration based on beam tetrodes. However, unlike the push-pull amplifier we saw last month, guitar amplifiers normally use an active phase splitter in preference to a centre-tapped transformer. You'll also notice that this differs from all the circuits presented previously in that the grid is biased using a separate bias supply rather than a dropper resistor with a capacitor bypass in the cathode circuit. Although the dropper resistor approach is common in small signal circuits, it's clearly quite unsuitable for use in power amplifiers.

Audiophile Hi Fi

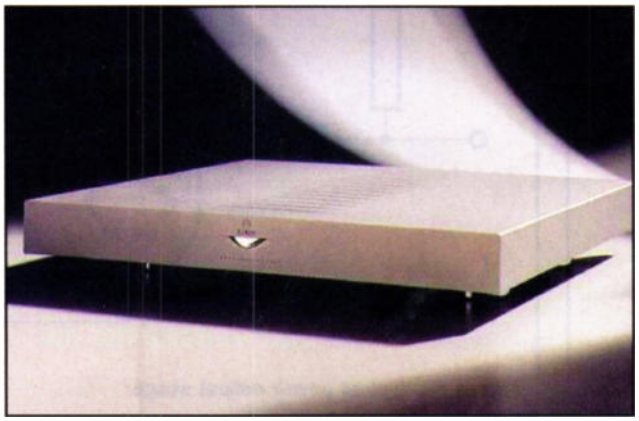
As we turn our attention to audiophile hi fi amplifiers, I can't get away with saying that it really doesn't matter if the amplifier is linear as I did in the case of guitar amplifiers. The situation here is very different – the vast majority of hi fi purists will say that the job of an amplifier is simplify to amplify the signal taken from the CD, vinyl record or whatever with as little distortion as possible. In other words a good hi fi amplifier is transparent, it doesn't colour the sound in any way and it's hard to disagree with this sentiment. Unlike the situation with the electric guitar amplifier where we can't say what a non-amplified guitar sounds like, many music enthusiasts know exactly what a tenor saxophone or a particular female vocalist sounds like in concert and expect to hear the same sound from a hi fi amplifier. Since the aim is irrefutable, we might expect that there'd be a good consensus on how best to achieve that aim. Furthermore, where there's a range of alternative technologies, we could reasonably expect that most people would agree on which sounds the better. In reality, this couldn't be much further from the truth. First of all we have the solid state versus valve debate and secondly, if we concentrate on valves we have two conflicting philosophies which we'll look at shortly. All these three camps will argue that their approach is the best for technical reasons, all will say that their type of amplifier sounds better, that is it reproduces music more faithfully, and many of the key players in this market are very vociferous in their views. This is a market in which people are by no means reluctant to criticise, indeed ridicule, those competitors who choose a conflicting design philosophy. Not wishing to fall out with any of these groupings, and recognising that music appreciation is a subjective area, I'll keep my views to myself and simply put forward the various arguments. However, if you really do want to get to the bottom of these questions – to your own satisfaction, at least – I suggest that you search out a hi fi shop which stocks the various types of amplifiers we'll look at and listen to the differences yourself.

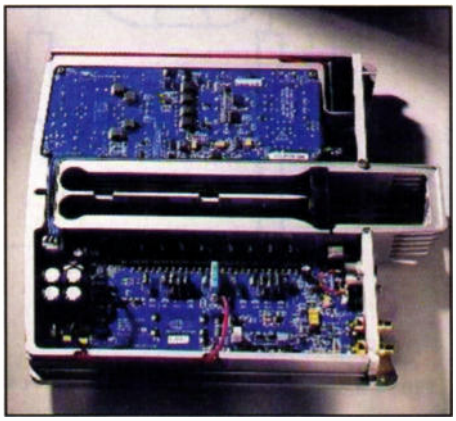
Loony Luddites?

Whether nostalgia is good or bad is very much a matter of personal opinion. But according to the more outspoken supporters of solid state technology, the interest in valves in audiophile hi fi is nothing more than nostalgia. Indeed the phrase 'loony minority' has been uttered on more than one occasion. Others will argue that manufacturers and owners of valve amplifiers are much more interested in aesthetics than in sound quality. And really, this links in with the nostalgia argument – I guess there is something quite nice about sitting in a darkened room, sipping a malt whisky and listening to your hi fi system with a golden amplifier glowing orange in the corner. Needless to say, the argument that aesthetics is paramount is one which the valve enthusiasts will firmly refute. But whether or not an undue emphasis is placed on appearances, most people would agree that many of today's audiophile valve amplifiers do look absolutely gorgeous. If you've never seen examples of these amplifiers, just feast your eyes on some of the photographs in this article. Of course, very few hi fi enthusiasts would suggest that acoustics should be traded in for looks and there's an interesting parallel here between the ongoing analogue versus digital debate. Most hi fi enthusiasts who still listen to vinyl records do so because they believe the sound to be superior to that obtainable from a CD even though this also attracts the 'Luddite' tag in some quarters. Despite this emphasis on sound quality, though, many of the top-end turntables are works of art giving rise, once again, to the criticism of aesthetics over musicality. But how do the designers react to this criticism? Peter Qvortrup of Audio Note, while denying that sound quality is ever compromised by the needs of aesthetics, did admit that looks are important, especially at the top end of the market. And the top end of this particular market attracts some serious price tags. Someone paying £159,000 for Audio Note's top of the range Gaku-On power amplifier would reasonably expect something which looks like it's cost ten times the price of a family car.

Transistors versus Valves

Unfortunately, much of what we read about relating to the pros and cons of valve amplification tends to be riddled with the sort of rhetoric alluded to in the previous section but let's try, at least, to stay clear of this for the moment and look at the electronics. To start off with, we'll take a brief look at the pros and cons of transistors and valves as viewed from each side of the great divide. This will only be a brief look, however, because many of the advantages of valves quoted by their supporters tend to be advantages, not of valves in general, but of their particular valve design philosophy. And since there's possibly more rivalry between the two competing valve camps than there





is between the supporters of valves and semiconductors, most of our discussion will be concerned with the differences between the two valve philosophies.

There are some common threads, though, and the one quoted most commonly by the valve lobby is that while neither valve amplifiers nor solid state amplifiers are distortion-free, transistors generate odd harmonics whereas valves generate even harmonics – most notably the 2nd harmonic. Many valve designers, while admitting that the output from their designs might have a higher total harmonic content than a good solid state design, will suggest that the human ear is far more tolerant of even harmonics than of odd ones. A very small amount of third harmonic, it's argued, will sound very unpleasant whereas a larger amount of the second harmonic can sound quite pleasant. Of course, this is rather different from saying that valve circuits exhibit far better linearity than solid state amplifiers – and this is surely the goal of hi fi amplifier design – and just to prove that you get different stories depending on who you talk to, some valve designers will indeed say this. The characteristic sound of some valve amplifiers, which is attributed to the second harmonic, is referred to as 'warm' by their supporters and 'woolly' by their critics.

A second common thread is that many of the differences between solid state and valve amplifiers are due to the passive components rather than the transistors or valves themselves. Specifically, since semiconductors have a much lower input impedance than valves, the inter-stage capacitors need to be much larger (i.e. higher value) and this means that they have to be electrolytics. A wide range of disadvantages of electrolytics compared to the high quality film capacitors in valve amplifiers is quoted. These range from high dielectric absorption and imperfect high-frequency characteristics, to poor ageing properties.

Needless to say, those audio designers who specialise in solid state design, have different views on a number of these issues. Space doesn't permit me to give the solid state camp opportunity to give their view of the world and this is, after all, a series of articles on valve technology. Nevertheless, I will present one interesting quote by Linn's Bill Miller. The quote in question is part of Miller's explanation of the design philosophy of the Klimax power amplifier, a top-of-the-range mono-block power amplifier using bipolar transistors in the output stage and costing £12,000 per pair. "The arguments about the relative merits of tubes, MOSFETS and bipolar devices have filled many technical journals, and needless to say, most are over-stated and over simplified to try to win the argument! It's possible to design a good amplifier using any of the available technologies. Turning it into a great amplifier takes more than just a good argument." As we move on to look at the arguments for the various valve architectures, we won't find many views as even-handed as this one!

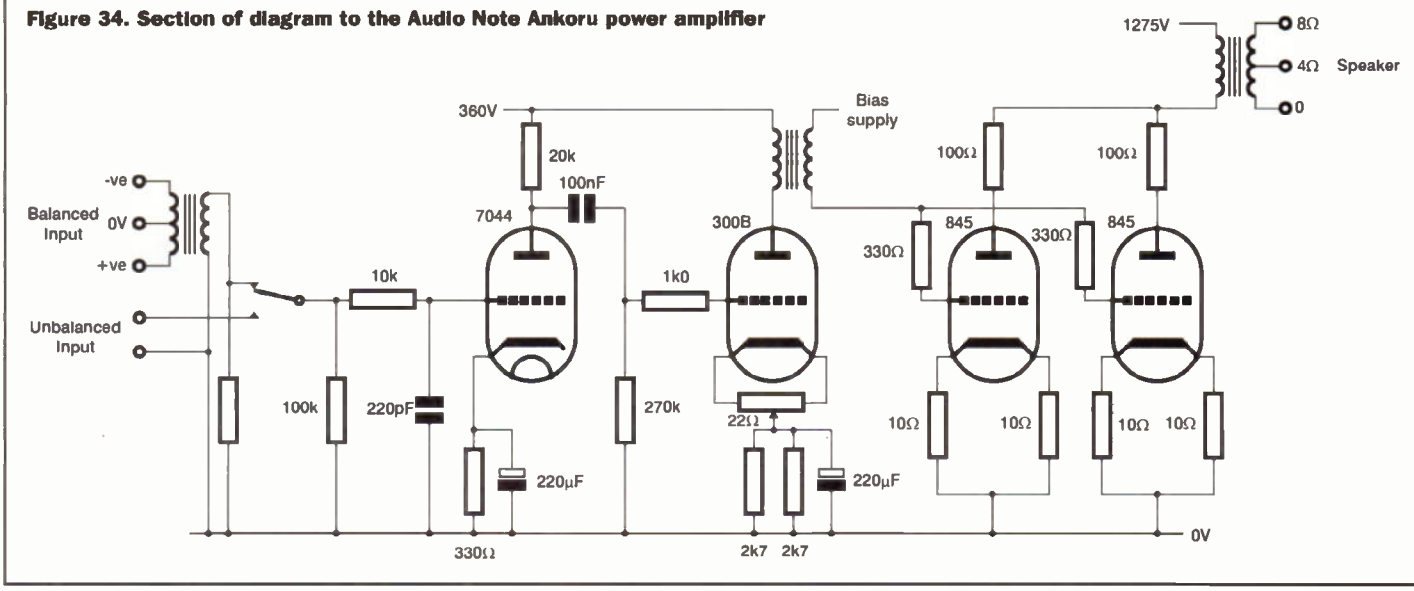
Keep it Simple

OK, let's now take a look at one of the rival valve camps I mentioned earlier, the one which I'll describe as following the 'keep it simple' philosophy. From what we saw in our introduction to valve technology in the first article of this series, you might reasonably expect that triodes would never by used in power output stages. So, surprise number one is that this type of amplifier uses triodes in the output stage in preference to beam tetrodes or pentodes. Furthermore, the triodes are often of a very early type, typified by the 300B which was first introduced to the market in 1935. Triodes with directly heated cathodes are even used by some manufacturers. Surprise number two is that the output valves are driven in Class A and the configuration is single-ended as opposed to push-pull. This contrasts with the Class AB push-pull configuration which is employed in virtually all top-end solid state amplifiers. The next element of the keep it simple philosophy is that the amplifier employs no negative feedback. And finally even the power supply is usually a valve design in preference to the much more common use either of a switched-mode design or, in the case of the more conservative companies, a design encompassing silicon bridge rectifiers and huge reservoir capacitors.

So that's the bottom line; let's now look at these issues in a bit more detail to see why this route is followed by its advocates.

Triodes are normally considered to be suitable for use as oscillators and as small signal amplifiers, mainly at audio frequencies. Use at high power levels is restricted by the anode current's high degree of sensitivity to the anode voltage. This drawback is cured in the beam tetrode and the pentode so these types of valve tend to be used for high power applications. So why do some designers prefer the triode? The argument is that the triode is the most linear amplifying device ever produced, more so than the tetrode, beam tetrode, pentode or any semiconductor, and any distortion which is produced is predominantly the inherently musical 2nd harmonic. Class A amplification might seem an obvious choice since, as we saw last month, the bias point is at the centre of the straight portion of the grid voltage/anode current curve so we might expect that this is the best configuration for hi fi. Despite this, most hi fi manufacturers, especially those producing solid state designs, do achieve extremely good results with Class AB and, of course, consume much less power than with an equivalent Class A design. Of course, this requires a push-pull configuration and this brings us to another element of the keep it simple approach. With Class A, push-pull operation isn't mandatory even though an inherent feature of this configuration is automatic cancellation of even order harmonics. And since, as we've seen, the main distortion of a triode is the 2nd harmonic, we might expect triodes, even when driven in Class A, to be used in a push-pull configuration. So why does the keep it simple philosophy encompass a single-ended architecture? According to Andy Grove, designer of Audio Note's Ankoru power amplifier, the purpose of the push-pull configuration is "to make amplifiers easier to design not better." He goes on to say that "reducing harmonic distortion to vanishingly small levels and increasing bandwidth from DC to cosmic rays does not make a more musically satisfying amplifier." Personally, I find this hard to accept given that the stated aim of nearly all hi fi enthusiasts is transparency. So

Figure 34. Section of diagram to the Audio Note Ankoru power amplifier

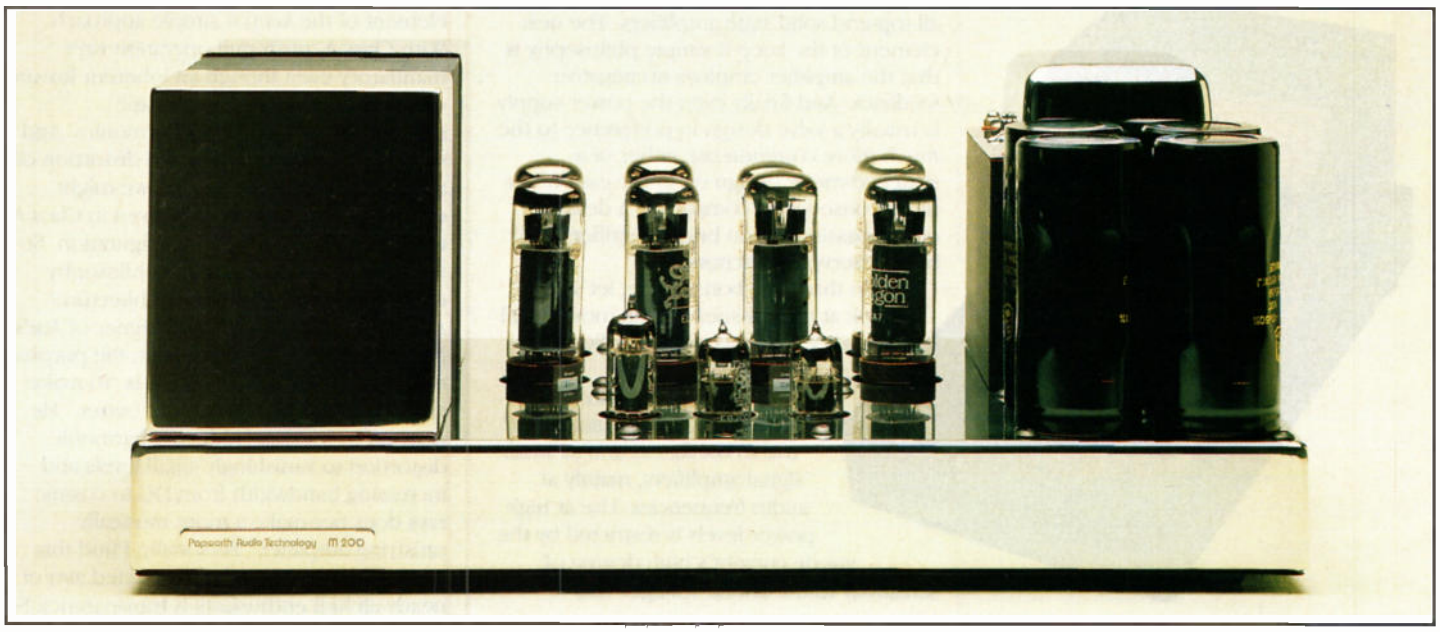


why is a single-ended design preferred to push-pull? The reason normally given is that a phase splitter (which could either by a centre-tapped transformer or an active circuit) is a prerequisite for push-pull yet this will rarely produce a pair of signals, exactly in anti-phase, as required to preserve the original waveform. Plus, once single-ended operation has been specified, by definition, the amplifier must be Class A.Now on to feedback, another design feature which is dismissed by Andy Groves' comment. Negative feedback is an integral element of virtually all solid state amplifiers and is used to make the amplifier more linear, more stable, and less dependant on the characteristics of individual amplification devices. Sounds like a good thing, therefore, but the keep it simple supporters have other views. First of all, feedback, while reducing the overall level of distortion, increases the amount of high order harmonics which are considered to be seriously bad news even in minute quantities. And secondly, concern is expressed that the feedback signal "disrupts the input stage that is probably busy with a new sonic detail coming from the signal source. Additional energy is filling in the natural spaces in the original spectrum and thus blurring musical expression.

"So on to the power supply. You might expect that semiconductors would be the component of choice here but not so for the valve purists, especially those who follow the keep it simple route. And the argument seems to be partly rhetoric (e.g. "transistors and all things silicon sound unnatural – put sand in the signal path and you get gritty sound!" – Andy Grove) and partly technical reasoning, albeit not reasoning which is accepted universally and which, I have to admit, I don't really understand. It's interesting to note, though, that a Class A amplifier doesn't need a power supply which is particularly well stabilised or which can respond to rapid transients since the load is much more constant than with a Class AB design.

That completes our run through of the key elements of the keep it simple design philosophy but, according to its advocates, there is one more big advantage. Because the component count is low, it becomes economically viable to use ultra top quality components – specifically passive components like capacitors and transformers. It's argued that every single component adds its own coloration to the sound so it's important to select each component either for minimum coloration or for coloration which sounds musical. And some pretty serious components are used – hardly surprising when we bear in mind the price tags of some of these amplifiers. For example, companies in this market have been known to use silver foil & Teflon or copper & paper in oil capacitors and transformers hand-wound with silver wire.

Figure 34 is a portion of the circuit diagram of the Audio Note Ankoru power amplifier (used with permission) which is typical of the type of amplifier we've just discussed. The power output is 60W which is unusually high for this type of amplifier – the rating of 'keep it simple' amplifiers is often much more modest necessitating the use of high efficiency speakers. Ironically, critics of this architecture suggest that the sonic properties of the high efficiency horn speakers which are often used with these low power triode amplifiers, more than cancels out any advantage which may be inherent in the amplifier.



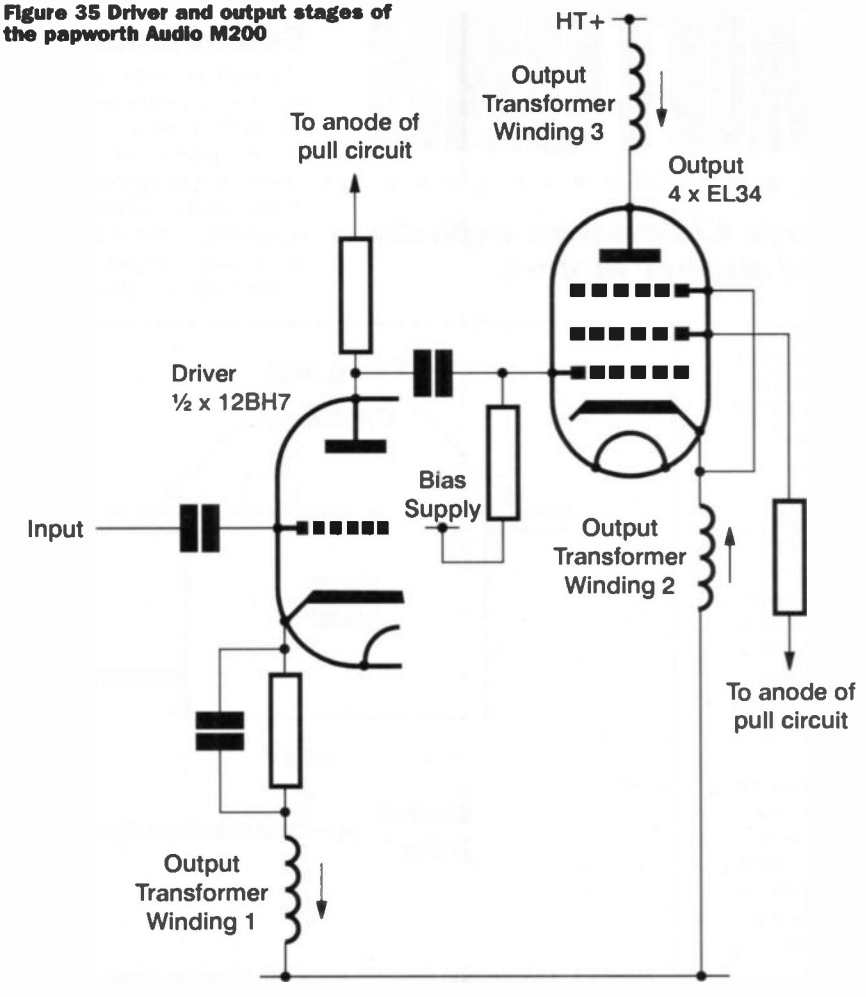
More Sophisticated Designs

Whereas it was easy to come up with the 'keep it simple' phrase to describe the design philosophy we've just looked at, the alternative philosophy is more difficult to label. We could call it a more sophisticated design philosophy since it uses a somewhat less simplistic approach but the 'sophisticated' label would suggest superior performance, something which the 'keep it simple' camp would fiercely deny. So rather than giving it a name, let's sum up a typical amplifier of this type. Pentodes or beam tetrodes are used in Class AB push-pull with a degree of feedback, albeit less than in a typical solid state design. The power supply is based on silicon rectifiers with very large reservoir capacitors. We'll now move on to take a brief look at the reasons for adopting this approach and this is based on discussions with Papworth Audio's Eddie Fincham. We won't give as much space to this as we did to the keep it simple rationale but this isn't because we believe this design philosophy is any less valid. The only reason we gave the lion's share of the coverage to the keep it simple approach is that the more sophisticated design philosophy is much closer to what most people would expect. It makes sense, therefore, to concentrate on why the keep it simple camp have made what most people would consider to be some very odd decisions.

Two reasons are given for picking pentodes, or occasionally beam tetrodes, in preference to triodes. The first is power handling, indeed just about everyone will acknowledge that these valves have far superior power handing capabilities. The only difference in opinion is that the keep it simple supporters will suggest that high power isn't important. The second is a very interesting assertion – pentodes are far more linear than triodes – the exact opposite statement to the one made by Andy Groves. Indeed the characteristic curves of the various valves would seem to support this view. Remember that the straight line grid voltage vs. anode current applies only at a constant anode voltage and that, unlike the pentode, the anode current is highly dependent on the anode voltage and hence the voltage dropped across the load. However, maybe it should be clarified that Andy is referring to a 'keep it simple' output stage, whereas Eddy is referring to the sophistication used in the McIntosh output stage, around which there are small elements of feedback to achieve a linear end result. Similarly, two reasons are given for choosing Class AB instead of Class A. As with the triode/pentode choice, one reason is in direct contrast with the views we saw earlier – Class AB is more linear, primarily because a Class A amplifier is more likely to be driven into the clipping area. The second is more of a practical reason – Eddie Fincham suggested that a 200W Class A amplifier would require a 1kW mains transformer and a 2kW output transformer and this would be prohibitively expensive, heavy and bulky. However, having chosen Class AB, the choice to go for push-pull is fixed – a single-ended design just isn't an option. Then we have the power supply. A conventional silicon rectifier and large reservoir capacitor is used since this provides a much lower impedance supply than a valve supply. The advantage of this is its improved stabilisation which, in turn, reduces clipping on high amplitude transients.

Figure 35 is the driver and output stages of the Papworth Audio M200 (used with permission), which is typical of the type of design we're looking at. The amplifier can deliver 235W into an 8Ω load and claims a total harmonic distortion of 0.18%. In fact, to save space, the diagram shows only half of the push-pull circuit which we'll refer to as the 'push' part of the circuit – the pull section is, of course, identical except that it's fed from an input which is 180_ out of phase and the output transformer primary windings are reversed. The circuit configuration is referred to as a McIntosh configuration which is differentiated from an ordinary push-pull by the output transformer primary windings in the cathode circuit. One unusual aspect of the configuration is the way in which the driver's anode circuit is cross-coupled to the anode of the pull circuit output valve. This is done to provide a higher anode voltage and consequentially a higher voltage drive signal to the output valve than would otherwise result. This, in turn, is needed to overcome the high cathode voltage which is inherent in this circuit configuration. The feedback which results from the transformer winding in the driver cathode all assists in this respect. Finally, you may be interested to learn that the output transformer is a 29 section monster weighing no less than 13kg.

Figure 35 Driver and output stages of the papworth Audio M200



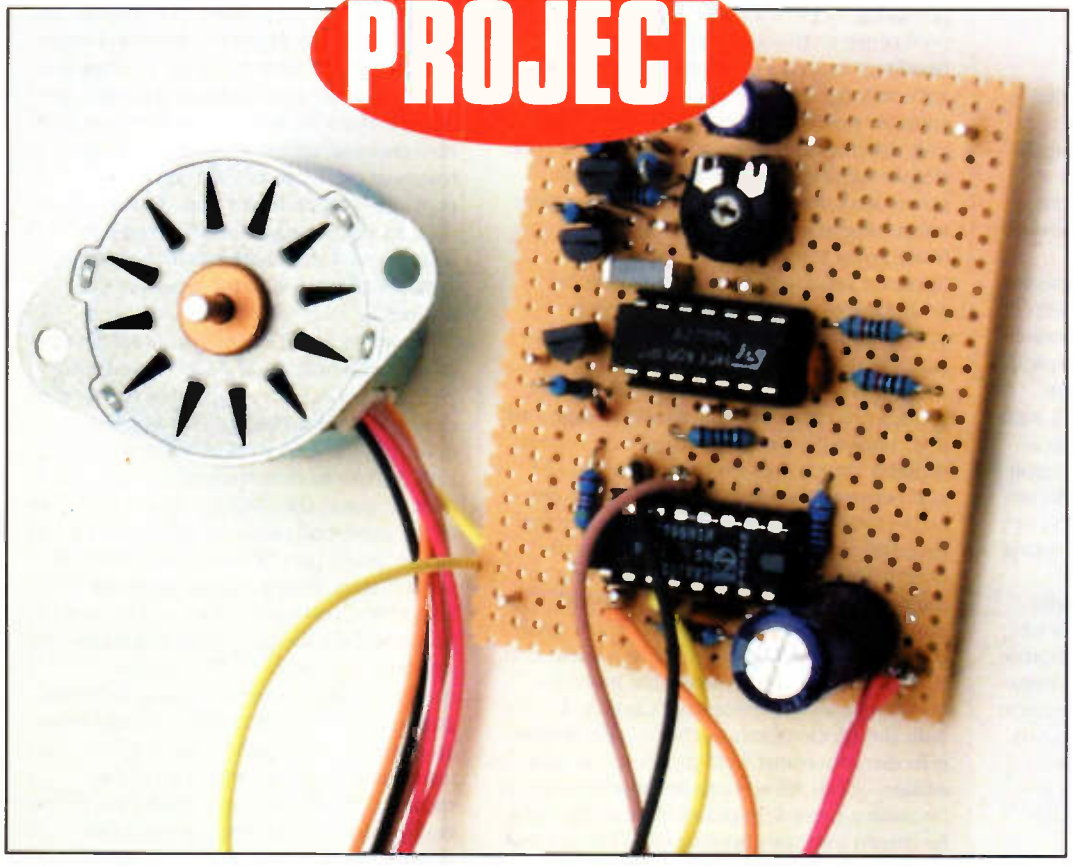
In Conclusion

Well, as promised, I've come to no definite conclusions, indeed you're probably more confused now than you were at the outset! Even if you're unable to say, from what is presented here, whether solid state or valve amplifiers are the best, hopefully I've given you some food for thought. And to reiterate my earlier comments, the most important thing about a hi fi amplifiers is what it sounds like. So if you're interested in hi fi and if you want to take this further, I suggest you audition a few amplifiers. Contact details for the three manufacturers who helped in the preparation of this article are given here – give them a call to find out where you can listen to their amplifiers.

Audion – 01903 750755,
www.hi-fidelity.co.uk;
Audio Note – 01273 220511,
www.audionote.co.uk;
Papworth Audio – 01480 831666,
www.papworthaudio.demon.co.uk.

Our investigation of valves in the 21st century continues next month with something rather less controversial. So if you're still sceptical that there really are genuine applications of valves in this era of semiconductors, our continuing series may just cause you to reappraise your views.

PROJECT



Using Servos & STEPPER MOTORS

PART 1

In the first part of this project, Gavin Cheeseman explains the operation of servos and stepper motors.

Introduction

Motion control is a wide and varied area in the field of electronics with an increasing number of applications. Of the many drive systems developed both servo and stepper motors are some of the most versatile, allowing accurate, reliable positional control. The terms servo and stepper motor cover a number of different technologies and within each category there are a wide range of variants. In this article we investigate some of the basic principles of operation and take an overview of various methods of controlling and driving the devices.

What Is a Servo Motor?

The term servo can be applied to a range of systems and is not strictly limited to the control of motors. A fundamental feature of a servo system is the reliance on data (analogue or digital) feedback to the controller. Control systems relying on positional feedback such as servo motors are known as closed loop systems. Servo motors come in a variety of different types and sizes (both AC and DC). Probably the most familiar to hobbyists is the type used in conjunction with radio controlled models for applications such as steering and rudder control.

Radio control servo units are, to a large extent, self contained and usually require just three external connections. A typical arrangement is shown in Figure 1. Two of the connections are for the power supply. The supply voltage is typically centred around 4.8V but there is some variation. The third wire carries the control data. The data consists of a train of pulses at a set rate with variable pulse width, as illustrated in Figure 2. The pulse repetition rate may be around 18ms but this varies. More important is the width of the pulse, as it is this parameter that determines the position of the servo motor shaft. The rotation of the shaft is limited, often to an angle of less than 180 degrees. Radio control servos are normally designed so that the shaft is set to the centre position when the pulse width is around 1.5ms. Altering the pulse width between around 1ms and 2ms (actual values vary) sets the position between the minimum and maximum points.

The system is designed so that the servo may be easily interfaced to a radio control receiver without complex additional circuitry. The data required to control a single servo unit may be modulated onto a radio frequency carrier at the transmitter without the use of complex encoders and decoders. More than one servo can be controlled over a single RF link using multiplexing techniques.

Internal Components

The main elements used to control the motor are contained within the servo housing and are transparent to the user. However, in actual fact the entire system required for controlling a motor in this way is relatively complex. Radio control servos consist of a

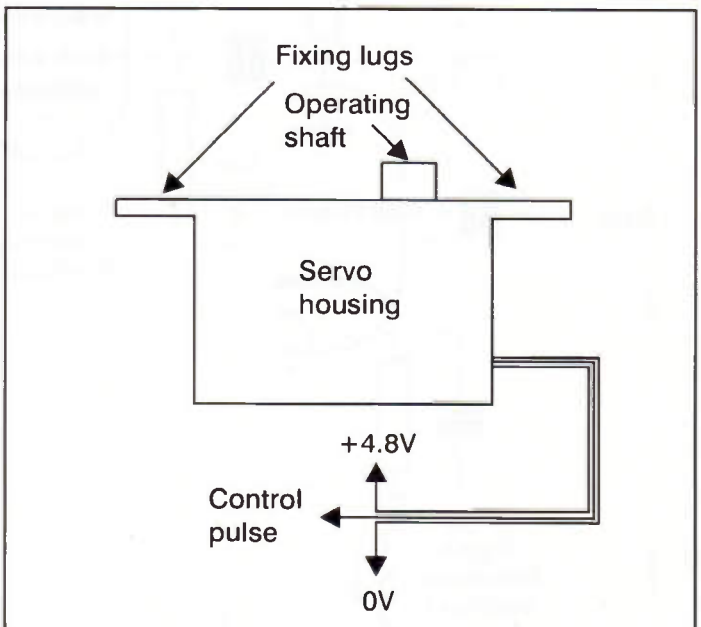


Figure 1. Connection requirements for a typical radio control servo unit.

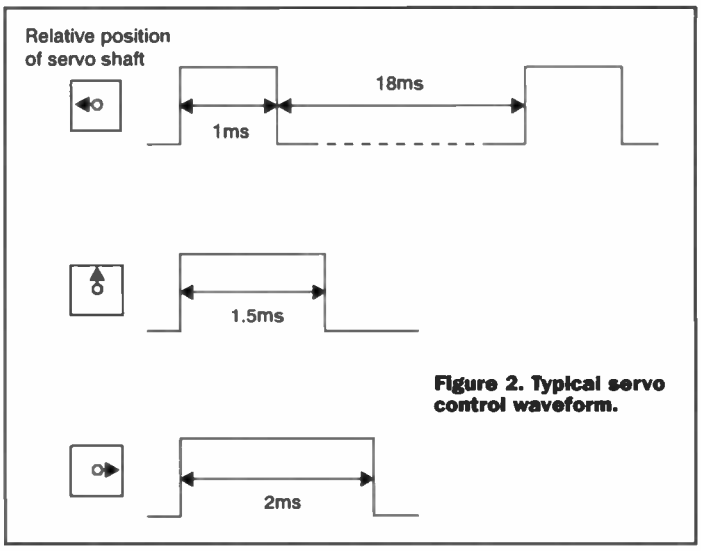


Figure 2. Typical servo control waveform.

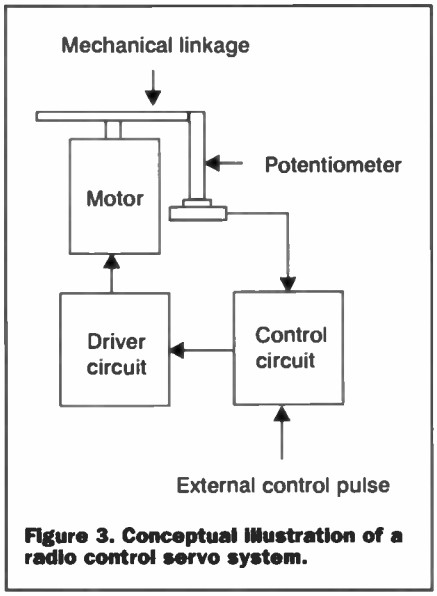


Figure 3. Conceptual illustration of a radio control servo system.

motor, potentiometer, gearing and control circuit all in a single housing. A simplified block diagram is shown in Figure 3. The diagram does not show power supply connections or details of the gear mechanism as these may vary considerably. As mentioned, the basis of this type of system is feedback and in the case of a radio control servo this is provided by a potentiometer linked to the motor drive shaft. As the drive shaft rotates, the potentiometer follows. As a result the position of the potentiometer wiper (and the associated resistance value) provides an accurate indication of the drive shaft position. The output of the potentiometer is connected to the servo control circuit.

The job of the control unit is to correlate the position of the motor with that defined by the width of the pulses on the external control lead. This may be achieved by using the output of the potentiometer to control a monostable circuit so as to produce a train of pulses that vary in width in a similar way to the external control signal. The width of the internally generated pulse is then compared with that of the incoming control pulse. If the pulse widths are different, the control circuit applies power to the motor in the appropriate direction so as to reduce the difference until both pulses are of corresponding width. The control functions often handled by circuits using specialised purpose designed ICs.

One advantage of servo motors is that the maximum current drain only occurs whilst the motor is in motion. Once the drive shaft has reached the specified position the current consumption is minimal. This is particularly advantageous for battery operation and is one reason why servos are popular in radio control applications.

Specifications for radio control servos vary considerably and before purchasing a specific unit, it is always advisable to check suitability. Particular points to look at are the rotational speed and torque. In addition some servo motors are designed for high duty cycle applications whereas others are only suitable for intermittent use. This is often reflected in the quality of the mechanics and possibly the power handling capability of the driver circuit.

Additional hardware will usually be required to allow the servo motor to be put to its intended use. The output shaft is typically connected to a servo horn that is linked to wheels, rudders etc. perhaps by a push rod. A wide range of different attachments is available for radio control servos to allow use in a variety of different applications. Readers are referred to the Radio Controlled Modelling section of the current Maplin catalogue for specific examples of the type of accessories available.

Stepper Motors

The operation of stepper motor technology is considerably different from that of servos. Unlike servos, stepper motors do not rely on feedback to determine their position. Instead, the position of the motor drive shaft is determined by rotation through a number of predetermined steps. Each step moves the rotor through a specific angle, so by counting the number of steps it is possible to determine the drive shaft position without the need for feedback. This type of arrangement, that does not rely on positional feedback, can be described as an open loop system. Applications include computer disk drives, industrial machinery and robotics.

There are several different categories of stepper motor, each operate using a slightly different principle. Here, we briefly look at some of the more common types in use. Figure 4 illustrates the concept of a 'variable reluctance' stepper motor. In this design a soft iron rotor is positioned at the centre of a stator assembly around which coils are wound at regular intervals. The rotor has teeth that are positioned at a specific angle. Passing a current through the windings magnetises the stator attracting the teeth of the rotor to the stator poles. If current is passed through one set of windings, the magnetic field created exerts force on the rotor moving the teeth into alignment with the relevant poles of the stator. The diagram shows an example of the rotor position when winding W2 is energised. Points A and C on the rotor are attracted to the magnetised poles. The motor is held in this position at full torque until the relevant winding is de-energised. The arrangement shown is intended as a conceptual example and in practice many different rotor and stator arrangements are in use. For continuous rotation to take place it is necessary to energise each set of windings in turn, effectively dragging the rotor round. Often one end of the windings are internally connected together and brought out on one common terminal. The other ends are each connected to a separate terminal. This simplifies the wiring arrangement since a single supply connection made to the common terminal serves all of the windings. The remaining terminals are switched to the opposite supply line depending on the required position of the motor shaft (more of this later).

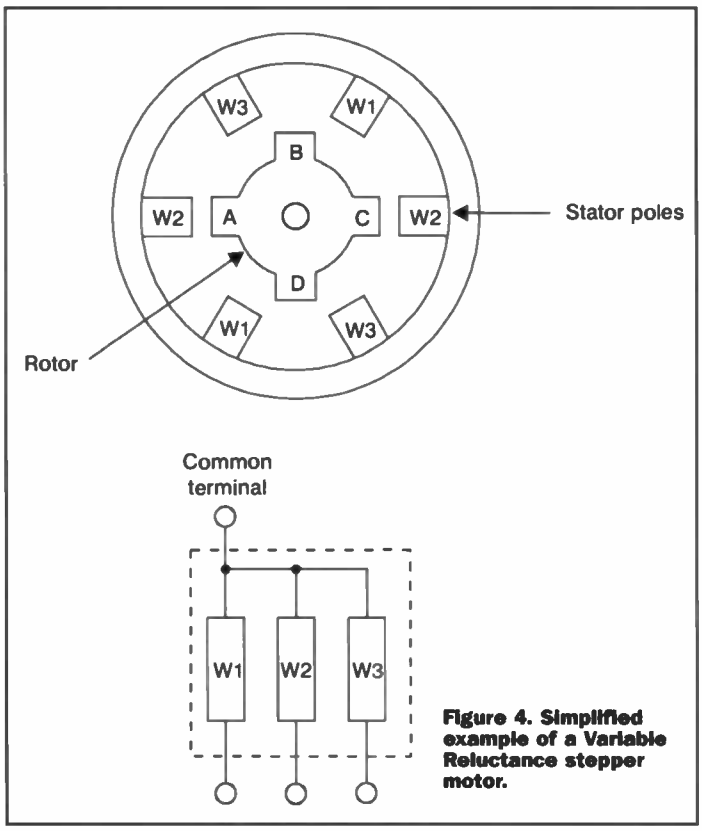


Figure 4. Simplified example of a Variable Reluctance stepper motor.

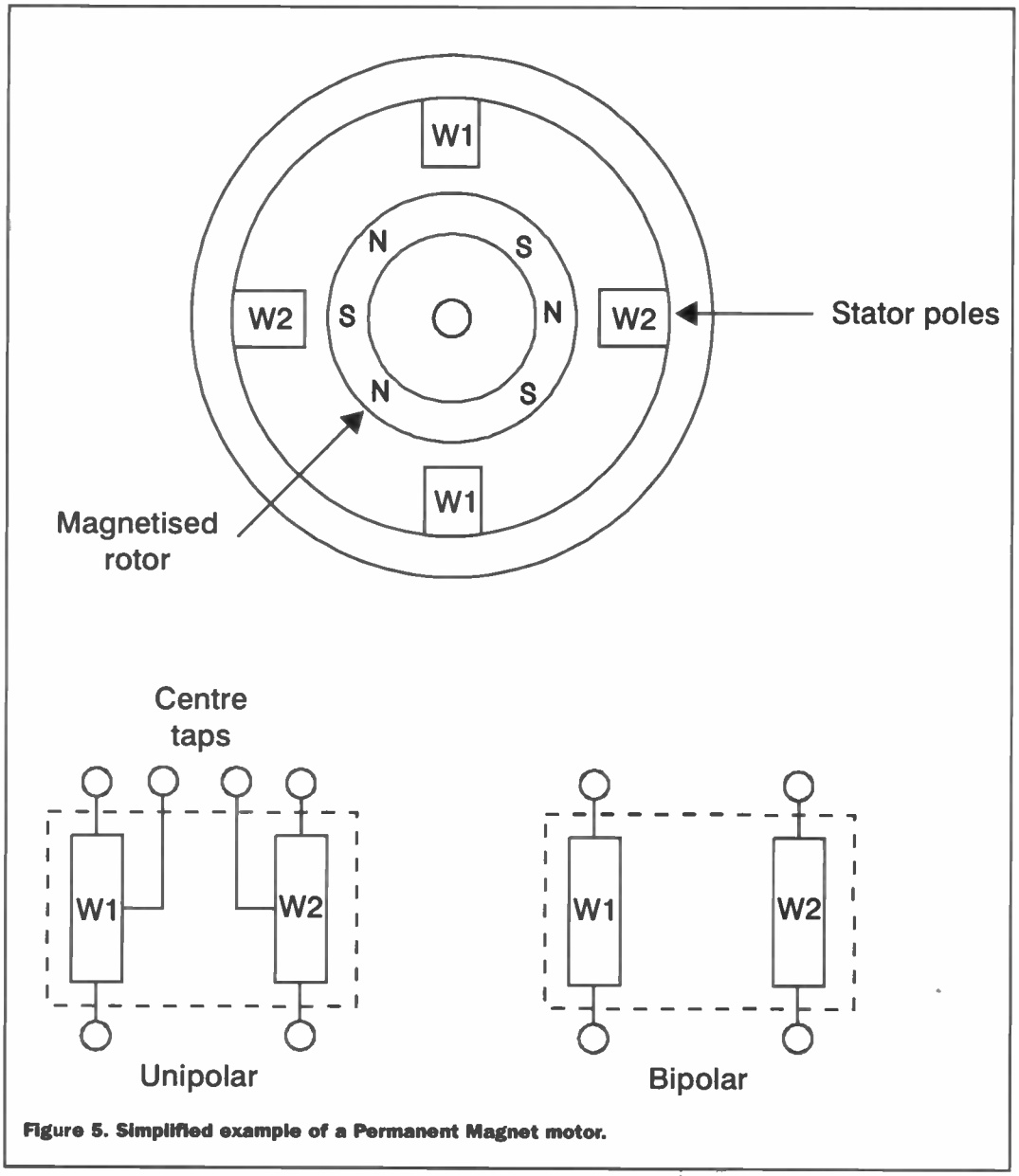


Figure 5. Simplified example of a Permanent Magnet motor.

Another type of stepper motor makes use of permanent magnets that form part of the rotor assembly. Figure 5 illustrates the principle of a permanent magnet stepper motor showing typical winding connections for both unipolar and bipolar types. Once again the illustration is conceptual and practical motors may differ in a number of aspects. The winding arrangement is somewhat different to that described for the variable reluctance stepper motor.

There are usually two windings. The unipolar type uses centre tapped windings. Normally the centre taps are connected to one power supply rail and the remaining terminals are switched to the opposite supply line depending on the required position of the motor shaft. The rotor is propelled by the interaction of the field around the permanent magnets and a magnetic field temporarily set up in the pole of the stator. The direction of the magnetic field depends on which end of each winding is energised.

It can be seen that the windings of the bipolar motor are similar unipolar motor described above but without the centre taps. The drive mechanism of the motor is fundamentally the same but because there is no centre tap, it is necessary to use an different switching arrangement to reverse the drive current. Unlike the stepper motors described so far, there is no common connection. Instead, it is necessary to effectively reverse the supply connections to change the direction of the magnetic field.

Driving Stepper Motors

As can be seen from the brief descriptions above, different types of stepper motor require different driver arrangements. Generally speaking, the type of driver required for motors with common connections or centre taps is simpler than that needed for bipolar types. Simple mechanical switches or relays can be used but in practice semiconductors are usually used for reasons of versatility and reliability.

A simple theoretical switching arrangement for directly controlling a unipolar motor is illustrated in Figure 6. Using this method, the winding common terminals are connected to the +V supply rail. Each of the remaining terminals is connected to the

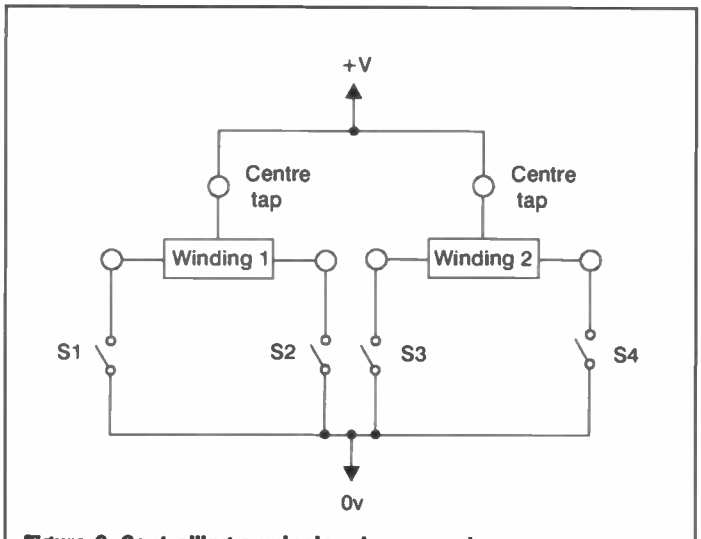


Figure 6. Controlling a unipolar stepper motor.

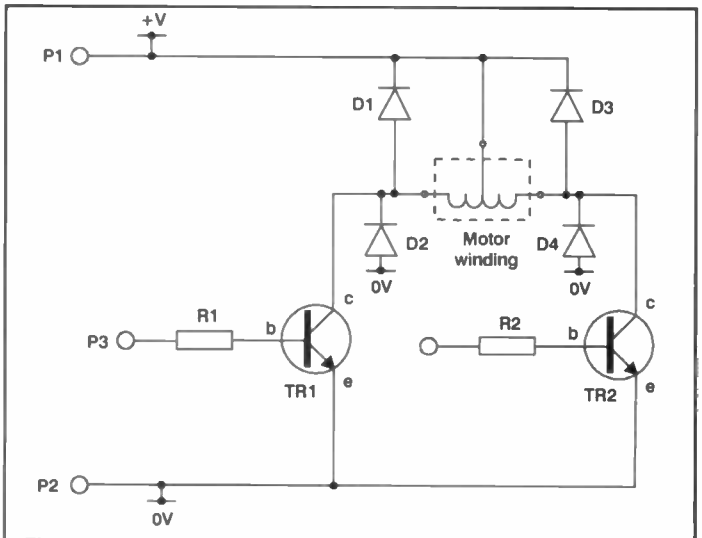


Figure 7. A simple transistor driver.

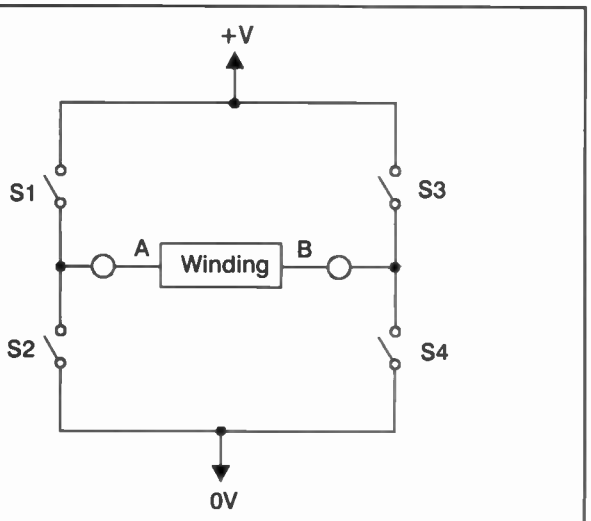


Figure 8. A simplified diagram showing an H bridge configuration.

0V supply via a switch. The direction of current flow is determined by closing either one or a combination of switches (S1 - S4). It is necessary to set a different switch combination each time the motor is required to rotate one step. To rotate more than one step a series of switching actions is required. It is obvious that a simple mechanical control system of this type has very limited practical application. To enable the motor to be controlled with any degree of versatility, electronic switching is required. Figure 7 shows a simple method of driving the motor using transistors. In the illustrated circuit the transistors are being used to drive one winding of a unipolar motor. In practice there would normally be two windings with a similar driver stage for each. The circuit shown is simple and is not intended for practical use. Specific component values are not shown as these may vary considerably depending on the current handling requirements of the motor. Control signals are applied to terminals P3 and P4. The transistors are easily interfaced to standard logic circuitry allowing accurate electronic control of motor speed and position. However, to reduce the possibility of damaging the controller circuit if breakdown occurs in the transistors, additional buffer stages would normally be used between the control logic and driver stages.

As mentioned, driving a bipolar stepper motor is not quite so straight forward since it is necessary to arrange for reversal of the drive current polarity. A common method of achieving this requirement is to arrange the switches in an 'H bridge' configuration. Figure 8 shows a conceptual example of this arrangement. Although the illustration shows mechanical switches, once again, it is normal to use semiconductors.

If switches S1 and S4 are closed (with S2 and S3 open) power is applied to the winding such that point 'A' is positive and point 'B' is negative (connected to 0V). However, if switches S2 and S3 are closed (with S1 and S4 open) point 'B' of the coil is connected to the positive supply and point 'A' to 0V. It is essential that S1 and S2 or S3 and S4 are not closed at the same time as this will short circuit the power supply.

Current Levels and Voltage Transients

Care is required when driving motors of any type. Drive circuits are easily damaged if the maximum ratings are exceeded. As with all high power circuits, it is sensible to provide suitable fusing arrangements to minimise damage and prevent any possible hazard if a fault should occur. It is also necessary to ensure that the drive circuit is suitable for the selected motor under the normal range of operating conditions. Two important points to consider when driving motors in this way are current consumption and transient voltage spikes.

Current consumption is normally specified per winding and depends on the type and size of the motor. The current drain also varies depending on how the motor is being used, for example, whether it is rotating or at rest. Unlike servos, stepper motors require considerable current to hold the drive shaft in a given position. It is therefore essential to ensure that devices used to switch the motor are suitably rated to handle the peak current requirement. Extensive heatsinking may be required when driving higher power motors.

Switching spikes produced when driving inductive loads can also damage the driver circuit in the absence of suitable protection. These transients mainly occur when the drive current is disconnected from the winding as a result of the collapsing magnetic field. The spikes can often peak at several hundred or even thousands of volts, and this can spell the end for semiconductors used in the driver circuit.

A common method of reducing switching transients is to reverse connect diodes across the winding and in some cases the semiconductor devices driving the motor. This is the function of diodes D1 – D4 in Figure 7. When current is flowing in the winding the diodes are reverse biased and do not conduct. As the current flow is interrupted this results in a switching transient. Because the transient is in the opposite direction to normal current flow the diodes conduct reducing the spike to a safe level. The diode switching speed is important as the transient voltages rise very rapidly. Diodes used for this purpose should therefore be capable of responding quickly. Fast recovery diodes are often used for this reason.

It is also possible to connect suitable capacitors across the motor winding to reduce voltage spikes. The effect of the capacitor charge and discharge currents on the driver circuit must be taken into consideration. Sometimes a small limiting resistor is connected in series with the capacitor to limit the current.

Several integrated circuit motor drivers are available off the shelf. Examples are the L6203 and L298. For further information, readers are referred to the Semiconductor section of the current Maplin catalogue, and to the individual manufacturers data sheets. Some driver IC's feature internal protection systems whereas others require the use of discrete components.

Controlling Stepper Motors

In order to control the speed or position of the stepper motor it is necessary to apply the appropriate code, or sequence of codes, to the driver circuit. In common with servo motors, the type and complexity of the control system depends on the application. Simple circuits can be built using standard logic ICs, allowing basic functions to be performed.

Dedicated devices are also available, an example being the SAA1027 (Maplin stock code QY76H). This IC is supplied in a 16 pin DIL package and may be used to drive unipolar stepper motors such as Maplin stock code FT73Q. The device includes the necessary circuitry to switch current to the motor windings in the appropriate sequence together with driver stages. This type of approach can considerably simplify circuit design.

More complex functions usually call for the use of microprocessors. This method of control is highly versatile allowing the motor to be controlled through software instructions. Microprocessors may be interfaced directly to the driver circuit or via an intermediate controller stage. The latter option is particularly useful when the stepper motor is remote from the controller. Using a software based control system offers the advantage that complex operations can be carried out with one single user command or entirely automatically.

Positional Sensing

The controller can keep track of the motor shaft position without the need for feedback by counting the number of steps from the initial start position. However, if the motor is under excessive load or a fault occurs, the motor may not rotate in the way specified by the controller. As a result, errors can occur whereby the controller misinterprets the true position of the motor drive shaft. In some applications this is not a problem but where positioning is critical the results may be disastrous. Where this is the case some form of feedback can be employed to allow independent tracking of the drive shaft position. The positional data obtained can be compared with the control data to confirm that the commands have been correctly carried out.

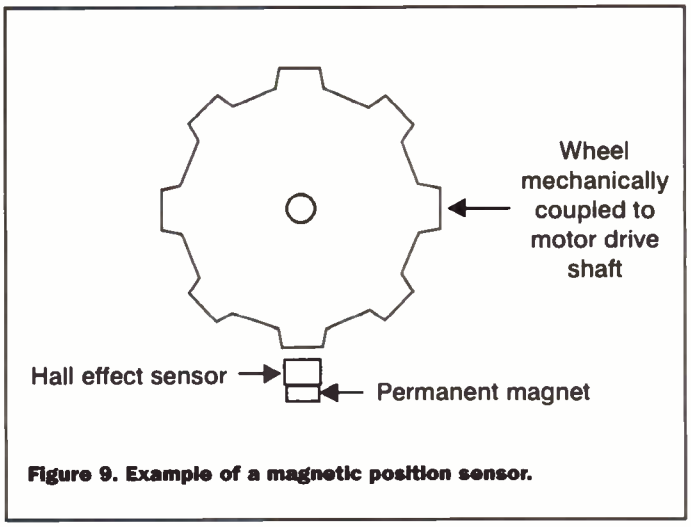


Figure 9. Example of a magnetic position sensor.

If an error occurs the system may be programmed to instigate remedial action or automatically disconnect power to the motor.

Various positional sensing systems may be used to feedback the position of the motor drive shaft. A simple method is to use a potentiometer in a similar way to radio control servo units. This system is fine when the motor is rotating through a limited angle and at slow speeds but in other circumstances other methods are more suitable. Optical and magnetic sensing are two methods that may be used.

One method of optical sensing makes use of a coded disk mechanically coupled to the motor drive shaft either directly or via a suitable gearing system. One or more optical (or infrared) emitter and receiver pairs are positioned adjacent to the disk A number of different physical arrangements may be used. The opto devices are positioned so the optical receiver only receives the light produced by the emitter when the disk is rotated to specific positions. Both the optical emitter and receiver may be positioned on the same side of the disk so that the light is reflected from the disk to the optical receiver. Alternatively, the emitter and receiver may be placed on either side of the disk and arranged so that the light from the transmitter passes through holes in the disk when it is in specific positions.

If a number of sensors are used then the position can be communicated using binary code. However, this can throw up errors due to the fact that each bit of the code does not change at the same instant. This problem can be overcome using a system known as Gray code. This system offers the advantage that only one data bit changes at one time.

Another method uses magnetic sensors (for example hall effect devices) to sense the drive shaft position. An arrangement such as that shown in Figure 9 may be used. A small permanent magnet is attached to the back of the hall effect IC and a soft iron wheel is attached to the motor drive shaft. The wheel is of similar construction to a standard gear wheel with teeth positioned at regular intervals around its circumference. The hall effect sensor is placed in close proximity to the wheel. As the motor drive shaft rotates, the teeth of the wheel pass close to the hall effect sensor. The soft iron modifies the magnetic field produced by the permanent magnet and this affects the output voltage of the sensor. By counting the number of voltage variations produced as the wheel rotates, it is possible to determine the position of the drive shaft to a high degree of accuracy. Similar systems make use of existing gears or permanent magnets attached to the motor.

What's next...

We have briefly covered some of the basic principles and requirements that need to be considered when using radio control servos and stepper motors. It will be appreciated that motion control is a wide ranging subject and therefore it has not been possible to cover all types of motor in the space available. In the second part, we take a closer look at motor control circuits from a practical viewpoint.

Software HINTS & TIPS

by Mike Bedford

If you don't have a separate drawing package, you can produce some pretty smart sketches using Word 97.

Last month we looked at the facilities available in MS Word 97 for including pictures in documents. So we looked at how to import and position images and we also looked at how to adjust and manipulate them. What we didn't cover, though, was how to create those pictures – we just assumed that the necessary line drawing or photograph was already available. In many instances libraries of clipart and photographs will be adequate, or you may be able to download photographs from the Web or take them on a digital camera. In other cases, though, especially in technical documents, you'll need to create your own line drawings. Many people will have a suitable drawing package, CorelDraw for example. Conversely, people who don't have a regular need to generate line drawings may not. If you come into this category, help is at hand since Word 97 has a built-in rudimentary drawing utility. This is the subject of this month's column.

The Draw Toolbar

If you're a regular user of a fully featured drawing package, most of the concepts we'll encounter will be familiar even though the user interface will be rather different from what you're used to. If you don't have a separate drawing package, though, then this would make you the most likely sort of person to make use of Word 97's drawing facilities, some of these ideas will be new. However, none of this is at all complicated and starting out on a simple utility like this will be a lot easier than trying to get to grips with the likes of CorelDraw. It will also be a useful grounding for when you do decide to invest in a fully featured drawing package.

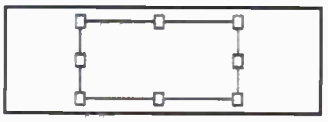
OK, now's the time to get practical. If you haven't already used the drawing utility, the appropriate toolbar won't be displayed so your first job is to select it. Right click anywhere in the grey area at the top of the Word window and select Drawing from the drop-down list which will be displayed. The Drawing toolbar (shown here) will be displayed and, as usual, you can move it around, anchor it to the toolbar area at the top of the window and change it's shape. Let's now look at the major facilities available.

Shapes

Icons for a number of the more common shapes are included on the Drawing toolbar but there are far more than these available. Whereas two types of lines, straight lines and single ended arrows, are shown as icons, there are, in fact, a further three types of line. To see them all, select AutoShapes > Lines. Let's try one out to get a feel for how things work so, from the Lines menu select the fifth icon which is a closed figure. The cursor will change to a cross. Move the cursor to an empty part of the page (actually you can draw on top of text but it's easier to see what you're doing if you choose a clear area) and left click. As you move the cross cursor away from this position a rubber band line will be drawn and this will be fixed when you next left click. As soon as you fix one line segment a new rubber band will appear and you can keep adding segments until the line is complete. If you fix a line by double clicking, no new rubber band will appear and the line is finished. You'll notice that the finished line has re-sizing handles just like the pictures we looked at last month. The fact that these handles are white indicates that the picture is floating over the text rather than being in-line. In our brief introduction we can't cover all the drawing objects available be do be sure to try them all out. Into addition to the six different types of lines, you'll find text boxes, Word Art and miscellaneous shapes and various special purpose symbols such as those used for software flow diagrams.

Elaboration

If you've played around with the various picture elements in the AutoShapes menu, you should now be able to place a rectangle on the screen and it will look pretty much line this:

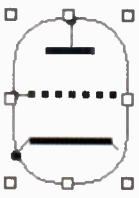


However, it's also possible to change the thickness of the line, the type of line and to fill the rectangle with solid colour. While the rectangle is still selected (i.e. the resize handles are displayed) pull down the menu next to the paint pot icon on the Drawing toolbar and select a colour. The rectangle will be filled in the selected colour. Now select a colour from the next menu, the one with the pen icon, and you'll see that the outline change colour. Also try out the line thickness menu and the line style menu next to it. And for some really interesting effects, try adding a shadow and 3D-ising the rectangle. Here is one of the many ways you can change the appearance of a rectangle:

You'll notice that my filled rectangle with fancy line styles and a drop shadow no longer has resize handles. In fact, as soon as you start to create a new picture element, the previous one will be deselected and the resize handles will disappear. However, if you need to move a picture element around or resize it, you only have to click on it to reselect it. You can also rotate the picture element, something which we couldn't do with the imported pictures we looked at last month. To do this, make sure the drawing object is selected and click on the circular arrow icon on the Drawing toolbar. The resize handles will be replaced by coloured circles at each corner of the object. If you now move the cursor near one of these circles the cursor will change to a circular arrow. When this happens, left click, hold down the button and drag – the object will be rotated.

Grouping

So far we've seen how to create lines and boxes and we've mentioned lots of other picture elements. Normally, though, a picture will be more complicated than a single line, box, circle or whatever. But if every element of a more complicated picture is an independently selectable object, things won't be as easy as they could be. Admittedly, it's possible to select multiple elements in the usual ways (e.g. dragging a rectangle around them or using Shift before clicking) but it's all too easy, in a complicated picture, to miss some elements out. For this reason, Word allows objects to be grouped together. To group elements together, select them all and then pick the Group entry from the Draw menu on the Drawing toolbar. As soon as you do this, the resize handles on each of the objects will disappear to be replaced by a single set of resize handles on the newly grouped set of objects. Everything you now do on this group – moving it, resizing it, filling it, changing the line style etc. - will be done to all the elements in the group. In the screen grab, 11 objects have been grouped together.



As always, we haven't been able to cover everything. In your own investigations, though, be sure to learn about the grid, ordering and aligning.

PROJECT

Velleman Kit

BRAIN GAME

John Mosely looks at this simple but addictive game from Velleman

I well remember my eldest son at the age of about six had a large circular plastic box with four coloured illuminating sectors that were also touch switches, and made a noise when pressed. The object of the game was to copy a random sequence of illuminating sectors - as the length of the sequence increased so did the speed. I remember there were four levels of difficulties, from a sequence of about eight to an awful lot more! It was addictive and kept children (and adults) amused, especially on car journeys.

It was nice to be reminded of such memories when this simple kit from Velleman turned up for it is very, very similar. The sectors in this case are four red LEDs, which of course, you could change for different colours. Four small push button switches are provided which are used to play the game, to set one of four difficult levels and to turn the sound on/off.

Three 'AA' size batteries provide the power, and since the game is controlled by a pre-programmed PIC, power consumption is very low, so

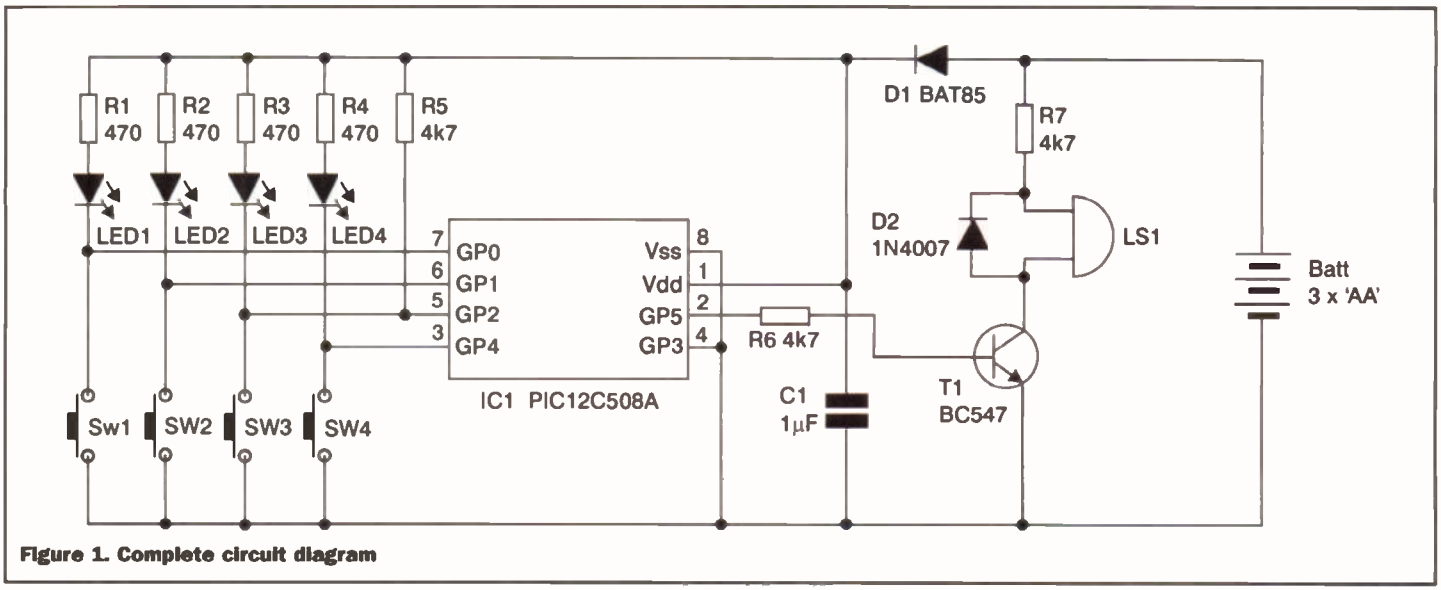


Figure 1. Complete circuit diagram

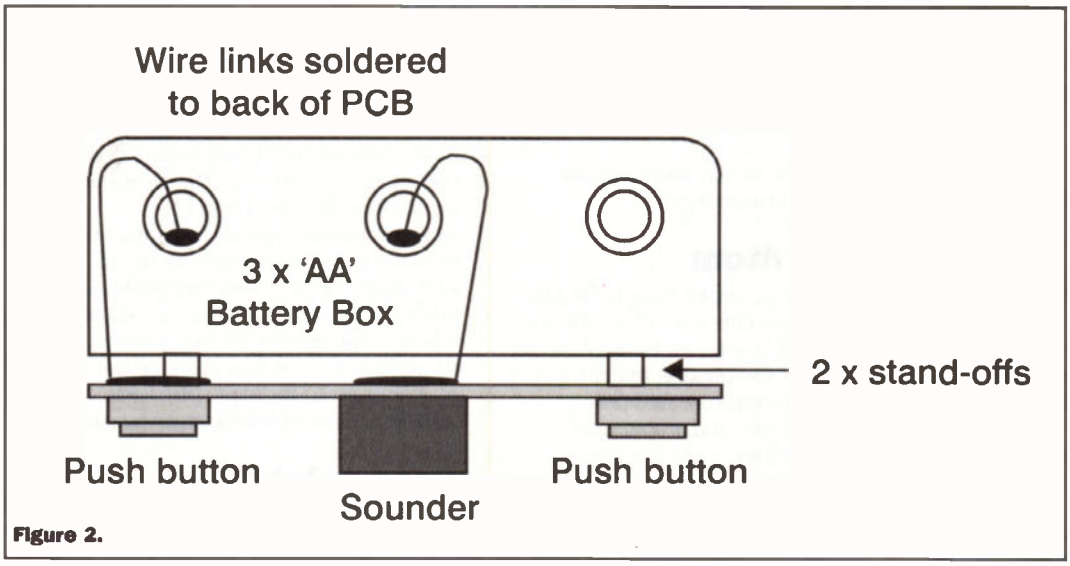


Figure 2.

battery life should be excellent. Auto shut off is incorporated to further enhance battery life. The completed kit measures just 65 x 50 x 33mm so fits neatly into the hand - even one belonging to a six year old.

Construction

Velleman class this as one of their 'Mini Kits' so instructions are a little sparse, relying mostly on diagrams. That said, the kit should present very little problems for the beginner to electronics. Velleman even include the colour bands for the resistors, so if you follow through the instructions all should be well. For reference, the circuit diagram is reproduced in Figure 1.

As usual, start with the small components and semiconductors, and finish with the small sounder and the battery box. Figure 2 illustrates how the 3-cell battery box is attached to the back of the PCB. For convenience, and ease of construction, the IC is mounted in a DIL 8-pin socket. All components are flush mounted against the PCB, except for the BC547 transistor.

Testing

When you are satisfied that you have constructed the kit correctly and all solder joints are OK, then insert the three 'AA' batteries. To start, press either the push switch marked Level 1, for sound on, or Level 2 for sound off, followed by any of the four switches to select the degree of difficulty.

Level 1 = 5 random flashes
Level 2 = 10 random flashes
Level 3 = 15 random flashes
Level 4 = 20 random flashes

I had a job getting to level 2! - but age is against me! I found it easier with the sound on since you have a 'musical' support that I found helpful in remembering the sequence.

Conclusion

It is possible to mount the finished kit in a box, but providing you are reasonably careful the kit should last, and perform well in its assembled state.

Yet again Velleman have come up with a excellent educational kit, and one that provides an amusing and enjoyable way to pass the time.

PROJECTS PART LIST

RESISTORS	
R1, 2, 3, 4	470R Min Res
R5, 6	4k7 Min Res
R7	47R Min Res
CAPACITORS	
C1	1µF Monore
SEMICONDUCTORS	
D1	BAT85
D2	1N4007
LED1-4	3mm Red Low current LED
TR1	BC547
IC1	PIC2C508A
MISCELLANEOUS	
SW1-4	Push-to-Make Switch
LS1	12mm Sounder
	8-pin DIL Socket
	3-Cell 'AA' Battery Holder
	3 x 'AA' Batteries (not supplied)
	2 x 5mm Spacers

The kit is available from Maplin Electronics (order code QE65V, £7.99 including VAT)

SPECIFICATION

Four levels of difficulty

Visual pattern with optional audio

Pre-programmed PIC

Auto power off

Low power consumption

The Quantum WORLD

PART 2.

In the second part of this series - Particle Physics - David Clark describes the findings of the twentieth century that led to the discovery of the fundamental particles of matter.

Introduction

In 1911 the Rutherford model of the atom was the best available, but it wasn't good enough. The model suggested electrons orbiting the nucleus as the planets orbit the Sun. Planets orbit the Sun, and satellites and the Moon orbit the Earth because their speed in a 'forward' direction compensates for the effect of gravity pulling the object 'downwards'; the object is continually falling but never reaches its destination. If the orbiting body lost some energy, for example through friction with the atmosphere, it would slow down and eventually fall to Earth. Although a satellite keeps moving at the same speed it is in fact accelerating because it is continuously changing direction in order to move in a circle. The consequence of a charged particle accelerating is electromagnetic radiation, so according to the Rutherford model if the electron were orbiting it would be continually losing energy as radiation and so would 'fall' into the nucleus, drawn by the electrostatic equivalent of gravity, and self-destruct. Clearly this doesn't happen as no matter could exist, but until quantum theory was applied to the model there was no satisfactory explanation for this.

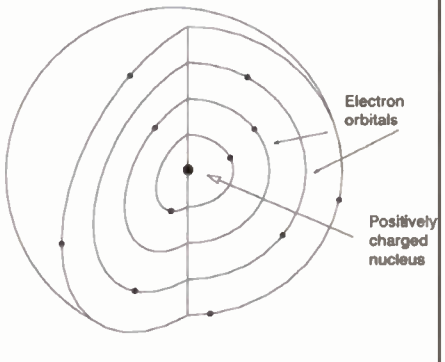


Figure 1. The Bohr atom model

The Bohr model has the electrons moving around the nucleus in fixed orbitals at distances corresponding to their energy levels.

The Bohr Atom

It was the Danish physicist Niels Bohr who applied Planck and Einstein's ideas about quanta and energy to the Rutherford model and provided the explanation that allowed it to be correct. If electrons could only possess, gain or lose fixed amounts or quanta of energy they could not lose it continuously and so spiral into the nucleus. Instead they could only 'jump' between fixed energy levels, which correspond to fixed distances from the nucleus, absorbing or emitting a quantum of radiation energy, (a photon), as they did so. See Figure 1.

One of the useful consequences of this is the existence of line spectra, patterns of lines in the electromagnetic spectra of hot bodies. These lines, corresponding to the energy 'jumps,' are unique for each element and this enables the analysis of the elemental composition of hot objects at a distance, for example distant stars (see Figure 2).

Photons have associated with them a frequency, and hence a wavelength, dependent on their energy, and in 1923 Prince Louis de Broglie suggested that electrons too could have a wavelength associated with them according to their energy. This was proved to be true by diffraction grating experiments (since electrons have a wavelength they behave like light and similarly are diffracted by a grating, though the grating spacing is much smaller because the electron's wavelength is much smaller than that of light). The importance of this is that coupled with Bohr's atomic model it gives the complete explanation of why electrons don't spiral into the nucleus - to get close to the nucleus its wavelength would have to be so small that it would have more energy than the attractive force of the nucleus could overcome, a sort of self-stabilising system. Figure 3 shows a practical device that uses electrons acting as waves - the electron microscope. A practical example of a device using photons acting as waves is the laser, the fundamental component behind optical digital technologies such as the CD ROM and DVD (digital versatile disc).

Schrödinger

The next developments brought philosophical questions on the nature of matter and science itself to the forefront again. In 1926 Erwin Schrödinger, a physicist and philosopher who had also studied ancient Greek science and philosophy, took a different view to the prevailing technical one. His differing perspective saw an electron orbit not as the fixed path traced by an electron but as a region where the probability of finding the electron is at its maximum. This had profound consequences not only for quantum theory but also for particle physics and theories on the origins of the universe. Schrödinger's theories do not limit an electron to a particular orbit but allow a smaller likelihood of it being outside its expected orbit (see Figure 4).

This means that there is a definite possibility that the electron can be outside of its atom without breaking any rules about the energy it possesses. This provides an explanation for the action of semiconductors, and when applied to other particles explains the random nature of radioactive decay. Using probability to describe, or predict, events introduces an inherent uncertainty or indeterminacy though, and this is where the philosophical problems arose for many physicists, not least Einstein and Schrödinger himself.

Uncertainty

Werner Karl Heisenberg was perhaps a physicist in the same mould as Schrödinger in that he too had a strong interest in

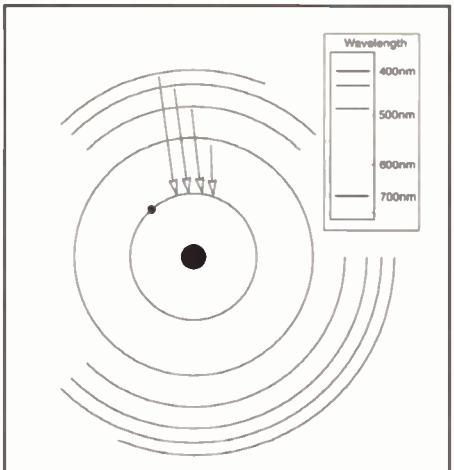


Figure 2. The hydrogen spectrum

When 'excited' electrons fall from one quantum energy level to another, they emit a quantum of electromagnetic radiation energy. This has a frequency (and hence wavelength), which causes a line on a spectrum image when a diffraction grating is used. The pattern of lines is unique for each element and so can be used to detect the presence of elements in distant radiation emitting bodies. Using this technique helium was identified in the Sun before it was on Earth, hence its name from helios, Greek for 'sun'.

philosophy and a belief that ancient philosophical problems were not irrelevant for physics. The philosophical concept of determinism says that everything that happens is a consequence of what happened previously and that everything that is going to happen is a consequence of what happens now. Nothing is random; if something appears to be random it is simply that not enough detail is known about all the factors that caused it to happen. Quantum theory demands that in the Quantum World, at subatomic level, events are truly random and probability defines what happens in the macroscopic world of classical physics. This is defined in Heisenberg's uncertainty, or indeterminacy, principle - there is a lower very small limit, ruled by Planck's constant, to the detail with which some things can be defined. This is so small as to be irrelevant for the macroscopic world, but for a subatomic particle it cannot be known for certain for example both its position and its momentum. This is very important in the world of fundamental particles and it also provides a clue to the possible beginning of the universe, since because of this uncertainty, particles with large energies are allowed to exist as long as they exist for a length of time less than the period that gives a value of (time x energy) which is less than the Planck constant (see Figure 5).

Uncertainty is also a consequence of measuring or even observing something; for example to be able to see something must mean it has lost photons. In the macroscopic world the effect is again usually small enough to be irrelevant. However, at a random quantum level it means it can never be known what state a particle was in before it was measured or observed, because measuring or observing it changes it from how it would be if it wasn't measured or observed. This split the science world into two camps which some took this to mean reality doesn't exist until it is measured. If this is taken to its extreme then an infinite number of universes must simultaneously exist until some form of intelligence

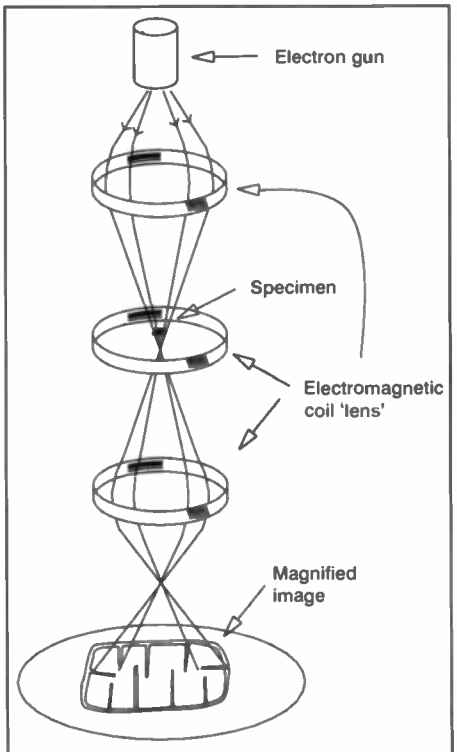


Figure 3. The electron microscope

According to quantum theory electrons are waves as well as particles, and in the electron microscope advantage is taken of this to give images of around 10,000 times the resolution of optical microscopes, since the wavelength of an electron is around 1/10,000 of that light.

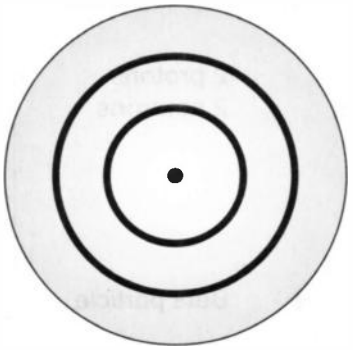


Figure 4. The Schrödinger atom

Quantum theory has established that the electron orbitals are the positrons where the electrons are most likely to be at any one instant. However, this means that there is a chance of them being anywhere in a 'cloud' around the nucleus, which can include beyond the 'limit' of the atom which it is part.

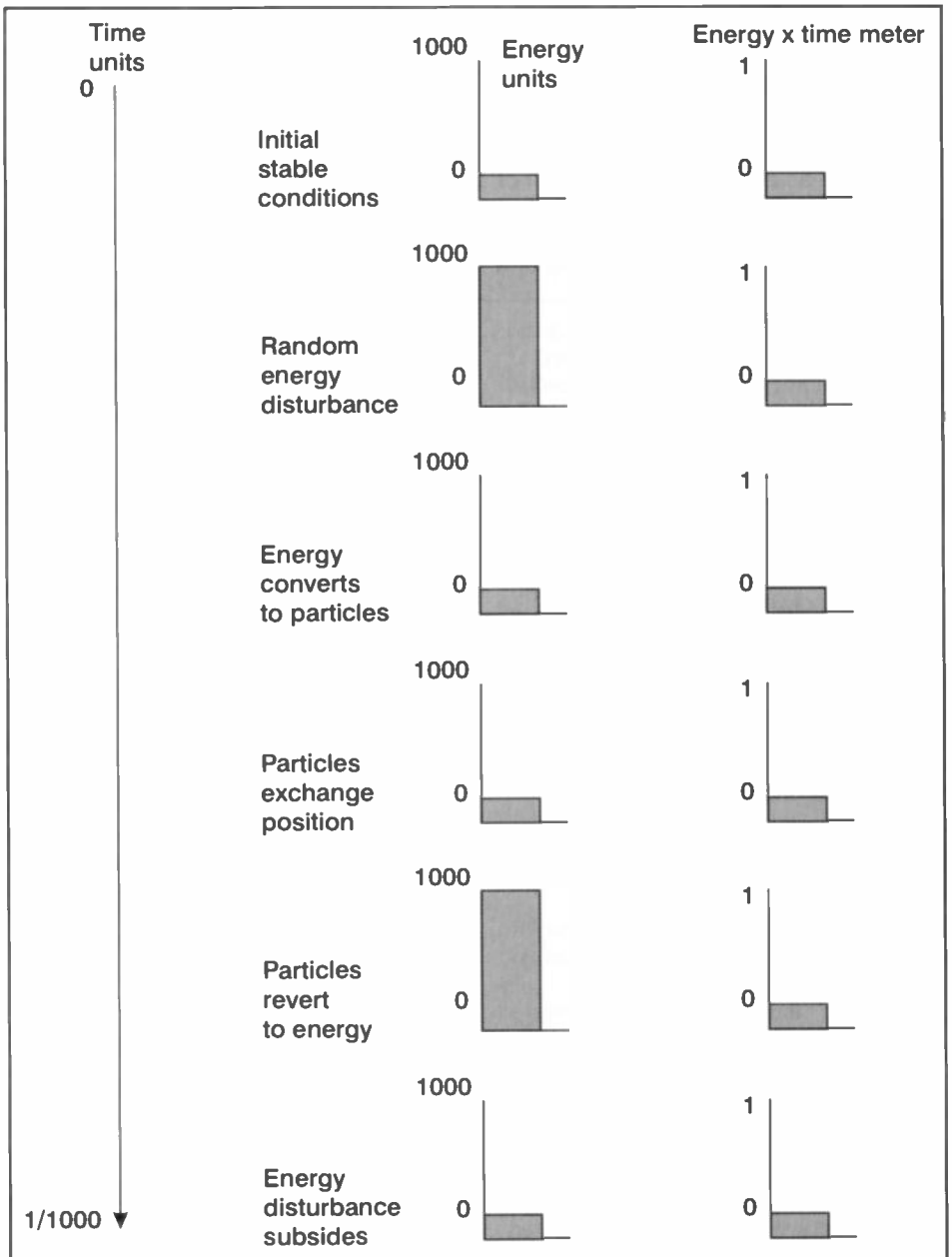


Figure 5. Quantum disturbances

For a meter that could measure energy and time (in whole, or 'integer', seconds) simultaneously and had a smallest displayed (energy multiplied by seconds) unit of one, a random energy burst of 1000 units lasting less than 1/1000th of a second would not register in the 'real' world of the meter. But in the quantum world where mass and energy are equivalent 1000 energy units means that two particles could come into existence and swap positrons as long as this happens in less than 1/1000th of a second. This is the principle that allows particles to come into existence for Quantum World times very much less than 1/1000th of a second.

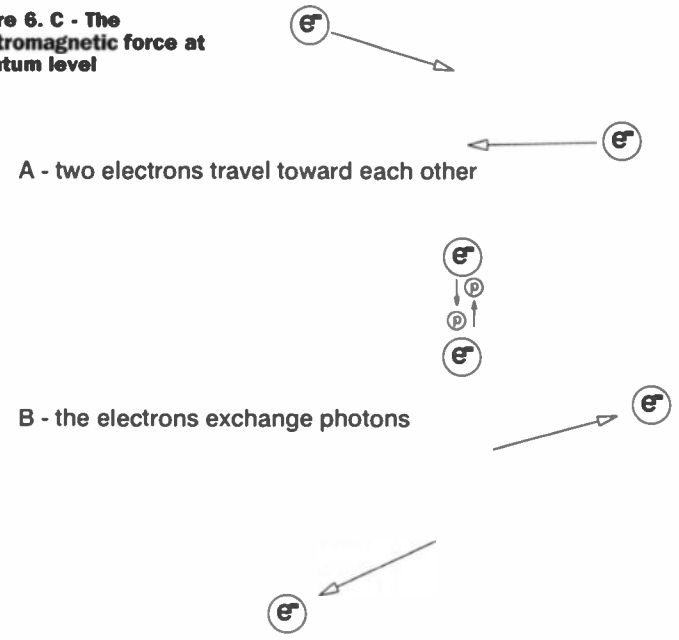


Figure 6. C - The electromagnetic force at quantum level

observes one of them at which point all the universes collapse into the one observed. Others, including Einstein, said the physical world must exist whether it is observed or not. Schrödinger highlighted the difficulty by using a scaled-up model to illustrate the problem. If a previously unobserved cat was sealed in a box could it really be both alive and dead at the same time and only become one or the other when someone opened the lid and looked in? The same type of arguments over what reality is were made by Parmenides and his ancient Greek contemporaries; will the search for the answer to questions like these replace the search for a 'Theory Of Everything' when the fundamental laws describing all matter are finally discovered?

Back To Particles And Fields

As quantum theory developed it became possible to give explanations for the forces of nature. In the 1920s Dirac built on Schrödinger's theories to bring Einstein's relativistic effects into quantum theory, which accounts for particles moving at speeds approaching the speed of light. Ironically, the first force described by classical physics, gravity, is proving to be the last to submit to quantum theory. Matters are also coming full circle in another way; the forces known to 17th century scientists, gravity and electromagnetism, were initially explained as the result of the forces between particles of mass or charge, and then they became subject to field theories in an attempt to explain action at a distance. Field theory is now explained in quantum theory by the exchange of fundamental particles between the interacting matter. For electromagnetism this fundamental particle is the photon, which 'carries' the force between two charged particles (see Figure 6).

This applies equally to the force between two wires carrying a current (a flow of electrons), to a current being induced in the turns of a transformer, and to radio waves carrying energy between a transmitter and a receiver; these are the same effects but operating at different frequencies and distances. What is the mechanism for this? At quantum world level two interacting charged particles swap photons at the speed of light. Photons don't have mass but they do have energy - Einstein showed these are equivalent, so although they have no mass photons do have momentum. A fundamental law of physics is that momentum, like energy, is conserved. The consequence of the exchange of particles and the conservation of momentum is that the particles change their direction of movement. Multiply the effect of this tiny subatomic quantum interaction up many times and in the macroscopic 'real' world the observed effect is seen as a force, a movement of the matter of which the charged particles are part, or as an induced current or voltage. Photons were discovered as 'real' particles in the 1920s in X-ray (another form of electromagnetic radiation) experiments.

Antiparticles

In 1932 the third subatomic particle, the neutron, had been discovered, and before the end of the same year, in experiments with cosmic rays, the first antiparticle, the positron, was discovered. An antiparticle has an exactly opposite quality to its equivalent particle, in the case of the electron and positron opposite electrical charge. Clearly the structure of matter was even more complex than the proton - neutron - electron model.

Radioactivity

The next developments came from the further study of radioactivity. Quantum theory explains the random nature of radioactivity, and the study of radiation given out during radioactive decay led to new theories about the structure of the nucleus, and also to theories on the existence of a fourth fundamental force to go with gravity, electromagnetism and the strong nuclear force. This fourth force was named the weak nuclear force. This force explains why some nuclei are stable, and others are not, and decay, giving off radiation. There are three types of radioactive decay, alpha, beta, and gamma. Alpha and beta radiation (see Figure 7) involve the emission of particles, whereas gamma radiation is electromagnetic

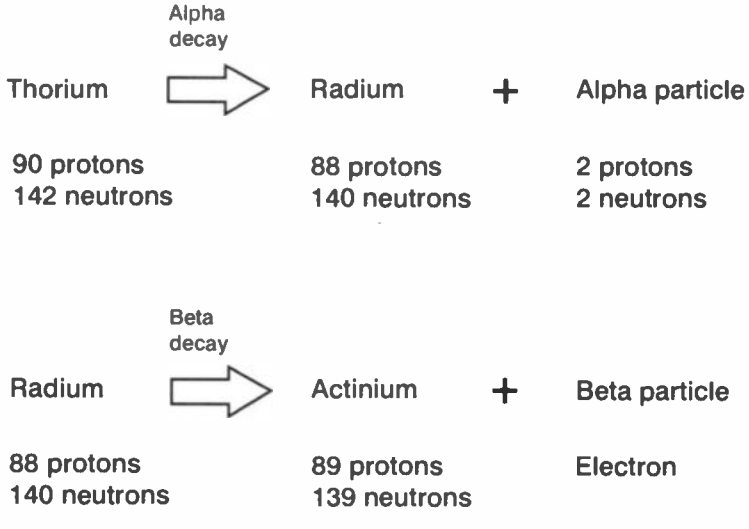


Figure 7. Radioactive decay

In alpha radiation an alpha particle is emitted from an unstable nucleus, in this case thorium, which then becomes radium, which has an atomic number, i.e. number of protons, two less. Radium then emits a radioactive beta particle, or high energy electron, and become actinium which has one less neutron but one more proton. The neutron has split into a proton and an electron.

radiation, ie photon emission, with extremely high energy.

In the same way that quantum theory allows a certain probability of an electron being outside the atom, quantum theory allows a certain probability of an alpha particle, that is a particle of two protons and two neutrons, to exist outside the nucleus (see Figure 8).

Since it is due to probability it is a random event and it cannot be predicted whether a particular atom will decay or not. This leads to the concept of the half life, the time in which half of a large number of atoms decay, since the average behaviour of a large number of particles is more predictable than an individual particle. This also is an example of how random actions at the quantum level 'collapse down' to predictable laws in the 'classical' macroscopic world.

When a nucleus emits an alpha particle the remaining neutrons and protons are no longer in their most stable state (though not unstable enough to immediately decay further). Just as an excited electron gives off electromagnetic radiation when it 'falls back' to its usual orbit in a 'normal' atom, when the protons and neutrons rearrange themselves into a more stable state electromagnetic radiation is again emitted. This is the high energy gamma radiation of radioactive elements.

Beta Decay

Beta decay is of particular interest for particle physics as it led not only to theories about the weak nuclear force but also to the prediction of the existence of a new subatomic particle and its antiparticle. A beta particle was found, in different cases, to be either an electron or its antiparticle, a positron. But the beta electron and beta positron were emitted from within the nucleus, not from orbit around it. It was theorised that the neutron could convert to a proton and an electron (negative beta particle), that the proton could convert to a neutron and a positron (positive beta particle), and that the force that normally held these particles together was the weak nuclear force. However one problem with beta decay was that beta particles had a range of energies. If the law of conservation of energy was to hold then the 'missing' energy had to be going somewhere. To overcome this problem the Austrian physicist Wolfgang Pauli suggested there must be another subatomic particle, which was named the neutrino, or 'little neutron', which had not yet been seen (see Figure 9). This particle was indeed found some years later.

By the mid 1930s then, the range of particles and forces known had grown to include positrons, photons and the weak nuclear force, and the existence of the neutrino and the particles which mediated the other forces in the same way that photons mediated the electromagnetic force was predicted. The race was on to find particles which were more and more fundamental, and the study of cosmic rays and the development of equipment capable of subjecting known particles to ever higher energies in order to break them down, coupled with some incredible theories, led to the discovery of some wonderfully esoteric particles with some suitably strange names.

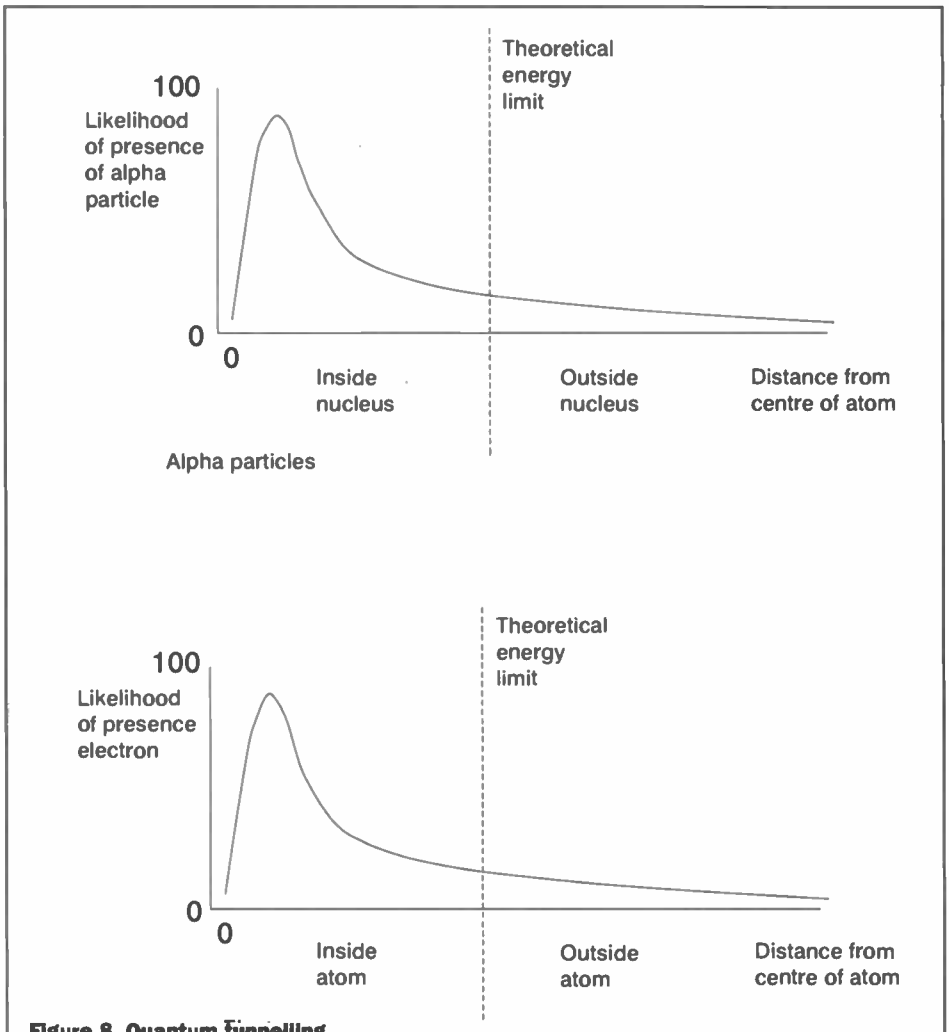


Figure 8. Quantum tunnelling

Quantum theory allows the possibility of particles outside theoretical distances and energy limits hence alpha particles can appear outside the nucleus - this is radioactivity: and electrons can appear outside their originating atom - this could be a semiconductor or even an insulator.

High Energy

An important point to remember when thinking about subatomic particles is that they don't normally exist outside of normal matter, which is composed purely of relatively stable electrons, protons and neutrons. They only come into existence in situations where there is a high enough energy in the system to overcome the fundamental forces which keep all material in its normal state. These high energy situations occur in radioactive material, in devices built to generate high enough energies to create subatomic particles, in high energy cosmic phenomena such as the creation and destruction of stars (this is nuclear fusion, where light atomic nuclei such as hydrogen combine to form heavier elements and give out energy), and in nuclear fission, where heavy atomic nuclei ie uranium split into approximately equal parts and emit neutrons, heat and radiation.

The Strong Force

Once the theory which explained electromagnetism as the force 'carried' by the fundamental photon was accepted, the search was on for particles which carried the other forces. In 1935 the Japanese physicist Hideki Yukawa proposed that a particle which would carry the strong nuclear force should have a mass somewhere between that of the light electron and the heavy nucleons (protons and neutrons). This was to be called the meson, meaning middleweight. Such a particle was found two years later in cosmic radiation. (Cosmic rays reaching Earth are the most energetic particles available for the study of subatomic particles, and in the early days of the study, before particle accelerators were built, they were the only ones). However, the new particle was found not to be satisfactory in explaining the strong nuclear force as its interactions with other particles didn't fit the theory. The meson theory was modified to say that two mesons were needed, both of which were produced by the decay of the first meson. A few years later both were discovered in cosmic radiation. These were called the pi-meson, or pion, and the other was the mu-meson or muon. The muon became re-classified as a lightweight particle, and not a 'meson' at all.

The hadrons can be grouped by mass into a group of ten and of eight, which suggested all could be composed from only three different more fundamental units. These turned out to be the quarks.

Table 1. Table of subatomic particles

Hadrons and Leptons

Neither the pion nor the muon turned out to be the mediator for the strong nuclear force either, and throughout the 1940s and 1950s, in cosmic ray experiments and then in the new particle accelerators, many other middleweight and heavyweight particles were discovered as the search for this mediator continued. These particles were given names like lambda, sigma plus, minus and zero, and xi minus and zero (all 'heavyweight'), and pi zero, K zero, and kaon (all middleweight). This huge variety of subatomic particles suggested that the discovery of a fundamental particle was quite a way off, and in the meantime these particles were categorised as baryons (meaning heavy) and mesons (middleweight). A further grouping was made of all the particles that were held in the nucleus by the strong nuclear force, namely all the baryons and the mesons, lumped together under the term hadron, meaning bulky. The particles not affected by the strong nuclear force, the electron, positron, muon and the electron neutrino (which had been discovered in one of the nuclear reactors which were coming into use in the 1950s in Britain and America), were grouped together as leptons, meaning small. The photon was at the time the only known member of a separate group which mediates the forces, a group called the 'bosons'. Table 1 shows these subatomic particles.These groupings made studying the particles more manageable, in particular by finding patterns or symmetries. One particular grouping based on mass had an eightfold pattern, giving the number eight a particularly universal significance, a number which it was noted also has significance in the teachings of Buddha. This led to the adoption of the term 'the eightfold way' for the use of symmetry groupings in reference to the Buddhist 'eightfold path'. However, before long a more fundamental grouping of three was found which also expressed the eightfold and tenfold groupings, and this eventually proved to be the correct way.

Baryon Number

In the 'real' macroscopic, low energy world, the concepts of material having mass, and positive or negative charge, are easily understood because these are familiar parts of everyday life. From this it is also relatively easy to accept that overall, positive and negative charges balance out, and that things like energy and momentum must obey physical laws and be conserved. However, in the Quantum World, largely perhaps as a consequence of our inevitable unfamiliarity with it, mysterious concepts have to be accepted. For example, although energy and momentum must be conserved, mass and energy can be equivalent, and particles can have momentum but no mass. In the macroscopic world particles can have a plus or minus charge, which can be labelled +1 and -1, in the Quantum World particles can have 'qualities' which have no analogy in the macroscopic world, but which can be assigned to them in such a way that they must balance overall in any interactions. One such quality is labelled the baryon number. Giving the baryons a baryon number 1, the mesons a baryon number 0 and declaring that like momentum, mass (or energy), and charge, 'baryonness' must be conserved, meant that the breakdown of nucleons into their more fundamental parts (and importantly why some breakdowns did not occur) was largely explained, even though there was still no sign of a truly fundamental particle from which all the other particles were formed.Changing the focus onto why things didn't happen rather than why they did led to the discovery of another quality which applied to some of the particles. These particles were larger than protons and neutrons but existed for a much longer time in particle reactions involving the strong nuclear force than expected. This quality was labelled 'strangeness'.

Strangeness

The quantum numbers of particles for the qualities of charge and 'baryonness' are +1, -1, and 0 only, that is the quality is positive, negative or not present. Strangeness however needs to have quantum values of 0, -1, -2, or -3, ie not present or one of three different values. This quality of 'threeness' is one of the clues that gave rise to the explanation for all the hadrons; this involved a fundamental particle named the 'quark'.

Conclusion

The final part of this series will look at how quarks, along with the leptons, appear to be the truly fundamental particles, and how these, coupled with the uncertainty of the Quantum World, may provide a 'Theory Of Everything,' including an explanation for the creation of the universe itself.

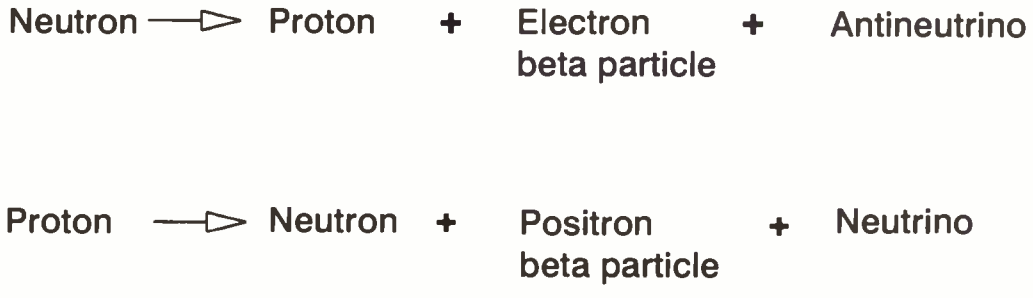


Figure 9. Neutrinos and Antineutrinos

Neutrons and antineutrinos are need to explain energy levels in beta decay.

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

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

413MHz Radio Microphone

Dear Sir

The above article which appeared at pages 18-23 of your January 2000 edition has been drawn to this Agency's attention. The Agency is responsible for regulating civil use of the radio spectrum.

Before any radio transmitting equipment can be legally used in this country it must have first been manufactured and approved by an accredited test house to the relevant technical performance specification. This applies whether the equipment is subject to licensing under the Wireless Telegraphy Act 1949 or has been statutorily exempted from licensing. I presume, given that the design of the radio microphone is based on the use of 418MHz transmitter/receiver modules that the equipment is intended to be used, despite the title of the article, in the 417.9-418.1MHz exempt frequency band.

As previously explained, before equipment can qualify for licence exemption under the Wireless Telegraphy (Exemption) Regulations 1999 it must be manufactured and approved to the relevant performance specification. In the case of the radio frequency band 417.9-418.1MHz the relevant specification is EN300 220-1. However, in accordance with schedule 6, Part 111 paragraph 2 of the 1999 Exemption Regulations that frequency band is designated for use for telemetry and telecommand purposes and the use of it for the transmission of music or speech is specifically prohibited.

Frequencies are available around 174MHz and between 863-865MHz for licence exempt radio microphone equipment where that equipment has been approved to specification 1-ETS 300422. Information on this frequency band and other short range devices can be found in the Information Sheet RA114. Information Sheet RA207 deals with the type approval of radio transmitting equipment.

I should be grateful if you would advise your readers of the legal position governing manufacture and use of radio transmitting equipment at the earliest opportunity. Anyone convicted of using non-approved equipment is liable on summary conviction at a Magistrate Court to a fine of up to £5000. It is also open to Magistrates to impose a custodial sentence of up to six months' imprisonment and order any equipment used in the offence to he ordered forfeit.

No doubt you will wish to pass the contents of this letter to Mr Dakin. If he, or you require any further information on this matter please do not hesitate to contact me.

Yours sincerely

D. S. J. GERMAN
Enforcement Policy Manager
Radiocommunications Agency

Whoops! Our apologies to all for this oversight. A copy of this letter has been passed to John Dakin.

Gregorain Calendar

Dear Sir

In your magazine dated May 1998 on page 38 there was a note concerning the start-date of the third millennium. This correctly describes how the then Julien calendar was modified by division into two time domains, called briefly, BC and AD, the former starting at BC1 counting backwards, and the other starting at 1AD, counting forwards. My problem, which I am sure you have encountered already, is the date ascribed to the change. Assuming the accreditation to 'Denys the Little' is right (where would one find a reference to him?) how can he have acted in 6AD when what subsequently became - initially - the Nazarene religion didn't yet exist? Is it a misprint for a more plausible 600AD?

A different account is given in the Grolier 1998 Encylopeodia, where it is claimed that a monk called Dionysius Exiguus suggested that the years should be counted from the birth of Christ, designating the year before AD1 as 1BC. This was in the year that became AD525. The Encylopoedia confirms that the next millennium will begin in AD 2001 Now, Dionsius translates into French as Denis, as in St. Denis the patron saint of France. Could the AD 525 Dioysius and Denis the Little be the same person?

Any information you or your readers have on this discrepancy, and on 'Denys the Little' would be appreciated.

E. C. Barrie
via email

I am sure this debate will rage on for some time, we look forward to hearing from our readers. Does this mean we might get two millennium celebrations?!

Digital Decoder without Subscription

Dear Sir

Are there plans to publish a project for a digital TV decoder? I realise that such boxes are available 'free' from On-Digital or B-Sky-B, but it is necessary to pay a minimum subscription to one or more of their viewing packages. Having far better things to do with my time than watch the selections that are available through these suppliers, all I neeed is a decoder to allow me to receive the non-subscription channels from BBC and ITV etc.

I have no plans to replace my old television which has been giving good service for at least 15 years, and digital sets are currently beyond my means, so a decoder project would certainly be welcome.

A. D. Green
London

We have no plans as yet, but if any reader would like to have-a-go, we would certainly be interested to hear from them.

Woodpecker Noises!

Dear Sir

The purpose of the previously mysterious 'Woodpecker' transmissions, as mentioned in Uri Geller's Extended Reality in issue 142, was in fact revealed quite some time ago.

It is over-the-horizon RADAR. Exploitation of the unnecessary shroud of mystery was perhaps beneficial to the authorities in the United States, as they had one too!

Dr G. L. Manning G4GLM
Edgware

Rather a disappointing explanation, I thing I prefer the original!

Northern Cross Rally

Dear Sir

On Sunday 13th February 2000, The Wakefield & District Radio Society is organising a large rally at the Thornes Park Athletics Stadium, Wakefield. Details are available from Roy Harvey G0TBY, tel: (01924) 893321.

I. R. Firth (G3WWF)
Leeds

This should be a good day out for our readers who live in the north, I hope you have a successful day.

RESEARCH NEWS

Solar Storms and Communications Fade Out

by Dr Chris Lavers

At the beginning of a new millennium it is natural to consider the scientific and technological progress that may be achieved during the next decade and possibly even the next century, but not the next millennium! History shows us the incredible pace of change that has taken place during the last 100 years, such that many of the predictions of science fiction authors such as HG Wells and Jules Verne (War of the Worlds excepted) have been surpassed.

As we peer into the next century, we foresee developments in many technologies, and areas that we have as yet barely contemplated, that will change our lives dramatically. The biggest impacts will be felt in: medical care, work and leisure time, personal communications and the virtual community, the interaction between man and his environment, biotechnology, and further growth in remote sensing for the needs of mankind on Earth.

Over future months some of these areas will be investigated; such as developing global communications networks which make the wealth of the Earth's information instantly available at our fingertips, artificial intelligence and virtual reality, future display devices, nanotechnology, smart composite materials and advanced sensors, and potential future power sources.

However, predicting the future has always been a risky business. True visionaries such as Copernicus, Galileo, Newton and Einstein, have consistently had to have the courage of their convictions, and the impertinence to question the most obvious, like the small boy in the Emperor's New Clothes, with the persistent determination not to let go of the question until they got an answer, whether ridiculed or not.

However, one of the biggest potential disruptions to our modern high-tech communications lifestyle is our increased reliance upon satellite systems for both civil applications and defence, making us increasingly vulnerable to space weather. It happens that in the decade since the last peak in the solar activity cycle we have experienced phenomenal growth in the use of satellite communications systems for routine television transmissions, phone communications and diverse other applications. A severe solar storm could easily leave our modern high-tech civilisation in considerable chaos for a long period of time unless sufficient warning and alternative arrangements are made.

Changes in electronic systems over the last decade aggravate satellites' vulnerability to future solar storms, far more than in the past, with potentially more devastating results than the much hyped Y2K 'problem'. Yet scientists are still unable to predict with certainty when such activity is going to hit the Earth.

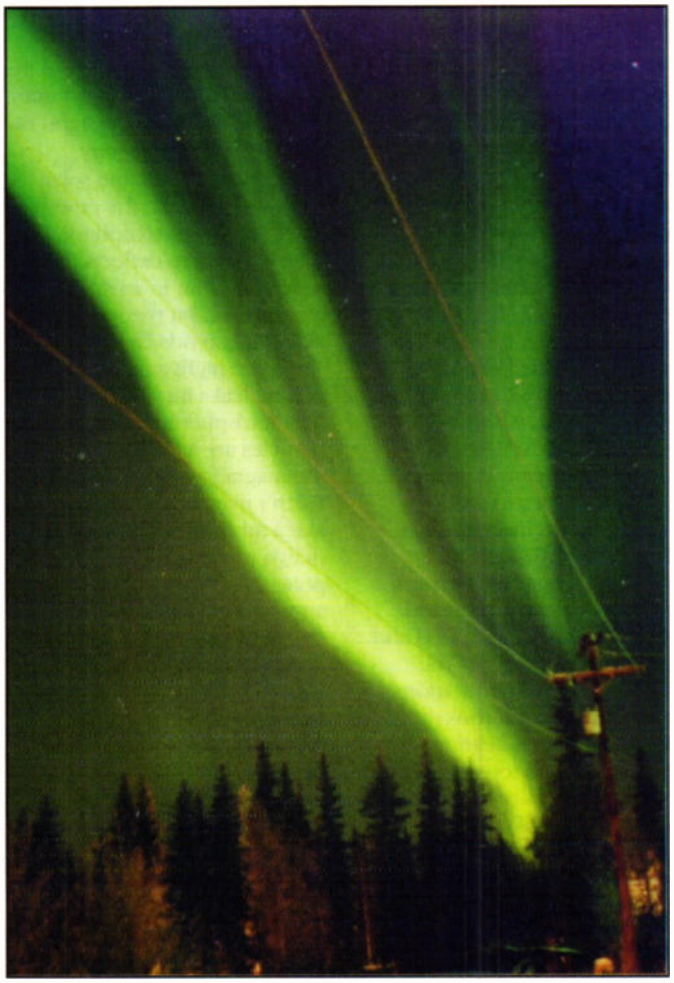
The risks of space weather, are not far fetched. During mid-March 1989 the fiercest sunstorm for 30 years struck the Northern hemisphere after travelling for 4 days from the sun, striking Canada and the North East United States, already in the grip of icy weather conditions. Within the Quebec power grid, which rests on underlying poorly conducting granite, voltage levels fluctuated dramatically generating excess current. Within a few seconds, lights across the entire province of Quebec tripped out in sequence, monitored at the Quebec National Power Control Centre, and viewed as a spreading wave by satellite, which threw 6 million people into darkness and left some without electricity for long periods and in temperatures of -15 degrees Centigrade! The consequences were even more dramatic than in France after the recent winter gales. Without power, subways sat still, traffic lights did not operate and even petrol pumps failed to work. To those in isolated communities, such solar storms could have

Jan Curtis, Geophysical Institute, Fairbanks, Alaska

Figure 1. Aurora

Jan Curtis, Geophysical Institute, Fairbanks, Alaska

Figure 2. View reflected in lake



Jan Curtis, Geophysical Institute, Fairbanks, Alaska

Figure 3. Power lines and aurora in sky

devastating consequences particularly for the old and vulnerable.

From time to time Geomagnetic storms will throw out bursts of high energy charged particles and significant levels of solar radiation. The high energy charged particles or plasma, will be trapped within a magnetic field. The polarity of the magnetic field of the plasma with respect to the magnetic polarity of the Earth's own magnetic field determines whether there is a relatively gentle 'buffeting' between the two, or a violent reaction when the two fields are in opposition. If the magnetic fields are opposed charged particles flood through the protective shield of the Earth's magnetosphere and into the Earth's upper atmosphere causing Mega Ampere electric currents to surge around which are responsible for inducing direct currents in power lines designed for alternating current and disruption of the medium frequency (MF) and high frequency (HF) bands used for skywave communications. These storms also increase the level of visible aurora, (shown in Figures 1 and 2), revealing both the aurora's beauty, and with the power line in the background, the potential threat of such storms on man-made systems (Figure 3).

When a magnetic storm hits the Earth, any power network of conductors acts like a giant dynamo. Power lines, telephone lines and even railways lines are all potential conduits for Geomagnetically Induced Currents (GIC's) of hundreds of amperes. Power companies are particularly at risk as the power lines guide the power to sensitive components in transformers causing the Hydro-Quebec's 1000 kilometres plus grid to blow spectacularly. Nothing can prevent these solar storms from happening, and unfortunately there is no way of indirectly inferring the polarity of the storm's magnetic field, which accounts for the fact that more often than not attempts to forecast the severity of a storm are very often wrong. Storm warnings are often given which do not occur and vice versa.Geomagnetic storms pose particular problems for space-based systems such as the accuracy of the Global Positioning System (GPS), which allows people to fix their position on Earth by comparing the reception of signals from several satellites. When the transmission properties of the atmosphere change unexpectedly during a storm, storms can make navigation fixes very inaccurate and for short periods satellite signals can be lost completely. Space Environment forecasters at the US National Oceanic and Atmospheric Administration (NOAA) predict increasing numbers of solar storms over the next 4 years to a peak of severe storms in 2002 and minor storms in 2005 of solar cycle 23 (Figure 4). By counting the number of sunspots (s) and the number of sunspot groups (g) allows an index of solar activity known as the International Sunspot Number to be determined $R=k(10g+s)$ where k is a constant. During the solar storm of 1989 it peaked at over 150 compared with a low of only 10 during the quiet period of the mid eighties.

Concern is not so much for the radiation hardened US Department of Defence satellites but for the performance of millions of civilian GPS receivers, now accounting for a significant part of a multi $Billion communications industry which should make $8B in 2000. In 1998 Magellan introduced the first hand-held GPS receiver for $3.5K, now GPS receivers are available for under $100 and weigh only a hundred grammes.

The impact of solar flares include: disruptions in satellite command up-links and data downlinks. Irregularities in the amplitude, phase and polarisation of radio signals as they pass through the ionosphere which tend to be most severe between sunset and midnight during intense solar activity. Links with communications satellites in geosynchronous orbits are particularly vulnerable to intermittent signal loss or scintillation. During the Persian Gulf war, such scintillations were initially taken to be enemy jamming. Even when the sun is relatively placid, as in 1994-5, about 150 satellite malfunctions occur annually. In fact studies of NASA and US Air Force spacecraft indicate that about 20-25% of all spacecraft failures are related to interactions with the space environment. The British Ariel 1 was probably the first documented satellite failure due to high-altitude atomic tests in the Pacific, during the Argus project, generating aurora lasting weeks. Other causes of failure are: meteoroids (Ulysses), increased drag (Skylab), arc discharge from charged satellite surfaces (Intelsat K) and phantom commands (on the environmental satellite GOES-7). When the communications satellite Galaxy 4 failed in May 1998 several communications networks were brought down and 45 million pagers were put out of action.

It is also important to distinguish between a satellite suffering from significant drag from that of an Inter Continental Ballistic Missile re-entry vehicle which could inadvertently start World War III! To this end space satellite watchers at Cheyenne Mountain AFB in Colorado, USA, track over 8,000 orbital objects, which during the last big storm took up to 96 hours to reacquire correctly. An enemy intent on mischief, sufficiently educated to realise this window of opportunity, could try and take advantage when defensive sights are down.

The cause of solar storms is

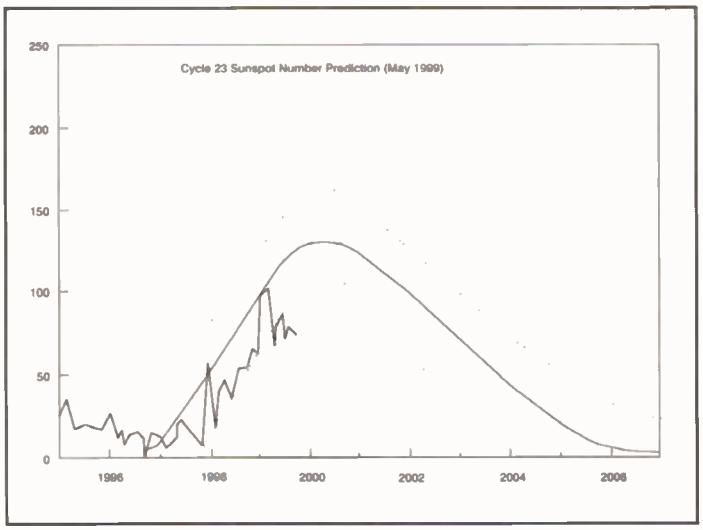


Figure 4. Sunspot cycle prediction

Courtesy: NASA

Figure 5. Solar prominence

as yet poorly understood but is due to the interaction between the hydrodynamic behaviour of the sun's fluid body during rotation and the powerful magnetic fields of the sun which starts to wind or tighten up on a cyclical basis, becoming rapidly unstable as they do so. As the fields tighten up there is an increased chance of a severe solar storm or Coronal Mass Ejection (CME) taking place which may if alignment condition are such strike the Earth. The best indicator that something may happen is the monitoring of solar sunspot activity, i.e. their number. Counting sunspots has taken place for nearly 2,500 years, notably by the Greek scientist Meton who observed blemishes on the Sun's surface at sunrise over a 20-year period, but the recording of accurate scientific data has only taken place reliably over the last 300 years, (from cycle 1 in 1755), allowing activity to vary in cycles of about 11 years. There is great variability between cycles, but the current Solar Cycle 23, is forecast to be of similar strength to Solar Cycle 22, which was the third largest on record.

Incidentally Meton speculated about the possible impact of these sunspots on the weather, since they were seen predominantly during periods when rainfall was above average. Several workers have correlated old data for temperature with sunspots from the 1860's to the 1980's and found a strong correlation, including the Armagh Observatory in Northern Ireland and more recently Professor Mike Lockwood's group at the Rutherford Appleton Laboratory in the UK have found that the magnetic field of the Sun's outer atmosphere, the hot corona, has doubled over the past century.

The rapid growth in GPS since the last period of high activity will make the effects of geomagnetic storms more widely felt. Civil users should expect to suffer from solar activity more than the military. The later also use dual frequencies which permit comparison of returns and calibration of the GPS signal for ionospheric errors. However even nuclear hardened Milstar communications satellites may require multiple reboots in bad storms. In March 1989 the same storm which devastated the Quebec national grid created an unstable ionosphere which made GPS signals untrackable for periods, so that even surveyors using dual-frequencies were affected in Southern California.

Solar flares usually occur near sunspots (Figure 5), but not always. Sunspots are indications of strong magnetic fields. When the fields become organised the manifestation is a sunspot, a region of slightly lower temperature on the surface of the sun. Disturbances on the Sun can have a number of effects. Increasing levels of extreme ultraviolet (EUV) flux and X-rays occur and rates of CME correlate well with higher counts of sunspots.

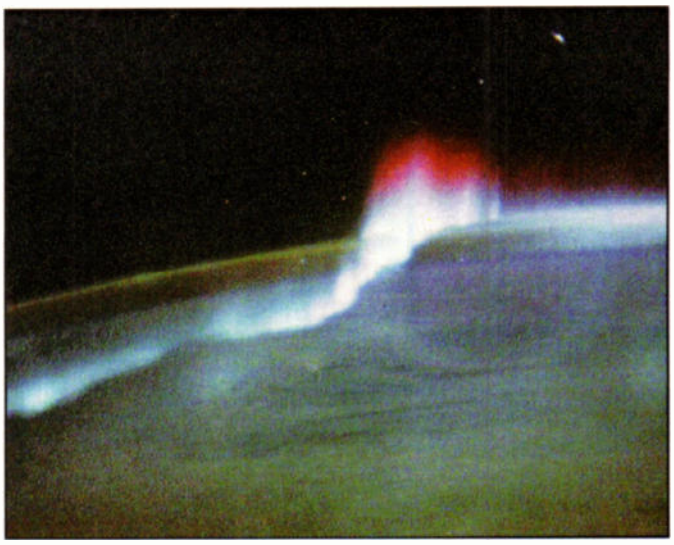
Another big problem is the energetic electrons that race around high above the Earth during a storm creating uneven build-up of charge on satellites. So called Electro Static Discharge (ESD) on sensitive microelectronics chips can have a devastating effect. Unfortunately valves are too bulky, with high power consumption, and too easily damaged during launch to afford normal terrestrial protection. Even sparks can occur and false commands may be generated in a 'fly by wire' system. In 1994 it was the Ottawa Canadian TV satellite operator Telesat's turn to lose Anik satellite E1, which took controllers almost 4 hours to recover, and then just as they thought that they had things under control a more serious failure of their E2 satellite controlling the sports network and phone systems occurred. Aircraft had to be grounded and significant disruption of the Canadian telecommunications network resulted. It took Telesat controllers nearly 6 months this time to get the satellite back under correct control. Failure of either satellite could have resulted in loses over $100M which would have been disastrous for the company. According to the US Air Force Phillip's Laboratory in Massachusetts, rogue electric currents commanded the satellites to turn their solar panels away from the Sun because of momentum control system failure. E1's back-up system prevailed but E2's batteries drained flat and it floated out of control for 6 months until its orbit brought the solar panels back into sunlight. This wasn't the first time that satellite operation had been significantly affected by space weather. In March 1989 the GOES-7 weather satellite lost half of its solar cells to a Solar proton storm, cutting the spacecraft's lifespan by 50%

The energy from magnetic storms and dramatic increases in Extreme UV can significantly disrupt satellite orbits. Increases in solar activity causes the atmosphere to heat up and as it does so the atmosphere expands. For a typical satellite in Low Earth Orbit (LEO) at about 400km altitude atmospheric drag may increase 20 fold. This is not necessarily a bad thing as this is nature's way of cleansing an otherwise cluttered LEO of significant amounts of space debris and 'dead' satellites.

Today a handful of stations world wide collect data from local observatories and satellites giving much needed and vital information to power companies at threatened latitudes, allowing them to isolate vulnerable regions of the power grid. The key to accurate predictions is to understand the Sun-Earth interplanetary interactions. When the solar wind strikes the Earth's protective shield the magnetosphere, the magnetosphere deflects the solar wind, but in so doing is compressed on the sunward side but extends far out on the sheltered night side. Solar plasma leaks into the magnetosphere. Charged particles are accelerated inside the magnetosphere along the Earth's magnetic field lines, and like a moth to a flame are drawn towards the magnetic poles. Here they collide with atmospheric molecules and create the terrestrial auroras- the northern and southern lights. One way to measure the strength of the ionosphere is found by directly monitoring the intensity of the auroral colours. Green light is observed due to the de-excitation of a molecule in a particular excited state, red is seen from a different excited state. The more green light visible the greater the ionisation of the ionosphere.

But what is the Ionosphere?

The Earth's atmosphere varies in density and composition as the altitude increases from the surface. The lowest part is the atmosphere, where our weather is turbulently mixed, and called the troposphere extending from sea-level to about 15km. The gases here are predominantly molecular oxygen and molecular nitrogen, accounting for 90% of the Earth's atmosphere. Above this lies the stratified layers of ionised gas known as the ionosphere. At the highest levels of the Earth's outer atmosphere solar radiation is very strong but few atoms are present to interact with it so ionisation is small. At sea level there are very many more atoms, but the ionising radiation is weak. Fortunately for us the Ozone layer, peaking about 25km, and consisting of only a few parts per million, soaks up huge amounts of otherwise lethal UV radiation. Weakly stratified layers of heavier molecular oxygen (90-120km) and isotopes of nitrogen (250-400km) permit



Courtesy: NASA

Figure 6. Sprites from upper ionosphere viewed from shuttle

the possibility of ionised gas layers. These are known as the D region, E, F1 and F2 layers. At dawn there is a big rise in ionisation, and at dusk a large increase in recombination of molecules, causing the D region to disappear completely, the E layer to weaken and the F1 and F2 to combine together to form a single F layer. Processes change over daily or diurnal cycles, seasonal cycles, position on the Earth's surface and upon the 11-year solar cycle.The aurora are a faint visual phenomenon associated with geomagnetic activity, occurring mainly in the high-latitude night sky. Auroras are also present around other planets such as Saturn and Jupiter, and have been extensively studied by Dr Andrew Coates of the Mullard Space Science Laboratory at U'CL, London, featured in previous Research News.

However, recent strange auroras or sprites have been observed from the Space Shuttle consisting of thousands of fiery streamers each a few metres wide- resulting from electrostatic charges left behind by lightning bolts (Figure 6, Courtesy of NASA). 30-50 miles up spark channels form, giving a blue glow and eventually streak upwards leaving behind glowing red streamers of ionised gas.

Until the advent of Skylab nobody knew about CME's. CME's occur several times a month with temperatures over 1MK and with enough energy to boil the Mediterranean sea dry. Travelling at speeds between 10km/sec and 1000 km/sec, the energy of just one storm would supply Europe's power needs for a full year. CME's take about 2 to 3 days to reach the Earth whilst radiation takes only 8.5 minutes. Hence the possibility of predicting a massive inrush of slower charged particles is possible. Using Imagery from the Soft X-ray Telescope on Japan's Yokoh spacecraft, led Richard Canfield of Montana State University to detect the formation of S-shaped patterns on the sun's surface often leading to a Coronal Mass Ejection. The rising of a mass of gas suspended over the sun's photosphere by magnetic fields is seen as a dark line or filament. A filament on the limb of the sun seen in emission against the dark sky is called a prominence. A prominence may extend up to 1 Mkm out from the surface of the sun. An S-shaped pattern near the centre of the Sun's disk once spotted is like a smoking gun pointed at the target Earth.

CME's likely to strike Earth are very unpredictable and the rising shockwave from the solar surface is usually too faint to be seen. Fortunately when the wave travels around the solar plasma it emits energy at a resonant frequency, in this case in the radioband, and as it travels through the thinning upper solar atmosphere, the radio broadcast is shifted to lower frequencies, revealing how fast the wave is moving thanks to the Doppler shift. This gives a good indication of the speed of the CME towards the earth.

In 1996 the European Space Agency (ESA) hoped to launch 4 satellites to study the Earth's magnetosphere to more accurately predict solar storm effects. However, the Cluster spacecraft, built to fly in formation round the magnetosphere boundaries, were on a free Ariane 501 launch from French Guyana which exploded spectacularly due to software error. To add insult to injury the Cluster mission was not insured, setting back the work of scientists, including those at the Rutherford Appleton Laboratory (RAL), by several years. Fortunately the successful launch of the Solar Heliospheric Observatory (SOHO) on an Atlas rocket on 2 December 1995 from Cape Canaveral meant that some information was being gathered. This is a major ESA NASA venture to study the Sun, and included a Coronal Diagnostic Spectrometer (CDS) from RAL which is an integral part in the programme. SOHO's more recent recovery has allowed spectacular pictures of the Sun's surface. SOHO offers some advanced warning of storms due to its use of a zero gravity Lagrange point where solar gravitational attraction cancels out the Earth-Moon attraction. SOHO operates from the so-called L1 Lagrangian point between the Earth and sun about 1M km from the Earth. With the launch in 1997 of the Advanced Composition Explorer (ACE) about 1 hour's warning is currently being given. However the vulnerability of satellites like ACE to space weather are akin to the vulnerability of a wind anemometer in a storm, which may itself be destroyed by a storm. RAL is involved with a number of missions including a second Cluster mission and the successful launch of Polar to study the Earth' aurora and high latitude magnetospheric phenomenon.

The need for forecast predictions is growing. The lighter, cheaper satellites now favoured by industry and Daniel Goldin of NASA (although some rethink is due after recent failures including two Mars probes), make ever-smaller electronic components more vulnerable to radiation damage. Future storms will disrupt both satellite orbit and their operation during the next 18 months and the consequences of a mistaken satellite re-entry mean that extreme vigilance must be maintained at all times.

Astronomers are forecasting storms just as big as those in 1989, if not bigger. According to NOAA the sunspot number could reach 190 sometime into 2000. As new technologies and communications networks emerge, new vulnerabilities to solar events are emerging. It is possible that the noise generated will put millions of cellular phones, pagers, navigational aids and other military systems out of action, as well as disrupting ELF/VLF communications to submarines and MF/HF skywave traffic. With the solar maximum approaching, we are about to find out the answer to this question.

Further details and predictions are available from the Boulder Space Environment Centre at:
www.sel.bldoc.gov.

SOHO
Soho. Details from
www.nascom.nasa.gov

Space Weather Bureau at
Marshall Space Sciences Laboratory,
Huntsville Alabama
www.SpaceWeather.com

Conferences and Meetings

Sensing Disinfection Efficiency
13th April, Mitchell Hall, Cranfield University.

Sensors for Water Interest Group.
The cost of the workshop is £55 inc VAT for members.

Contact SWIg, 27 West Green, Barrington, Cambridge, CB2 5RZ Tel Fax: 01223 870967.

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email:
The_Diagnostics_Club@compuserve.com
web url -
http://www.diagclub.co.uk

COMMENT

by Keith Brindley

Breaking Windows

Not long after this magazine hits the streets the long-awaited (read very long-awaited) new release of Microsoft Windows operating system will hit the very same streets. February 17 is slated as release date of Windows 2000. Expect a lot of hype in the media coming up to that date, and bear in mind that Windows in its present incarnation - and if early samples of the operating system prove representative of its final appearance as Windows 2000 - will be little better in terms of its user interface than it ever was as Windows 95, then in Windows 98. While Windows in general is a robust enough operating system, and Windows 2000 is to be an impressive enough operating system it is based on principles that are considerably older than its new name would suggest.

There's no doubt that Windows has tried to emulate other operating systems over the years. Indeed, it's a documented fact that the head of Microsoft, Bill Gates, argued with his design team for Windows 95 that he wanted a Macintosh on his PC. Nothing less would do, and hence Windows 95 was born with the now well-known interface. At the time it was a standing joke among Macintosh users that Windows 95 was indeed like a Macintosh - it was just that Mac users had been using the Macintosh since 1984! I've got the T-shirt saying "Windows 95 = Mac OS 84" to prove it.

Windows 98 was to be a vast improvement over Windows 95, but it turned out to be a relatively minor upgrade, merely a bug-fix update - as proved by the fact that Windows 95 is labelled Version 4.0, while Windows 98 is simply Version 4.1 in the Setup dialog boxes of each operating system. The step to Windows 2000 promises to be a more major upgrade than that from Windows 95 to Windows 98, but it's still not going to be the earth-shattering improvement that Microsoft would have us believe by the hype that's soon to scream at us from every newspaper, magazine and television screen over the coming few weeks.

While it may hurt many Windows users' pride to consider such matters, things have changed in the Macintosh world since 1984. The Mac OS doesn't see such small upgrades every two or three years. Indeed, since the time of Windows 95 there's been a regular (and often massive) system upgrade roughly every year or so from Apple. The Mac OS has moved along from version 6 - on which Windows 95 and Windows 98 were loosely mirrored - and is now at Mac OS 9. What's more, in a move to possibly pre-empt the Microsoft hype, Apple recently announced Mac OS X (pronounced mack oh ess ten).

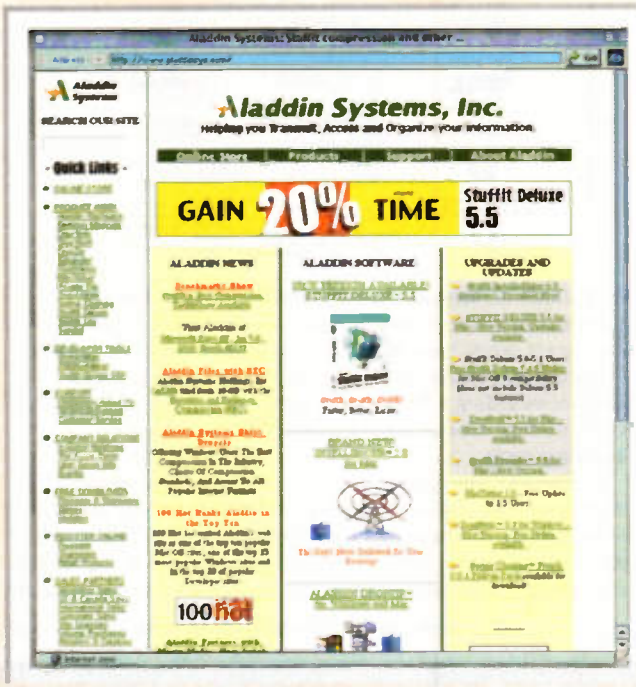
Windows users may cite this as an example of sour grapes on Apple's behalf, coming so soon before Windows 2000 release, but when you read between the lines of Apple's announcement you soon realise that Mac OS X will be much more than just the typical operating system upgrade. Announced at the MacWorld Macintosh exhibition in San Francisco which ran in the first week of January, Mac OS X was a total surprise to the exhibition visitors. Oh yes, all Mac users know that the upgrade to Mac OS X was due to be a big one, and they know that it's due by the summer, but when Steve Jobs (Apple's chief executive officer) gave an on-stage demonstration of its new features and abilities, most visitors were simply yet totally gob-smacked. Mac OS X virtually redefines the computer desktop as most Windows users and Mac users know it - more of which soon - but first we'll concentrate on the underlying principles of the new operating system. First off, it is a new operating system. It's not based on the same basic kernel that any Macintosh operating system over the last few years has been. Instead it's based on the famous Mach 3.0 and FreeBSD 3.2 cores that are recognised as being the most solid yet powerful operating system kernels of all times. Personal file sharing is handled by the Web server that runs over half of the world's Websites - Apache - which means that anyone with a Macintosh running Mac OS X (together with an Internet connection) can produce their own Internet servers in just a few mouse clicks. Graphics and sounds are handled by a combination of in-built portable document format (PDF), OpenGL, and QuickTime format engines, which will make the Macintosh simply the best computer platform to generate and use 2D, 3D graphics, games, music. Coupled with Apple's latest personal computers based on the G4 PowerPC processor, Windows-based personal computers will not - and actually cannot - produce anything like the performance or abilities that Mac OS X will offer, whatever clock speed Intel hikes its processors up to.

Such high technology means that Mac OS X will be extremely up-to-date, capable, and powerful in terms of technology. Yet the Mac OS is nothing if not being famous for being easy to use (it's what Bill Gates wanted Microsoft Windows to be, remember). So over and above all this technology is a brand-new user interface too, with features so advanced that other operating systems can only dream of having them years down the line.

The new interface is called Aqua, in a nod towards its fluid appearance and operation. It comprises several parts that are a drastic improvements over previous operating system parts, but it also contains a great deal of parts that are, quite simply, brand-new to any operating system. The handful of new features that Steve Jobs wowed the MacWorld audience with (together with the others that he didn't feature) will define the desktops of all personal computers - not just the Mac - for many years to come. We'll take a closer look at Mac OS X as its release time approaches.

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

Genie in a Lamp



The most popular compression standard used on the Macintosh platform is - by far and away - Aladdin's Stuffit standard. For Mac users this comes in several flavours. There's a freeware utility called Stuffit Expander that allows files compressed in the format (along with those of other compressed formats common to Windows and Unix computer users) to be decompressed. Next is a shareware utility called DropStuff that lets a Mac user compress files into an archive. And there's a full-blown application called Stuffit Deluxe that gives full compression and decompression tools along with several complementary utilities for compressing and decompressing in other formats, archive splitting over disks, along with security enhancements. It really is the most fully featured compression suite of tools available.

Stuffit Expander and DropStuff are supplied as part of Apple Mac OS system software, of course, and for many users they do everything required of compression and decompression utilities. However, any Mac user seriously into Internet usage will find the extra features of Stuffit Deluxe worth their wait in gold.

Recently, Aladdin has updated the general Stuffit format as a cross-platform device, which allows PC users to take advantage of Stuffit format files. There's a Windows utility called Expander for Windows, which is the freeware equivalent of Stuffit Expander on the Mac, together with its complementary compression shareware tool DropStuff for Windows. Also, Mac users already know they can decompress Windows compressed files with Stuffit Expander, but a recent addition to the Aladdin utility armoury is DropZip - which compress files in the Zip format. If any user finds themselves swapping files with users of other computing platforms then utilities like these are essential. Latest versions of all Stuffit utilities and applications are all downloadable from Aladdin, at: <http://www.aladdinsys.com>.

Microsoft Updates for Mac

The New Year saw a clutch of minor updates and bug fixes available for Mac users from Microsoft, and if you use any of the products involved you are advised to download them free of charge from Microsoft's MacTopia Web page, at <http://www.microsoft.com/mac/>.

One of these updates specifically fixes MS Word and MS PowerPoint for users that are running the latest Mac operating system, Mac OS 9, although the PowerPoint fix corrects a problem with PowerPoint when printing to an Epson ink-jet printer so could be of interest to other users too. A second fixes a long-standing Year 2000 problem with Excel, and finally makes all Microsoft products on the Mac Y2K-compliant. The last update is Year 2000 related, although is not strictly speaking due to the so-called millennium bug. Certain security certificates within the Mac version of Internet Explorer were scheduled to expire at midnight on 31 December 1999, and will produce expired certificate warning thereafter. The Internet Explorer fix corrects this problem.

Apple Updates

Although not directly of interest to many UK Mac users, Apple has recently produced an update to correct a problem experienced by a few US customers running Mac OS 9 who are permanently connected to the Internet. There appears to be a concerted hacking attempt to produce what's known as denial of service (DoS) at many Internet servers around the world. The aim seems to be to bring the servers down by either genuine hacking into the servers, or simply by producing so much network traffic on the servers that they cannot be accessed by legitimate users.

One variant of this activity is to use other computers on the Internet to act as unsuspecting traffic generators, and it's this variant that's has been causing the problem. By sending particular Macs a signal, the hackers have found that they can cause the Macs to generate a much longer signal, in a sort of digital amplification which the hackers intend to use in the denial of service attempt. Only Macs running Mac OS 9 are involved (with the exception of PowerMacintosh G4, iBook and iMac computers running Mac OS 8.6) and only those that are permanently connected to the Internet are affected (because the setup of the activity means that hackers have to locate the Macs in the first place, test them with signals, then blast all associated Macs together at a later time). This means that Macs connected with a dial-up modem connection really aren't affected, so only those logged on using either high-speed cable modems or ADSL lines are involved. As cable modems are pretty new in the UK and at present are only rolling out in a few locations, and as ADSL isn't past its trial stage yet, only a relatively few Macs in the UK are currently affected. Nevertheless Apple recommends that anyone running Mac OS 9 on their Macs (or those exceptions already listed) should install the update (called the Open Transport 2.6 Updater), which is downloadable from Apple's Web site, at <http://www.apple.com>, as it addresses some minor DHCP issues experienced in Mac OS 9 too.

myWebOS Web-Based Operating System Goes Live

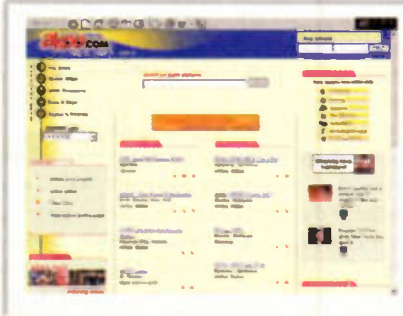
For the first time, Internet users can access data and files in a traditional Windows-like environment using myWebOS at <www.mywebos.com>, without the hassle and expense of installing individual applications on a user's computer.

As a true Web operating system, myWebOS goes beyond client-server configurations by utilising the Internet as the network to offer users reduced IT maintenance costs, universal access to data, and improved speed and performance in remote computing through a single mobile environment.

In addition to cost efficiencies, myWebOS provides users with unmatched speed and performance because the Web-based operating system's speed does not rely on the Internet connection or PC performance.

Currently, myWebOS offers Hyperoffice 2000, an office productivity suite that includes Hyperword, the first free Web-based word processor, email, calendar, and contact management, as well as other business-oriented applications. myWebOS will also include business-to-business applications from a variety of e-commerce and business application industry leaders.

AKOO.com Introduces Streaming Media Search Engines



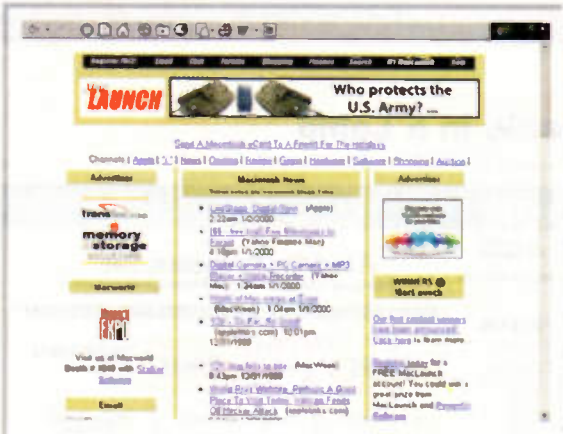
Akoo.com at <www.akoo.com> has introduced a streaming media search engine, a streaming media scheduler/manager available at no charge via the company's Web site and wireless technology that retransmits streaming media from a PC to any home stereo or portable radio system.

Through akoo.com's search engine, end-users may access thousands of radio and television stations from around the world to find programming in every area of interest.

Search results, and profile pages, include a detailed description of each streaming media source and, very often, full program schedules and additional information, such as personality profiles.

From the search results page, end-users either may listen live, link to broadcasters' Web sites or add a station/program to their day's play list.

Mac-Centric Internet Portal Goes Live



MacLaunch at <www.maclaunch.com>, claimed to be the Internet's first comprehensive portal site targeted exclusively at Macintosh users, has officially opened its doors to the public.

MacLaunch consist of a range of Mac-orientated portal services including a Web search tool, free e-mail, news, sports, weather, chat, stocks, message boards, and a full array of shopping tools.

In addition, MacLaunch focuses on the specific needs of Macintosh users by offering several channels of Mac specific news, listings of Macintosh software updates and releases, a Mac-specific search engine. Mac product reviews and columns addressing issues important to the Macintosh user community.

HearMe Brings Voice to Web

HearMe has announced the immediate availability of HearMe VoicePresence at <www.hearme.com/company/products/vp> for Web sites, a free product for instantly adding live voice to any Web page.

VoicePresence enables personal and engaging experiences for Web users that translate into site 'stickiness' and a more effective selling environment for businesses. In its push to make live voice ubiquitous on the Web, HearMe has released VoicePresence and at the same time, empowered Web-based organisations with a simple way to offer consumers one of the most compelling experiences online.

More than 8,000 Web sites have registered for Voice Presence during a preview in November and December. In that time, there have already been more than 350,000 downloads of the VoicePresence plug-in by users on these Web sites. Such positive response at an early stage demonstrates the growing demand for a more 'human' environment on the Web.

Drowning in Web Content? Annotate.net Solves Problem

Annotate.net at <www.annotate.com>, a Silicon Valley start-up, has announced beta testing of the first Web-navigation network and Find Engine that cuts through Web-content clutter to guarantee the relevance of Internet information. The combination instantly delivers customised, personalised content that's 100% relevant to a Web page being viewed.

Web content more than doubled from December 1997 to February 1999 and search engine coverage of that content dropped from approximately 34% to 16%, according to an NEC Institute study on Web search tools.

Today, an estimated 8,000 new Web pages are added every day, with no way for users to discern the veracity or the dependability of that content. And, according to eMarketer, consumers don't like leaving their Web a full 40% never click on a banner.

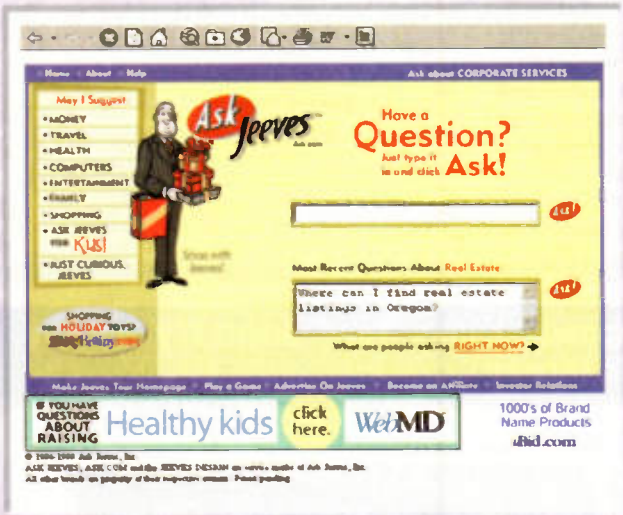
The Annotate.net Find Engine is a persistent desktop icon that does not interfere with the Web page being viewed. The tool detects a browser URL and instantly delivers customised, personalised content that's 100% relevant to the Web page being viewed. The Annotate.net Find Engine is a thin (400 Kbytes) client module that users download for free from the annotate.net Web site.

Unlike traditional search engines, the Annotate.net Find Engine delivers relevant content without interfering with the Web page being viewed and without requiring users to leave a Web page to gain more information. Further, users retain control over which content providers can deliver their information.

After downloading the thin client module, Annotate.net users subscribe to their preferred content and commerce advisors and automatically begin receiving 100% relevant content whenever they surf the Web.

For content providers, joining the Annotate.net Network offers the chance to turn brand equity into brand addiction. Because it is a persistent desktop client, the Annotate.net Find Engine stays with users as they roam the Web, enabling network members to create a persistent presence with subscribers and potentially driving significant traffic to home sites.

Ask Jeeves to Establish Global Presence



Ask Jeeves at <www.ask.com> has joined with Carlton Communications and Granada Media Group, the two largest commercial television companies in the UK, to create Ask Jeeves UK. Ask Jeeves UK will be designed to meet the specific needs and interests of users in the UK.

Using the same natural-language technology and question answering approach available at Ask.com, Ask Jeeves UK will provide users with an easy way to get answers to questions ranging from 'What films are on at a cinema in central London?' to 'Where can I find information on the Liverpool football club?' The new service will be accessible at Ask.co.uk in early 2000.

Currently as many as 650,000 UK visitors use Ask.com every month, which will serve as a user base for Ask Jeeves UK. In addition, Carlton and Granada Media Group will make Ask Jeeves UK available on the companies' existing Web sites, providing access to hundreds of thousands of Internet users.

Shop@AOL Launches LiveProducts

Shop@AOL at <www.aol.co.uk>, the e-commerce arm of AOL, has launched LiveProducts interactive product demonstrations to allow online shoppers to experience many of the most popular consumer electronic holiday gifts from the comfort of their own homes.

Featuring e-SIM technology, the leader in electronic product simulations for e-commerce, interactive training and product development, LiveProducts enables Shop@AOL customers to instantly experience fully interactive product simulations that recreate the look and sound of the real product, or watch animated walk-throughs of the product features.

By simply clicking on one of the products displayed, shoppers can easily test the ringer on a cell phone or click on the phone keypad and digits will appear on the phone's screen; they can manoeuvre the features of a digital camera; or even learn how to program a VCR before deciding whether to make a purchase.

If shoppers then want to buy the product, it's only one click away. In addition, LiveProducts stores the complete owner's manual for each of the products to enable users to quickly find all the information they need.

Study Shows Europe Now Much Closer to US in Adoption of E-Business

Contrary to popular belief, Europe is not far behind the US in the basic uses of the Internet - communication with customers and suppliers, promoting products and services, and recruitment.

Many European companies are neck and neck with the US in getting 'switched on' to the Internet. With e-business about to take off, the Internet is seen as a major new revenue stream, with all those surveyed forecasting total e-sales averaging 13% of total sales, equivalent to £170 billion in the next two years £74 billion in the US and £95 billion in Europe. However, many admit it is the fear of going out of business that is driving them to invest heavily in e-technology.

These are some of the main findings of research carried out among 700 companies in Europe and the US by MORI for Intentia at <www.intentia.com> and co-sponsored by IBM at <www.ibm.com>. It is the first annual comparative tracking study of tier-two companies (revenues of £30 million to £600 billion) to establish a picture of how quickly e-business is being adopted, and intentions for the future.

It focuses exclusively on board directors - 100 each in the UK, France, Germany, Sweden and Spain, and 200 in the US - with responsibility for e-business or business development strategy. All respondent companies operate in one of three industry sectors: manufacturing, wholesale and retail.

The Intentia study reveals the e-business market is on the verge of a massive explosion. Of all those interviewed, 56% say e-business will become essential/very important in two years time in dealing with suppliers and customers. This compares with just 24% today who say it is important. By country, forecasts of its becoming essential/very important were highest in Sweden (66%), the UK (64%) and the US (60%), while expectations of its importance were lowest in Germany (53%), Spain (49%) and France (42%).

The study found that e-business is also a hot topic on boardroom agendas. Of all the companies interviewed, 75% now have someone at board level responsible for e-business. In Europe as a whole the figure is 68% and in the US, 91%. However, the UK leads marginally with 95%.

Respondents believe that e-business is set to have a profound effect on whether they prosper or fail in the new digital economy. When asked if they agreed or disagreed that if they don't use e-business they will have difficulty surviving, 42% of US companies and 38% of European companies agreed. In the US 64% of companies and 51% of European companies say they will have to invest significantly in systems, processes and business applications.

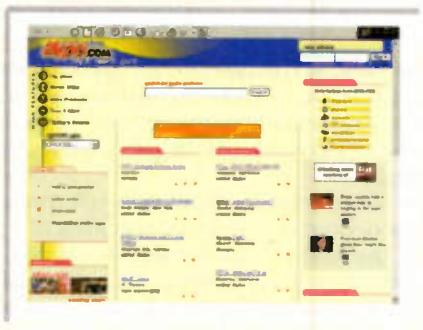
However, when companies were asked what they understood by the term e-business, very few were able to describe e-business in the context of integrated enterprise-wide business processes, and linking suppliers, partners and customers in the supply chain. Of all those surveyed, 40% describe it as business activities conducted using electronic mechanisms.

When companies in all six countries

were asked to say, spontaneously, what they consider to be the main benefits of e-business, surprisingly few said increase sales (21%), access to new market segments (17%), access to overseas markets (14%) and integration with suppliers (16%). The most widely mentioned were improving business efficiency and customer service (both 44%) access to larger customer base (33%), greater efficiency in the sales process, and more able to respond to customer demand (28%).

There were also fairly wide variances in what companies in different countries are currently using e-business for. For example, companies based in Sweden (81%), the US (76%) and the UK (72%) are more likely to be using e-business to conduct financial transactions than are their counterparts in Spain (62%), Germany (61%) and France (45%).

Up to One in Four Says Never Again to E-Commerce



Two new studies report that although online shopping reached record levels last year, so did frustration over the process.

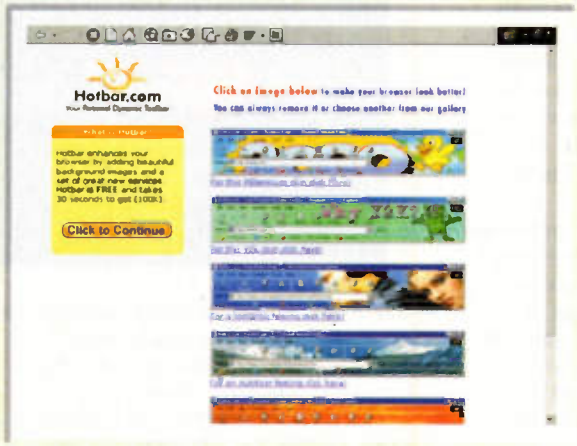
About 25% of would-be e-shoppers abandoned their transactions due to annoying delays and confusion in navigating the Web site, according to a report by Enamics at <www.enamics.com>, an information technology consultancy.

A separate survey by the Software and Information Industry Association at <www.siia.net> indicates that 10% of experienced online shoppers gave up for the same reasons.

Nobody Knows Your Identity on the Internet

Software company Zero-Knowledge Systems at <www.freedom.net> has developed software that will allow a person to use five different anonymous and untraceable identities on the Internet, preventing companies or agencies from using technology to track people's buying habits or other personal information.

Hotbar.com 'Skins' Makes Browsers Better Looking



Hotbar.com's plug-in, based on Microsoft's ActiveX open architecture programming technology, makes the browser more visually appealing and adds features not found on any other Internet browser. At the same time, it retains the familiar interface and standard functionality.

Hotbar.com's compact plug-in is available free of charge from the Hotbar.com Web site and is compatible with the Internet Explorer browser, used by more than half of Internet users worldwide. The company is actively developing a version that will be compatible with Netscape browsers.

Hotbar.com allows users to add 'skins' that quickly and easily customise the appearance of the Web browser. The skin is overlaid on top of the interface and does not affect normal operations.

More than 1,000 different colourful and artistic skins in a variety of categories are available, with more to be added to the site's Skin Gallery regularly at **<www.hotbar.com>**.

Ringing in the New Year with Greenwich Electronic Time

January 1, 2000 marked the debut of a new time standard that supporters hope will become the online equivalent of Greenwich Mean Time. Greenwich Electronic Time at **<www.get-time.org>** will offer ISPs and Internet users a new way to time-stamp electronic documents.

Companies involved in the deployment of GET clocks include the London Internet Exchange (LINX), a non-profit group of ISPs that share data centers in order to speed Internet traffic within the UK; Datum, which is supplying three atomic clocks that will deliver GET from Greenwich's zero meridian line; and Enron Communications, an energy and communications firm.

Madge.Web and RealNetworks to Launch Streaming Media Network in Europe

Madge.web at **<www.madge.com>** and RealNetworks at <www.realnetworks.com> have announced an agreement to build and operate Europe's first Internet broadcast network, bringing Europe in line with the US to enable high-quality Internet broadcasting around the globe.

Tapping into a streaming media market with more than 92 million registered users of the RealPlayer worldwide, Madge.web is constructing an Internet overlay network and broadcast operation facilities in Europe to offer similar services to the existing Real Broadcast Network (RBN) in the US.

The new network, to be known as the Madge Broadcast Network (MBN) powered by RealNetworks, is designed to serve European content providers as well as U.S. content providers wishing to distribute their streaming media in Europe.

iNEXTV.com Improves Internet Video

While everyone else is waiting for broadband, iNEXTV is focusing on enhancing video for the Internet now. iNEXTV at **<www.inexttv.com>** has announced the availability of online video that is significantly clearer, smoother and 50% larger than existing Internet video.

iNEXTV is the first to use this innovative technology for the Internet - delivering enhanced video to the more than 90% of online households with 56kbps connections or less, as well as those Internet users with higher speed access. Using industry standard player software from companies such as RealNetworks and Microsoft, users can access the much-improved video.

Later this month, the new technology will preview on iStyleTV.com, a new site on the iNEXTV network. iStyleTV will combine this superior imaging, the persuasive power of video and original Internet programming to target the lifestyles, passions and pursuits of affluent Web users. In the future, iNEXTV will also apply the new technology to its other sites.

Age of E-Trail Has Arrived

The Internet and changing customer demographics are radically altering the landscape of consumerism argues Alex Birch, co-author of a new book on electronic shopping The Age of E-Tail.

Among the authors' key contentions are that: Existing retailers must build presence on the Web which is complementary to their off-line presence in one of three ways: through context, dialogue or loyalty and service complementarity.

Few European retailers have yet grasped this challenge. The new age of E-Tail heralds the death of 'legacy' brands. Mass market built to order products for individual customers will become the norm- which will call for flexibility and re-localisation of supplier bases.

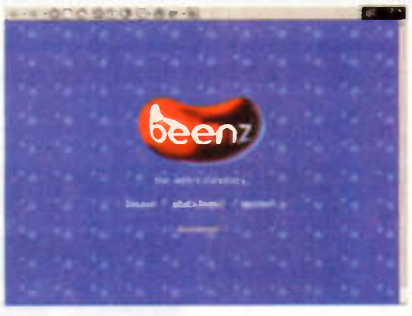
Beenz Gets Smart with Mondex

beenz.com at <www.beenz.com>, creator of the Web's currency beenz, and Mondex at <www.mondex.com> have announced a technical and marketing agreement to develop a smart card capable of carrying Mondex e-cash, beenz and complementary e-commerce services.

The agreement is intended to extend the market reach and strength of both companies through a process of technical integration, mutual marketing support and the creation of a suite of e-commerce services running on a single smart card. It is envisaged that the card will be used with PCs, wireless devices and Digital TV as well as in the high street.

A beenz counter smart card application is currently being developed by Mondex International and both parties are in detailed discussions with a range of technology and manufacturing partners to create the necessary devices and systems to support the new card.

In addition to technical development, the companies will begin recruiting merchants and service providers to enable real/virtual world use of the applications. For example, a consumer



with a beenz account could earn beenz in return for purchasing goods using Mondex e-cash and then spend those beenz at a high street shop.

Alternatively, Mondex card holders would be able to earn beenz at retail outlets by uploading them onto their cards and then spend them online with a participating Web merchant.

AOL to Offer Monster.com's Online Job Search Services

Monster.com at <www.monster.com>, the online job-search services, has become the exclusive provider of such services to AOL. Members and visitors will be able to search for jobs, do research on the companies offering, and submit formal applications. In turn, company recruiters will be able to post jobs, search through Monster.com's resumes, and screen and communicate with candidates.

Bookmarks for Life

Backflip at <www.backflip.com> provides a service that categorises your bookmarks and creates a personalised directory, making it easier to relocate obscure URLs from what can easily be hundreds of bookmarks. Users can then search all stored pages using keywords for fast retrieval.

BookBrain Set to Revolutionise Buying Books on the Web

BookBrain at <www.bookbrain.co.uk> is the most comprehensive and accurate way to search all major UK online bookshops for book price and availability information.

BookBrain contains a powerful search engine, which can identify a required book by title, author, publisher, ISBN or a combination of these.

To achieve this, BookBrain uses data from the acknowledged authoritative source Whitaker. This means that the price and availability search only returns information on the relevant book, which makes BookBrain the most accurate site in its field.

BookBrain identifies significant savings on books. For example, by comparing online bookshop prices you can currently save £10 on The Naked Chef by Jamie Oliver, £16 on The Dorling Kindersley World Atlas and £10 on The Oxford Companion to Food.

As well as price and availability information, the site also provides the Top Ten Online Bestsellers and will soon provide objective information including book reviews, forthcoming releases, and performance ratings of the online bookstores.

Internet Penetration in Europe Set to Double

A new survey published by Forrester at <www.forrester.com> predicts that the number of Internet users in France, Germany, the Netherlands, the UK and Sweden is set to almost double by 2003, with nearly 60 million people online.

By 2005, nearly 30% of those users will be accessing the Web at least part of the time via a non-PC device, such as a cell phone or a personal digital assistant (PDA).

Meanwhile, interactive TV will languish as a means for surfing the Web, primarily because of competing technical standards.

Hewitt Welcomes Guidelines to Protect Online Shoppers

Patricia Hewitt welcomed new guidelines agreed yesterday, which will help ensure that consumers shopping online will enjoy the same levels of transparency and protection that they get off-line.

The Guidelines on Consumer Protection in E-commerce were agreed between the twenty-nine members of the Organisation for Economic Co-operation and Development (OECD).

Stressing the need for co-operation between governments, businesses and consumers at a national and international level, the guidelines call for:

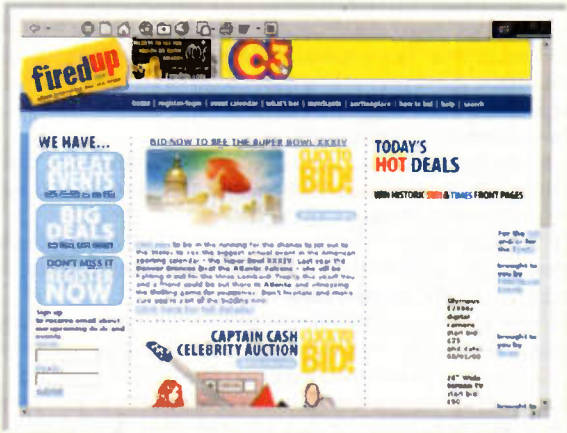
fair advertising and marketing practices.

- Clear information on sellers and their goods and services.
- clear and fair contract terms.
- secure payment mechanisms and privacy protection.
- fair access to redress.

E-Minister Patricia Hewitt said: "These guidelines will play a valuable role in eliminating some of the uncertainties that consumers and businesses face when shopping on the internet. They will boost confidence and encourage more people to do business online.

"The UK has already adopted a number of measures covered by the guidelines. We are currently developing the TrustUK scheme, announced in the Consumer White Paper earlier this year. This will give consumers the confidence to shop online and is a further step in the Government's aim in making the UK the best place in the world for e-commerce by 2002."

News Network Launches FiredUp.com



News Network, the Internet arm of News International, has launched FiredUp.com at <www.firedup.com>, an events and entertainment-driven auction site. Unlike other Web-based auction businesses, FiredUp.com will offer UK consumers access to real-time online auctions that focus on entertainment-related events and merchandise. Through the promotion of exclusive online events, FiredUp.com is designed to appeal to a broad range of UK consumers seeking to buy online.

Net2Phone Makes Long Distance Connection

Net2Phone has announced the international rollout of the latest version of its' Net2Phone software client with new features designed to make Net2Phone a more viable alternative to long distance communications.

Since it was previewed on the Net2Phone Web site at <www.net2phone.com> in beta format last month, more than 1,000,000 Internet telephony minutes have been routed using the new software. More than 500 resellers around the world will be offering Net2Phone v.10 to their customer base. Net2Phone v.10 software is free and can be downloaded from www.net2phone.com.

Net2Phone enables free PC-to-PC voice conversation over the Internet, via Net2Phone's proprietary IP telephony network. Along with the new PC-to-PC service, Net2Phone users can take advantage of Net2Phone's low global rates for PC-to-Phone service.

Those using Net2Phone's PC-to-PC service must designate a Net2Phone virtual number or nickname in order to be called by another PC. Future versions of Net2Phone will allow users to receive calls on your Net2Phone, via an actual telephone, to these phone numbers.

Ladbrokes Kicks-Off First Web Advertising Campaign

Ladbrokes.com based in Gibraltar, the tax-free betting arm of the 'bricks and mortar' bookmaker of the same name, has launched its first online advertising campaign incorporating innovative Web call-back technology from RealCall, the world's leading digital-to-human response company.

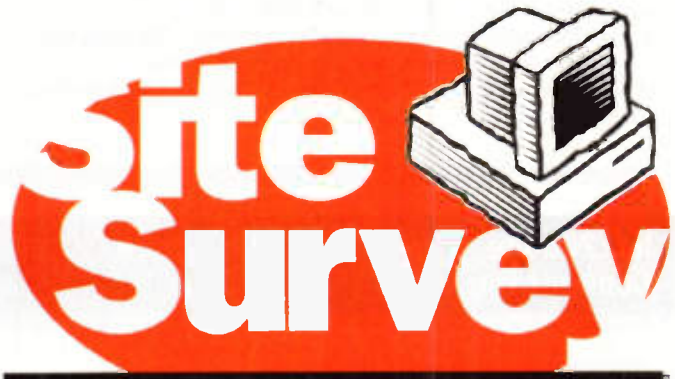
RealCall's Alert and Telebanner products will provide a free telephone link for potential Ladbrokes International customers to the company's Gibraltar call centre.

The RealCall service will also be incorporated into Ladbrokes International's online betting site set to be launched during the first quarter of 2000 at <www.ladbrokes.com>.

The new Internet betting site is set to offer the widest variety of regulated gaming services targeted at punters the world over. In the future Ladbrokes International plans to offer unique gambling opportunities during events - for example golf punters may have the opportunity to bet whether Tiger Woods will land his shot on the fairway or in the rough just before he makes the stroke.

RealCall's digital response services work by allowing an online customer to request a telephone call from a Web advertiser, or service, to find out more information, or complete a transaction over the phone. This is possible either through a Web callback button on a Web site, called RealCall Alert, or a callback button located on an online banner advert, called Telebanner. Ladbrokes International will be using both these products to promote its online service.

Ladbrokes International will be featuring RealCall's technology in a series of online banner adverts, and partnership deals appearing at key sites including service provider sites such as <www.freeserve.co.uk>, sports sites such as <www.skysports.co.uk> and media sites including <www.bun.com>, <www.telegraph.co.uk> and <www.pa.press.net>. The sites will offer a hotlink to the Ladbrokes current Web site, or a callback facility, at the time of the customers choosing from the Gibraltar call centre.



The months destinations

Destinations of the Month

If you want to know how much money you can save by switching from your current telephone supplier to another, take a look at: <http://www.phonebills.org.uk/>, where you'll find a means of finding out. Telephone companies have a habit of making things as difficult as possible for anyone to work out whether one service is cheaper than another, simply because the process is clouded in different call rates and terms. This site cuts through all the jargon and gives you a simple way to find out what any or all or your telephone suppliers can do for you. All you have to do is enter your postcode, and you'll find the various services that are offered. From there, you can generate a comparison of costs. It's rather clever.

MP3 is the current buzzword, of course. MP3 format audio files have become the standard method of storing and playing audio on personal computer, simply because they are so much smaller and easier to handle than CD audio files. More than this, files are so small in comparison with CD audio tracks (smaller than one tenth), that they have also become the norm when transmitting audio files over the Internet. Napster is a Windows-based utility that allows you to maintain your own archive of audio tracks and offer the archive for use by others. Checkout <http://www.napster.com/> for details. Mac users have a similar utility that's currently only in preview form (but is being regularly updated), called Macster, which is available from <http://www.blackholemedia.com/macster/pages/about.html>. From within Napster or Macster you can search for audio tracks by artist or track name, then download tracks significantly more easily than searching for them manually over the Internet.

Colouring THE WORLD

Douglas Clarkson looks at colour. This is becoming an important issue for all computer users.

Introduction

While colour has always been an important aspect of our visual heritage, it is only relatively recently that technology has made possible the absolute determination of this quantity. Also, just as technology has taken a lead role in the measurement of colour, so also the ability of individuals to design with and manipulate colour using computer systems is unparalleled. The elements of colour of display screen equipment, of colour printers and colour rendition of scanners is now not an issue of interest just for the professional graphics artist, it is a consideration for many millions of PC users.

While the aspects of colour theory are exceedingly complex a practical system of colour measurement has been developed which is intended to provide for an absolute determination of colour for a broad range of applications such as in the textile and printing industries. A key skill of modern manufacturing is often to maintain colour rendition of product within a narrow acceptable range of defined values.

There is also beginning to appear products which are designed to allow computer users to control elements of the colour quality of their various systems. This will become of increasing importance as more and more products are designed and presented using computer based products - and with colour rendition of designed product on hard copy.

This can make colour measurement into a specialist discipline, but an overview of the basic concepts related to standards and measurement systems will hopefully be of value in appreciating work undertaken previously and for identifying useful areas of future investigation.

Basics of Colour Measurement

A basic concept is that of spectral sensitivity of the human eye. This level, every colour can be considered to be made by visually matching a colour under standardised conditions against the three primary responses - red, green and blue. One of the first international standards to have been adopted, related to the measurement of colour as defined by Commission International de L'Eclairage (CIE) in 1931.

Based on three colour receptors in the retina, three separate response curves have been identified in accordance with the 1931 CIE standard observer referencing a 2° viewing angle. A 10° viewing angle, (Supplementary Standard Observer) was introduced in 1964 for viewing angles greater than 4°. For most work with the estimation of tooth whiteness, the 2° Standard Observer is appropriate. These two sets of colour matching functions are currently specified in reference (1) - see end.

Figure 1 depicts the three separate colour sensitivities of the corresponding retinal colour responses. The x( ), y( ) and z( ) components relate respectively to red, green and blue. These colour sensitivities are assumed to be active in ambient light levels when colour sensing is present. These responses are averaged responses and variations are expected to be present between individuals and with also changes in a given individual with age.

For a given spectrum of light falling on the retina, the relative fractions detected by the respective colour receptors are obtained by multiplying the input spectrum in turn by the specific colour sensitivity response. Thus in Figure 2, the spectral response A (a red apple), when multiplied by the separate colour responses yields an area under the curve proportional to the perceived colour component. Initially this gives X (red), Y (green) and Z (blue) tristimulus values. The values are in turn scaled so that the Y value provides the value of relative reflectance compared to an ideal reflecting diffuser.

The incident spectrum of 'white' light on the sample will significantly affect the values of X, Y and Z that are observed. This calls for standardisation in the light source that is used. In consideration of the many different conditions for colour measurements, a range of standard illumination conditions are available for measurement purposes.

The standard illuminant D65

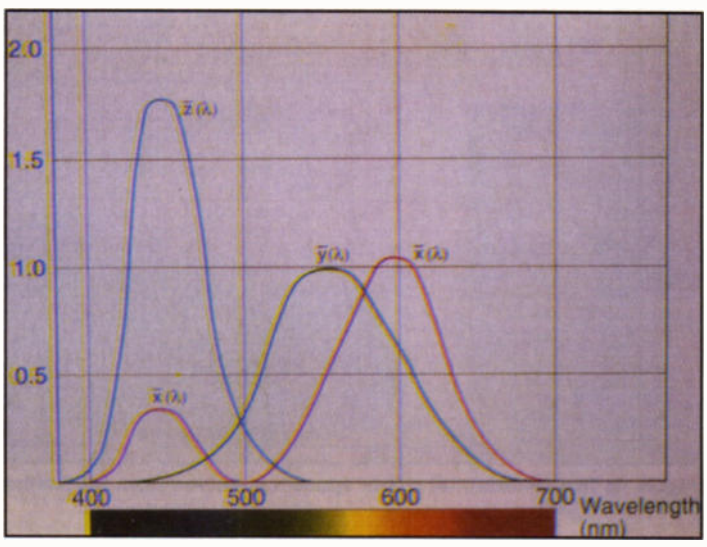


Figure 1: The three separate colour sensitivities of the corresponding retinal colour responses. The x( ), y( ) and z( ) components relate respectively to the red, green and blue. (Courtesy Minolta UK Ltd).

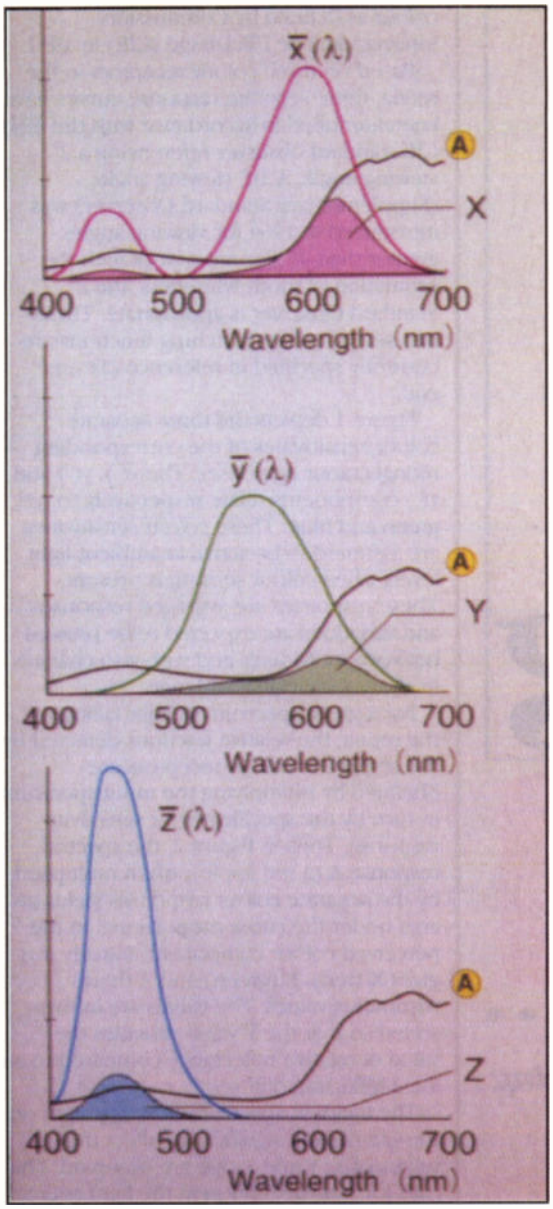


Figure 2: Derivation of tristimulus values X (red), Y (green) and Z (blue) from incident spectrum and standard colour responses. (Courtesy Minolta UK Ltd).

incorporates average daylight including ultraviolet radiation. The standard illuminant C equates to average daylight but without a significant ultraviolet contribution. The standard illuminant A equates to that of an incandescent light with a colour temperature of 2856 Kelvin, and should be used for specimens which will be illuminated by comparable incandescent lamps. Colour measurement equipment may utilise a specific standard illuminant and also be able to compute the equivalent colour measurement for other standard light sources. Measurements quoted in tooth whitening studies, however, are seldom referenced against the illuminant used. Standard definitions of D65 and standard illuminant A are also provided by the CIE [1].

Thus surfaces can be considered as manifesting a spectral reflectance graph and this is the measurement function that tends to be provided with current more sophisticated colour measuring instruments. Figure 3 indicates a set of spectral reflectance graphs for a range of coloured materials - D blue printing, E pink textile and F red paint. Graphs such as these are the starting point of any system of colour and brightness quantification. The process of metamerism relates to changes in perceived colour being associated with changes of illuminant.

Colour measurements were initially made based on representation of chromacitity in a two dimensional diagram, as indicated in Figure 4 where x, y, z chromaticity values are derived from:-

$$x = X/(X + Y + Z) \quad .....(1)$$

$$y = Y/(X + Y + Z) \quad .....(2)$$

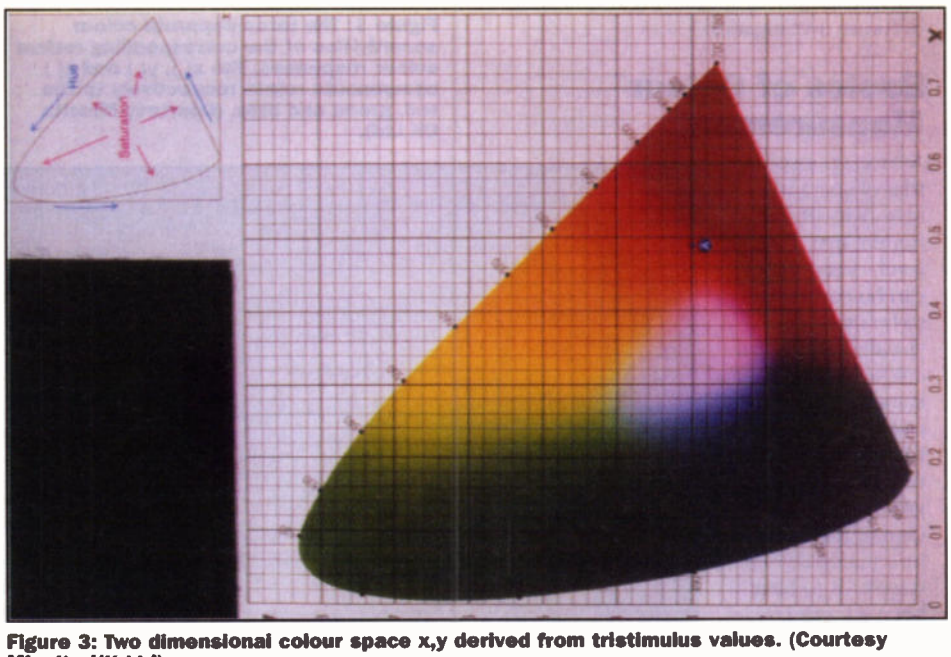


Figure 3: Two dimensional colour space x,y derived from tristimulus values. (Courtesy Minolta UK Ltd).

$$z = Z/(X + Y + Z) \quad .....(3)$$

However, it was felt that perception of colour changes using this system did not correlate well with perceived colour changes. The L*a*b* colour space, also known as the CIELAB space which was adopted around 1976 and has subsequently been reviewed [2], has become as the colour measurement system of choice for a broad range of commercial applications. A useful background to the historical development of these measurement systems is published by CIE(3).

While the L*a*b* colour space is often referenced, the actual derivation of these parameters based on tristimulus values is often not appreciated. It is useful, however, to be able to relate L*a*b* measurements to relative changes in X, Y and Z tristimulus contributions.

The L* value is given by :-

$$L^* = 116(Y/Yn)^{1/3} - 16 \quad ..... (4)$$

where Y is the fractional component of green sensitivity from the tristimulus value of the sample and Yn is the corresponding value of a perfect reflecting diffuser. Thus the blue and red (X,Z) responses are not referenced in calculating the L* value of a surface. Thus L* has a similar but not exact derivation relative to the Y tristimulus value as indicated in Table 1.

Presumably the L* factor is scaled in accordance with the reduced ability of the eye to detect brightness differences at high values of reflectance - indicating a logarithmic response.

The value of a* in the typical range of measurements is given by:-

$$a^* = 500[(X/Xn)^{1/3} - (Y/Yn)^{1/3}].....(5)$$

Similarly the value of b* in the typical range is given by:-

$$b^* = 500[(Y/Yn)^{1/3} - (Z/Zn)^{1/3}].....(6)$$

where X, Y and Z are the tristimulus values for the specimen and Xn,Yn and Zn are the corresponding values for the perfect reflecting diffuser. Thus the a* value can move between positive values of dominant X (red) to negative values of dominant Y (green). The b* term can change between positive values of dominant green to negative values of dominant Z (blue).

Figure 5 indicates the L*a*b* colour space. Three basic terms are used in association with colour descriptions. The hue relates to the defined colour around the periphery of the a*b* circle. The lightness of a colour increases with elevation. The saturation of a colour increases outward from the centre.

Knowing values of L*, a* and b*, it is possible to calculate specific values of (X,Xn), (Y/Yn) and (Z,Zn) where basic changes in tristimulus components are wished to be determined.

The colour difference dE*ab in this colour space, which describes the degree of colour difference but not its direction, is given by the equation :-

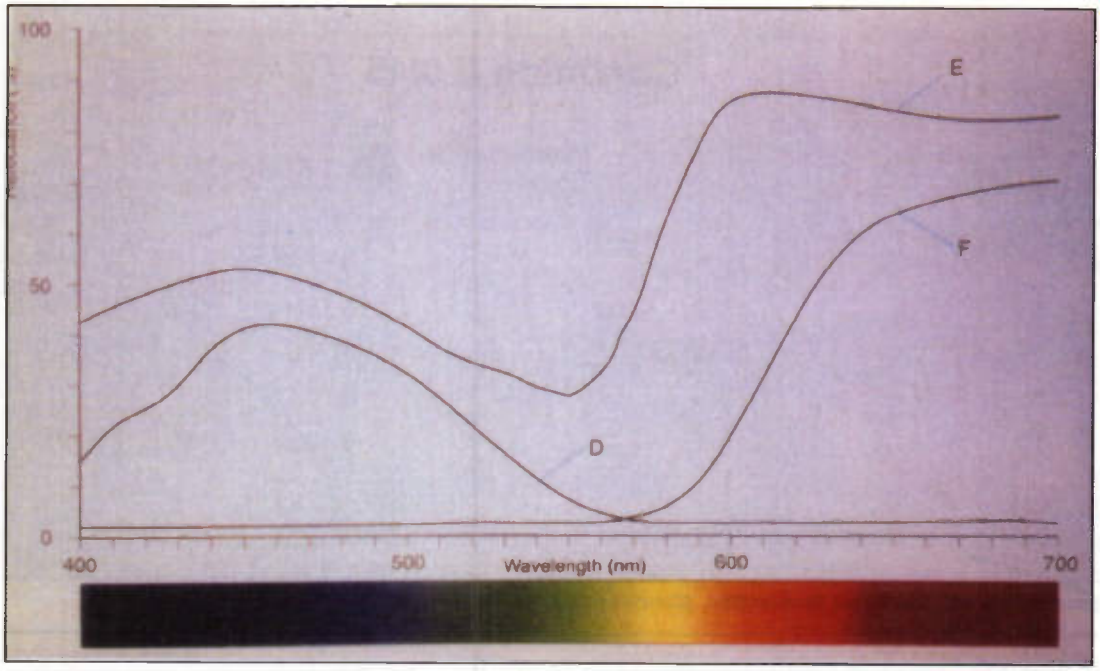


Figure 4: Set of spectral reflectance graphs for a range of coloured materials - D blue printing, E pink textile and F red paint. (Courtesy Minolta UK Ltd).

$$dE^*ab = [(dL^*)^2 + (da^*)^2 + (db^*)^2]^{0.5}$$

where dL*, da* and db* are the corresponding changes in L*, a* and b*.

But with the sophistication of modern instruments, the basic tristimulus component data can be expressed in a range of colour spaces including x,y,z, L*c*h*, Hunter Lab Colour Space, L*u*v* colour space and the CIE 1976 UCS diagram. Moreover, these values can also be expressed for a range of standard illuminants.

Geometry of Measurement

It is not generally appreciated that different geometries of illumination of surface and detection of reflected light exist within specific colour measuring instruments and that this will in turn influence the values of L*a*b* made. Up to six separate geometries of illumination exist for undertaking surface colour measurements. Problems certainly do occur when instruments are used which are not appropriate for the surfaces being measured. However, manufacturers of colour measuring equipment have clear views on appropriate instruments to use with specific measurement surfaces.

Standard geometries are indicated in Figure 6 for unidirectional illumination system. This is where light from a given direction is used as the illuminant. The 45/0 geometry indicates illumination at an angle of 45° and vertical detection of light and 0/45 geometry vertical illumination and 45° detection.

For systems of diffuse illumination, i.e. where the light is incident on the sample from all angles, the range of options are indicated in Figure 7. Two basic options apply - that of SCE (specular component excluded) and SCI (specular component included). This allows the option of reflected light within ±5° from the measurement geometry to be excluded or included.

High gloss surfaces may give lower values of L* compared with unidirectional illumination since the portion of 45° light is 'lost' to the illumination system - i.e. not available for scattering at 0° geometry. If this is driven to its logical conclusion, i.e. a mirror surface, the L* value at 45/0 illumination will fall to very low values.

It is therefore important to use the correct type of illumination for the surface being measured.

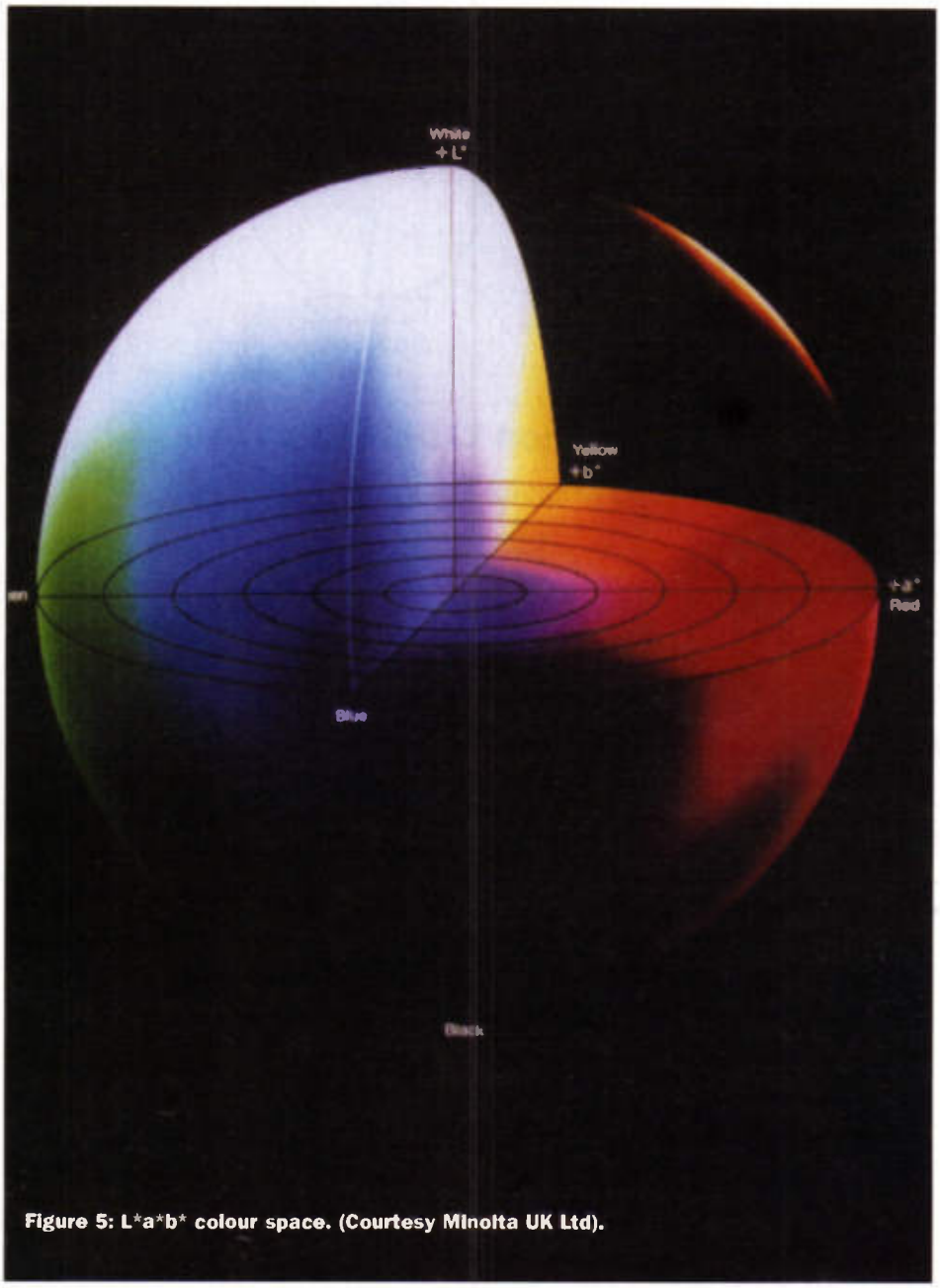


Figure 5: L*a*b* colour space. (Courtesy Minolta UK Ltd).

Current Technology

Modern spectoradiometers provide information about the reflective properties of surfaces, eg using solid state diode array assemblies where each element is associated with a specific wavelength gap in the range 380nm to 730nm and with a physical

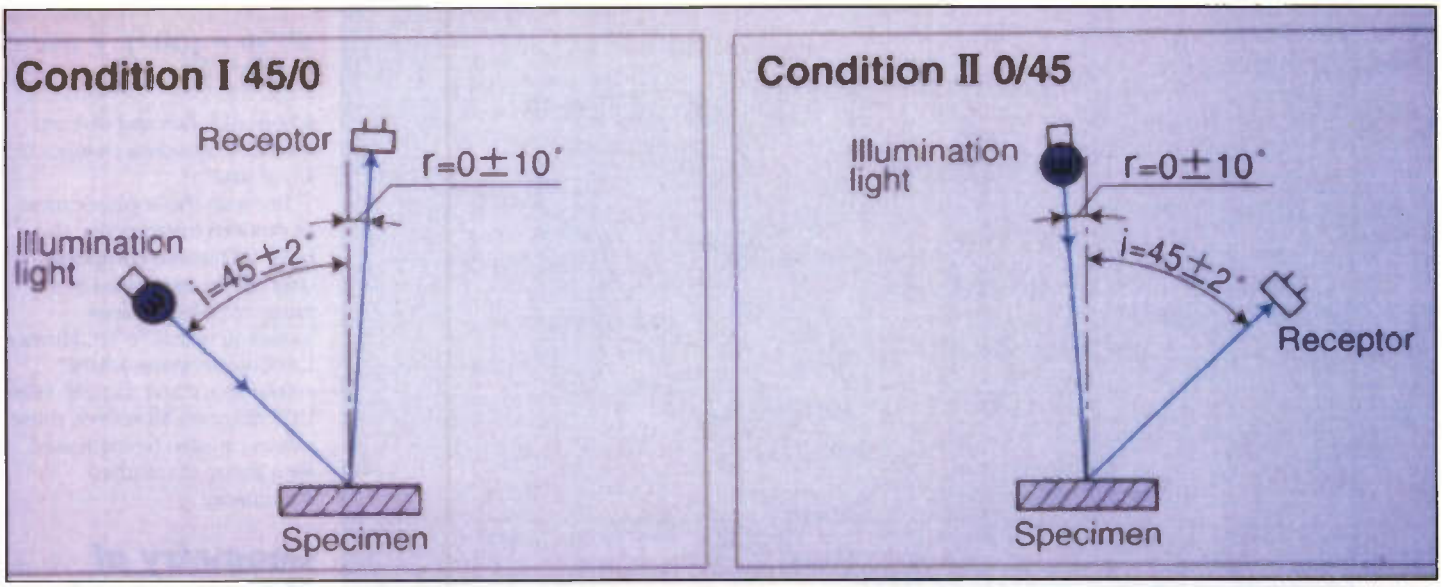


Figure 6: Summary of standard geometries: unidirectional illumination. (Courtesy Minolta UK Ltd).

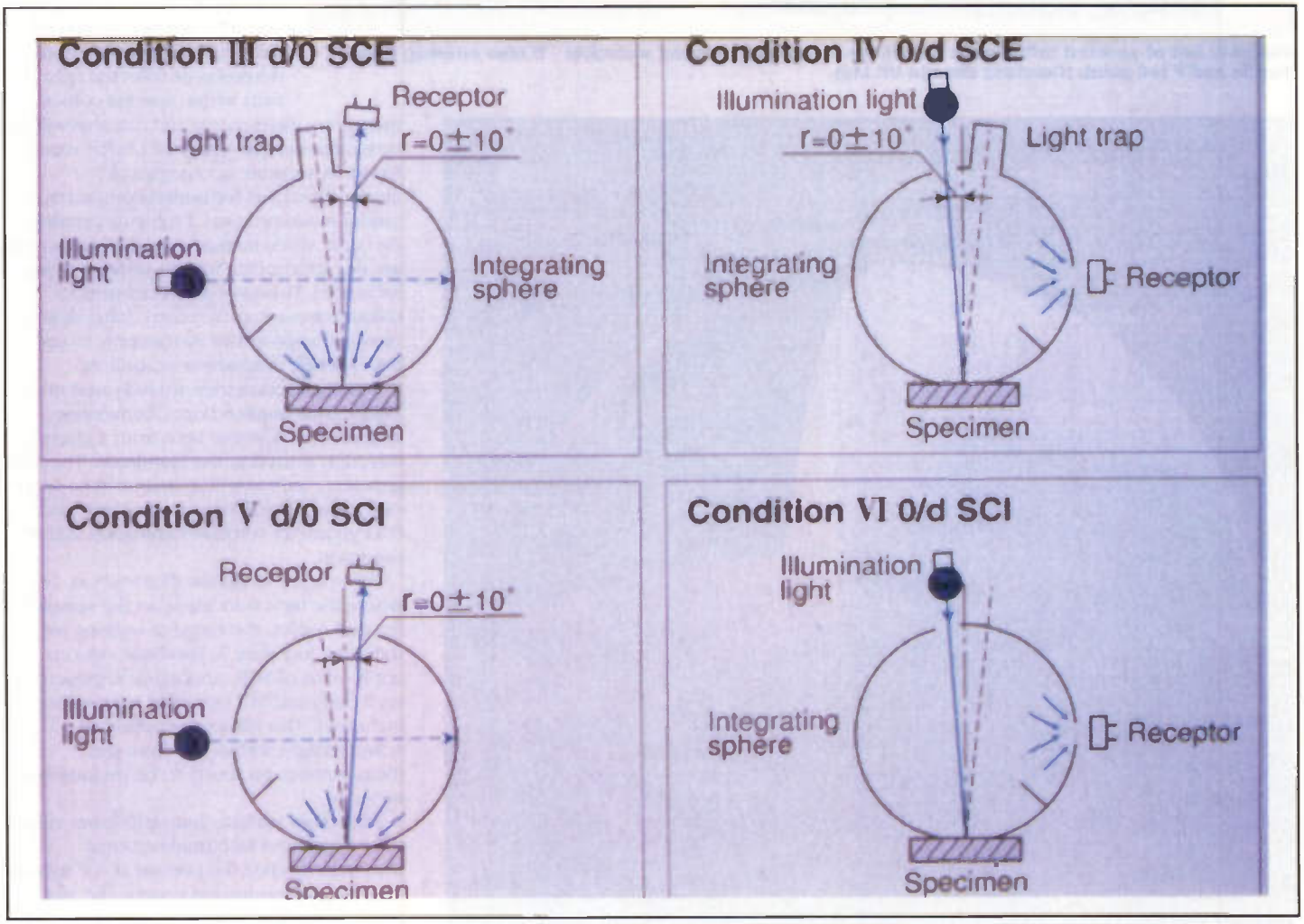


Figure 7: Summary of geometries: diffuse reflection. (Courtesy Minolta UK Ltd).

wavelength gap of 10nm. This implies that an array of standard measurement heads with a minimum array of 36 discrete detectors is used. While previous designs of systems would utilise rotating filter wheels, current products tend to have no moving parts, and in fact split light using high quality holographic diffraction gratings. Also, xenon flash lamps are increasingly being utilised to give high intensity light levels to cope with dark and poorly reflecting surfaces.

Colour Perception Changes

Changes in colour vision can occur for a number of reasons. Caffeine will reduce blue sensitivity and enhance red sensitivity. Adrenaline enhances green sensitivity and reduces red sensitivity. Tobacco can cause red-green defects but mainly affects the red, plus both effects being possibly permament. In terms of chemical agents, carbon monoxide can cause transient colour vision changes and ethyl alcohol can produce red-green and blue-yellow changes which can both be permanent.

Making Colour Today

While the measurement of colour relates primarily to the determination of tristimulus components of effectively red, green and blue, the majority of commercial printing (and PC printers) utilises subtractive colour of yellow (blue absorbing), cyan (red

absorbing- appears light blue) and magenta (green absorbing - appears red).

While the description of colour relates to the determination of tristimulus components of effectively red, green and blue responses, the majority of printing utilises subtractive colour. Considerable confusion is caused by describing cyan as 'blue' and magenta as 'red' since these are not the same as the 'pure' tristimulus colour. The characteristic of subtractive colours are indicated in Table 1.

Subtractive Colour	RED	GREEN	BLUE
yellow	Y	Y	N
cyan	N	Y	Y
magenta	Y	N	Y

Table 1: Summary of subtractive colour characteristics: Y = present, N = not present

We obtain 'pure' colours red, green and blue by adding two components of appropriate subtractive colour. For red we have to add yellow and magenta, for green yellow and cyan and for blue cyan and magenta. In theory if all are added together then black will be achieved.

In practice, it is simpler to use a specific black ink.

Conclusion

From various directions our world is becoming increasingly visual and as part of this colour perception and absolute measurement of colour will become increasingly important. The summary presented presents the core of current concepts in colour measurement in relation to L*a*b* values.

Points of Contact

http://www.umist.ac.uk/UMIST_OVS/UES/UES_CB1.HTM Contains demonstration colour vision test to detect colour vision abnormalities.

CIE Publication Search
http://www.hike.te.chiba-u.ac.jp/cgi-bin/cieS

CIBSE, Delta House, 222 Balham High Road, London, SW12 9BS.
Tel: 0181 675 5221 Fax: 0181 675 5449
(contact for list of current CIE publications)

COLORVISON (computer based colour matching products)
http://www.colorpartnership.com/new/index_.html

Further Reading

1 ISO/CIE 10526: Colorimetric illuminants: (includes definition of CIE 1931 Standard Colorimetric Observer and CIE 1964 Supplementary Colorimetric Observer and standard illuminants D65 and A)
2 CIE 116-1995, Industrial Colour-difference evaluation, ISBN 3 900 734 60 7 (Extension of CIE 1976 (L*a*b*))
3 Proceedings of the CIE Symposium '93 on Advanced Colorimetry., Publication CIEx007-1993, ISBN 3 900 734 45 3
4 Precise Colour Communication, Milolta, 1998.

Diary Dates

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

March 2000

6 to 9 March. Electrex 2000 - International Electrotechnical Exhibition, NEC Birmingham. Tel: (01483) 222 888.

9 to 10 March. Softworld in Accounting & Finance, Olympia, London. Tel: (0181) 541 5040.

14 to 16 March. Service Management Europe, NEC Birmingham. Tel: (0208) 232 1600.

29 to 30 March. Softworld Supply Chain, NEC Birmingham. Tel: (0208) 541 5040

April 2000

30 March to 1 April. Apple Expo - Apple Platform Show, Olympia, London. Tel: (0117) 904 9388.

4 to 5 April. Electronic Design Solutions, NEC Birmingham. Tel: (0181) 910 7934.

4 to 6 April. NEPCON - Electronics & Semiconductors, NEC Birmingham. Tel: (0208) 910 7910.

10 to 13 April. Automation & Robotics. NEC Birmingham. Tel: (01737) 768 611.

10 to 14 April. Engineering Lasers, NEC Birmingham. Tel: (01737) 768 611.

11 to 13 April. Infosecurity - Info Security & Network Management, Olympia, London. Tel: (0208) 910 7910.

18 to 19 April. Government Computing Conference & Exhibition, Business Design Centre, London. Tel: (0207) 608 0900.

18 to 20 April. WebCom 2000 - Corporate Intranet Technology, Olympia, London. Tel: (0208) 742 2828.

28 to 30 April. PC@Home+Internet 4All, Earls Court, London. Tel: (01895) 630 288.

May 2000

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

23 to 25 May. Internet World Conference and Exhibition, Earls Court, London. Tel: (0208) 232 1600.

June 2000

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

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

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

September 2000

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

October 2000

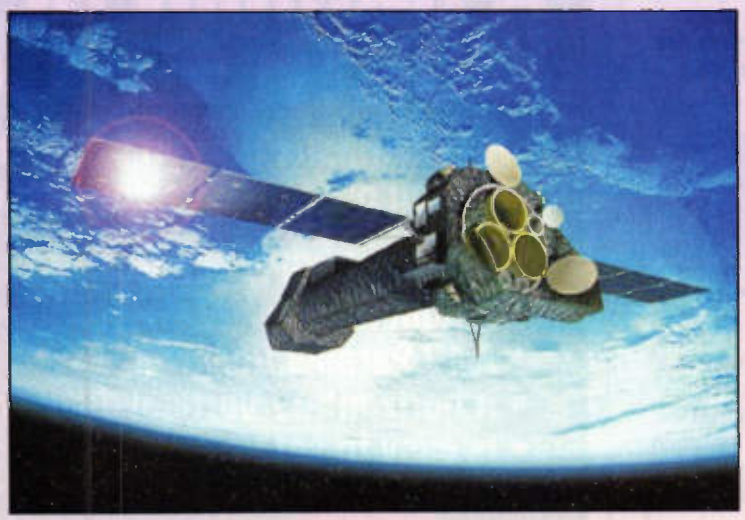
3 to 5 Oct. Coil Winding 2000, NEC Birmingham. Tel: (0207) 417 7400.

November 2000

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

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

What's On?



Satellite Launch Shows UK Science at its Best

The last European satellite launch of this Millennium could not have been made without crucial contributions from UK scientists, Science Minister Lord Sainsbury said.

"Once again, the UK has played a leading role in a European project, which is of great scientific importance," he said.

XMM is the largest X-ray space telescope ever built. It will be the most powerful telescope in the world and will detect millions of X-ray stars, even peering close into black holes.

Lord Sainsbury, who is also the current chairman of the European Space Agency (ESA), was speaking from the European Space Operations Centre (ESOC) on the day of the launch of the XMM satellite from Kourou in French Guiana.

He added, "This is a pan-European venture with instruments conceived and built by a number of scientific institutes from across Europe. Teams working on two of the three instruments have been led by British experts and UK industry has proved its ability and innovation, meeting the technical challenges offered by this important project.

"The XMM is an excellent example of what can result when European knowledge, people and resources are pooled together. The result is a flagship for European space science.

The UK's collaboration in the XMM (X-Ray Multi-Mirror) mission has been guided by the Particle Physics and Astronomy Research Council (PPARC), which is the UK's strategic science investment agency.

PPARC has contributed £76 million to XMM, mostly over the project's six-year construction period. The total cost to ESA and other European countries will be about £500 million to the end of its life - between two and 10 years.

XMM is five times more sensitive than NASA's Chandra X-ray satellite and was built at one third of the cost. It will be controlled from ESOC, which recently achieved the quality standard ISO 9001.

"XMM will bring exciting information back to us, measuring and recording the hottest and fastest moving objects in the Universe, including exploding stars and black holes," said Lord Sainsbury.

"It will also allow us to see the most distant objects in the Universe and look further back in time than has ever been possible until now.

"Space science of this calibre amply justifies our commitment to this field of research and our priorities for space developing technologies to exploit new commercial markets and to excel in science."

For further details, check: <www.dti.gov.uk>.

Contact: Department of Trade and Industry, Tel: (0171) 215 5000.

ISPCON Europe 2000

As major changes in the ISP market alter the face of the industry, and European ISPs look to compete in the global market, ISPCON Europe 2000 is set to be a key aggregation point for the European ISP community to debate the issues and address the challenges that the industry faces in the next millennium.

With the number of Internet users rapidly increasing (there were 47.15 million online in Europe in September 1999), and Internet technologies like WAP and VoIP, gaining prominence, the demands placed on ISPs are becoming more and more complex.

"This is a critical time for ISPs," says Dr Philip Lakelin, Senior Analyst, Analysys, and a speaker at ISPCON Europe 2000. "The Western European market is in the thick of a major change due to telecom liberalisation and the advance of broadband access technologies. The economics of

business are also causing transformations.

Pricing changes and free ISPs are provoking a huge move in the market, and increasingly European ISPs are having to find new ways to make money - many of them are feeling their way in the dark," he concludes.

The education agenda at ISPCON Europe 2000, gives delegates the opportunity to harness business critical knowledge to address these challenges and gain vital competitive advantage. In a market where only the fastest, fittest and most flexible will survive, a comprehensive combination of keynote speeches and Business and Technology streams will give practical advice as well as provide vital insight into the European ISP industry of the future.

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

Contact: ISPCON Europe, Tel: (0870) 7511 505.

Science Minister Announces Funding for Small Satellites

A £15 million investment in the UK small satellite sector has been announced by Science Minister Lord Sainsbury.

The funding is intended to help transfer the UK's world-leading capability in small satellites from the academic into the scientific and commercial markets.

Lord Sainsbury said, "I hope this initiative will stimulate industry to invest in small satellite missions, particularly for satellite communications, the largest and most rapidly expanding market for space products.

He also announced that research into microgravity and astrobiology is to get a £1.4 million boost from UK Government.

Welcoming a report from a panel of experts, seeking to establish astrobiology as a new science for the millennium, Lord Sainsbury announced that the UK is to invest in the research opportunities offered by the European Space Agency's EMIR-2 programme.

He said, "EMIR-2 will offer our scientists experimental and research opportunities in astrobiology and microgravity"

"UK teams will be able to lead challenging research designed to improve our development and preparation of important new drugs, smart fluids and high performance sensors".

Their initial results will allow us to evaluate the relevance of the International Space Station to achieving UK priority. We will accelerate our involvement in a new science that will exploit our lead role in the Mars Lander, Beagle 2".

Lord Sainsbury went on to say that the UK would not enter ESA's Future Launch Technology Programme (FLTP), preferring instead to press ahead with more immediate national measures in partnership with UK firms that are already having success exporting to European and International builders of launch vehicles. He confirmed that the National Space Technology programme would be extended to provide specific opportunities to support innovative ideas at the equipment and component level, rather than at the vehicle level.

"My decision supports the priorities set out in the UK Space Strategy published in August", the Minister said. "The Strategy confirmed major investments in space science, remote sensing, satellite communications, technology and navigation."

"We gave relatively low priority to launch vehicles. After careful consideration, I have decided that the high costs of FLTP in the longer term would have an unacceptable effect on other, higher priorities. To enter Phase 1 and then to withdraw later on would have confused our partners in ESA and those firms seeking a consistent approach from Government in the high priority sectors".

For further details, check: <www.dti.gov.uk>.

Contact: Department of Trade and Industry, Tel: (0171) 215 5000.

Software Quick Review

Dance e-jay
Hip Hop ejay
Rave ejay

£9.99 each

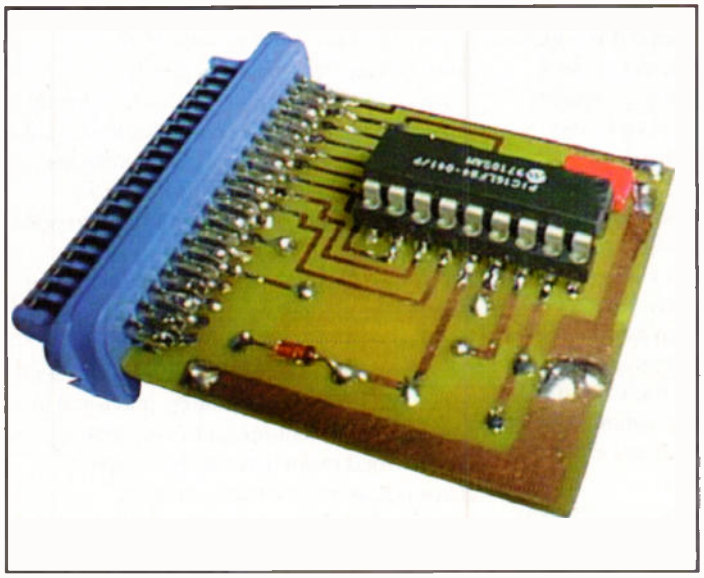
from Focus Multimedia

These are mean pieces of software and for the price of a tenner you cannot go wrong. These have just got to be the quickest fixes for dance and party music ever. With full 8 track arrangement and stereophonic effects you can pick your voice samples, base line, melody, percussion and effects on a drag and drop basis from over 1000 samples on each disc. The simplicity is breathtaking for even young kids can get to operate it in seconds and put together these samples. Autosynchrony means you can never be out with your timing and each sample is quantised and can be joined seamlessly. The sound quality of the samples are excellent. If you get fed up with all the sounds on the disc you can import your own .wav files or go on to the internet to down load some more. Store your creations on hard drive or record straight to tape or CD and party the night away! OK, you are limited to a fixed tempo, but for the sake of a tenner for each music type, you really cannot go wrong. As it says on the front: **Warning: Seriously Addictive** - they certainly are!

Available from selected Maplin Stores along with the full range of Focus Multimedia.

Maplin order codes are:

Dance TH48 Rave TH49 Hip Hop TH50



Printer Head TESTER PROJECT

Richard Grodzik describes a simple tester for bubble and ink jet printers.

Introduction

All printers have a built in print test which is activated by pressing a hot button on switch-on. These tests usually print a 'swirl' test of alpha-numerics. Printers for PC's evolved from the humble 9- pin dot-matrix, which have a printing head consisting of nine fine needles which impinge against an inked ribbon. As greater resolution, print quality and graphics symbols were needed, the 24-pin printer evolved. Today, most bubble jet and ink jet printers contain 24 fine nozzles and accept the same codes for printing. Sometimes one or more pins fail to fire and this can easily be missed in a graphics picture. In large office 24-pin dot matrix printers, the print head(s) can cost hundreds of pounds. This tester individual 'fires' the pins or nozzles in turn and any problem can easily be identified. Note that this tester will not work on Laser printers which use an entirely different technology.

Codes

The ASCII character code is probably understood by most readers, but lets just re-cap. Letters and numbers in the English language are represented by 8-bit logic codes whether they are printed on the computer screen, printed on a printer or sent via an RS232 communication link. For example, the letter 'A' upper case is represented by the bit pattern 01000001b (41H), lower case 'a' by 01100001b (61H).The letter 'B' by 01000010b (42H) etc. When graphics are required, special codes preceded by 'escape' (1BH) are sent to the printer so that each individual dot on the print head can be turned on or off. A table showing some of these codes is given below:

1B	1A			RESET THE PRINTER
1B	4F			BOLD
1B	25	00	00	SELECT STANDARD CHARACTER SET
1B	54			CANCEL SUPERSCRIPT
1B	21	00		SELECT MULTIPLE PRINT MODE
1B	2D	C0	12	CANCEL UNDERLINE
1B	57	00		CANCEL DOUBLE WIDTH
1B	30			SET LINE SPACE 1/8"
1B	72	00		PRINT COLOR BLACK
1B	32			START VARIABLE LINE SPACE
1B	43	46	0D	FORM LENGTH IN LINES
1B	4A	48	1	DOT LINE FEED
1B	2A	27	LSB	MSB (BYTE1 BYTE2 BYTE2)

This last code is the secret to printing graphics.

For example:
1B 2A 27 01 00 80 55 01

will print the following dots

	MSB	1 .
	0	
	0	
	0	
BYTE	1	0
	0	
	0	
	LSB	0
	MSB	0
	1	.
	0	
	1	.
	0	
BYTE	2	1
.		
	0	
	LSB	1 .
	MSB	0
	0	
	0	
	0	
BYTE	3	0
	0	
	0	
	LSB	1

Codes 1B 2A 27 signal the printer electronics to enter the graphics mode. The next two byte 01 00 specify the number of columns of dots to print. In this example 1. The last three bytes 80 55 01 specify which dots in the 24 positions are fired. To print a large graphics image the code would be something like this:

1B 2A 27 0A 00
byte1 byte2 byte3 byte1 byte2
byte3 byte1 byte2 byte3
byte1 byte2 byte3 byte1 byte2
byte3 byte1 byte2 byte3 byte1
byte2 byte3
byte1 byte2 byte3 byte1 byte2
byte3 byte1 byte2 byte3

total of 35 bytes.

The print head would move 10 print positions or approximately 2mm across the paper. So it can be seen that graphics demand a very high amount of code. In addition to the escape codes there are 'control' codes which give instructions to the printer's carriage and platen motors:

07 BELL
08 BACKSPACE
09 HORIZONTAL TAB
0A LINEFEED
0B VERTICAL TAB
0C FORM FEED
0D CARRIAGE RETURN
11 SELECT PRINTER
18 CANCEL LINE BUFFER
20 SPACE

Description

The circuit diagram is shown in Figure 1, and uses very few components, but does require a double-sided PCB. The tester uses conventional acknowledge/strobe handshaking, and since this is universal, it will work with 99% of printers which have a Centronics (parallel) interface. Power is derived from pin 31 of the printer - an input pin! However, this has an internal pull-up and is thus able to supply a few milliamps at 5V, which is sufficient for the PIC16F84 to operate. The 8-bits generated by the PIC are fed from port line RB0 - RB7 to the Centronics plug (pins 2 - 9). An online facility is provided to stop the printer at any time without loosing any code.

Construction

It is preferable to use a double-sided board with the PIC mounted on the component side. If using a socket ensure that it is a turned-pin type since the socket pins act as 'plate-thru's' and need to be soldered on both sides of the board. The complete board is simply inserted between the two rows of pins of the Centronics plug and soldered in place.

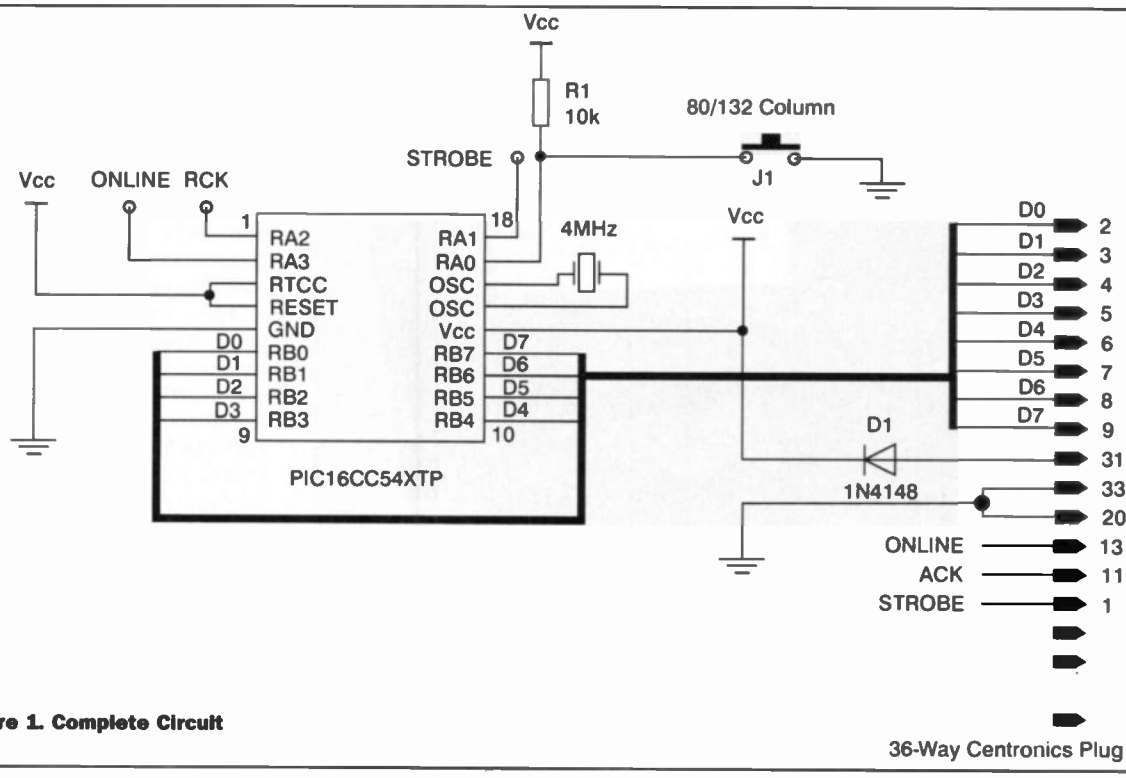
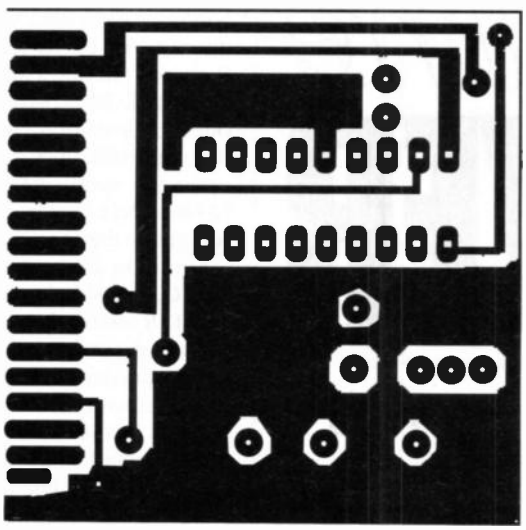
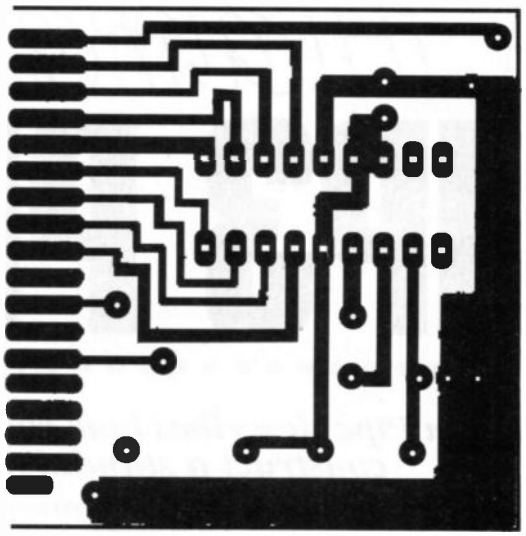


Figure 1. Complete Circuit



PCB Track layout bottomside



PCB Track layout topside

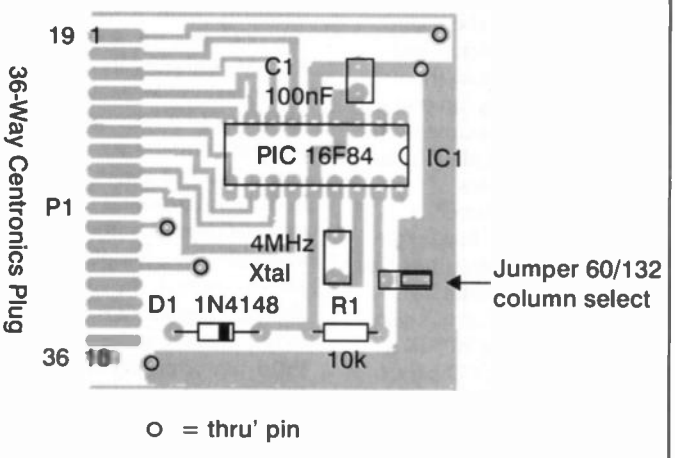


Figure 2. Complete overlay

Operation

Connect the tester into the printer in place of the cable, ensuring that paper is in position, and then switch on. Each individual pin will now be tested in turn, and finally, all pins will be fired at once to produce a vertical line.

Note that a pre-progammed PIC is available from R. Grodzik (MICROS) 53 Chelmsford Rd, Bradford West Yorkshire BD3 8QN. Price £12.00 p&p included.

Also visit the author's web-site at:
http://members.netscapeonline.co.uk/dickgrodzikemail
dickgrodzik@netscapeonline.co.uk.

PARTS LIST

RESISTORS:

R1	10k

CAPACITORS

C1	10nF

SEMICONDUCTORS

IC1	PIC16F84	See Note.
D1	1N4148	

MISCELLANEOUS

4MHz Xtal
Centronics Plug
Jumper 0.1"

PROJECT

A Hardware MP3 PLAYER

Martin Pipe describes how you can use an 'old' PC to construct a standalone MP3 player.

The Theory

The MP3 file format, which compresses audio to around a tenth of the original size without any obvious loss in sound quality, is now publicly well-known. It's possible to download music tracks from the Internet - legitimately or otherwise. Computer fair traders quite openly sell illegal MP3 compilations of music - thanks to the efficiency of the format, one disc may be spacious enough to accommodate the complete repertoire of a band! Other discs contain hitherto rare bootlegs and concert recordings, and these discs are prized by fans who might already have all of that artist's albums on CD. It's quite ironic that one of the applications of MP3 technology is bootlegging the bootleggers!

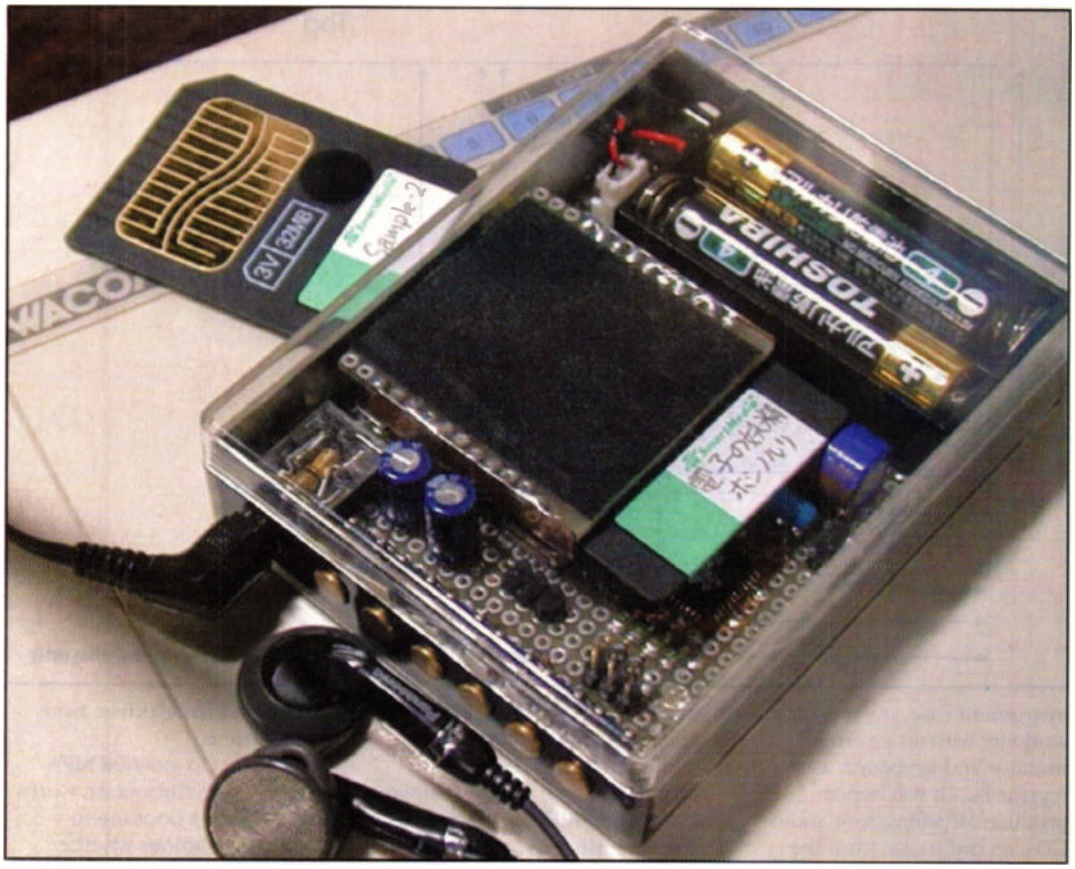
You can also convert your own CD tracks to WAV files using 'ripper' software (some CD-ROM drives, including my own Plextor Ultraplex 40x SCSI, are supplied with 'digital audio extraction' software) and use a MP3 compression program to turn the WAV files into much smaller MP3 files. But what do you do with the songs once they're on your PC? An obvious option is to transfer them into the one of the personal audio players that are proliferating at the moment. These devices, the most famous of which is the Diamond Rio, make excellent companions for joggers and commuters. Unfortunately, they have a very restricted memory - typically 32 or 64Mb - that will only accommodate a relatively small number of 'CD-quality' (i.e. 128kbps) tracks. When you tire of the music, you have to wait for the new tracks to transfer from your PC - this is hardly as convenient as changing a disc or tape!

What's more, the issue of MP3 playback in the home or car hasn't really been addressed yet. Wiring personal players to an existing sound system isn't really practical, owing to the restricted playback times and hassles involved when changing music. In any case, the sound quality is fairly restricted and output levels fairly low (how much voltage swing can you get when your power source is only 1.5 volts in the first place?). As somebody who writes frequently on consumer electronics issues, I have often suggested to manufacturers that a 'killer' product would be a personal CD player that is also capable of handling MP3 files. In 'MP3 mode', the CD player would act as a CD-ROM drive, and an enhanced user interface would provide for the selection of tracks and playlist files from the various directories on the disc. The bitstreams of the selected tracks would be decoded by a DSP chip running MP3 decoding algorithms. These would then be passed to the same 16-bit DAC that's provided for ordinary CD playback. Note that CD burners, which are now cheap, allow you to produce your own MP3 compilation discs. If you don't have a CD burner, then no problem. Our ideal personal CD player would also have a memory slot compatible with the SmartMedia cards found on the current generation of personal MP3 players, and a USB or parallel-port interface for the transfer of MP3 files from a PC.

One mainstream consumer electronics manufacturer is looking quite seriously at such a product, which would have line-level outputs compatible with home or car audio systems. On which subject, certain movers and shakers in the car audio industry are reputed to be taking MP3-compatible hardware seriously. Out of interest, one Far-Eastern source is already offering a MP3-compatible DVD player. It has one significant drawback, though. Unfortunately, the optics are incompatible with CD-R discs, which have a lower reflectivity than mass-produced 'silver' CDs. The vast majority of MP3 CDs tend to be produced on CD-R media - MP3 disc producers tend to be clandestine back-street operations with a bank of CD burners. These individuals simply cannot afford commercial CD duplication, which is only economical if you want the same dubious disc replicated in its thousands. For this reason, there are very few, if any, MP3 collections supplied on silver CDs. One was supplied with the DVD player in question - sadly, it was the only way of testing the MP3 playback feature. Rumours abound of a self-contained MP3 CD-ROM player for hi-fi systems, although one has yet to surface in the UK. This unit, the M3PO from German sound card manufacturer Terratec, resembles an audiophile CD player - indeed, the unit will also play regular CDs. According to the Terratec web site (http://www.terratec.net/ttuk/default.htm), the remote-controllable M3PO will sell for £349, and can be upgraded with an IDE hard disk for storing music tracks internally. Further details on this exciting

development can be found at http://www.m3po.de/_eng/index_eng.html. Perhaps fittingly, the MP3 format was itself a German innovation. Find out yourself by visiting the home page of the Fraunhofer Institute (www.iis.flhg.de).

Presently, the only other way of enjoying MP3 files is to hook up your PC soundcard's line outputs to your hi-fi system. Many MP3 playback applications for the PC exist - one of the most popular examples is the freely-downloadable Winamp (available from www.winamp.com). The PC approach does have some major benefits. It can play a collection of music stored on the hard disk. The average PC hard disk, with its multi-gigabyte capacity, is capable of storing hundreds of MP3 songs. If high phone bills are of no consequence to you, such music could be obtained from the Internet. For most of us, though, much of the music would be sourced from an existing CD collection. You could store all your favourite music on your PC, and then place the original space-hogging CDs into storage of another kind! PCs will, of course, also play MP3 files stored on CD-ROMs. Provided, of course, that they have a CD-ROM drive - but how many modern PCs aren't equipped with such hardware? The sound quality can also be rather good, particularly if your



A Japanese electronics enthusiast, working under the name of 'Eim', has built his own personal MP3 player, rather than buying a ready-built one. It's good to see that the hobbyist element still thrives in this era of cheap mass-produced consumer electronics!

PC soundcard has a SP/DIF digital output - and you have a DAC to feed it with! Fortunately, most MiniDisc decks can be converted into a DAC by selecting the relevant digital input, and switching to 'record' when no disc is present.

A Practical Solution

Unfortunately, the conventional PC approach isn't the most practical one - not least because the PC seldom sits in the same room as audio equipment. I instead advocate an unconventional approach - basically, a custom-built PC that can be installed alongside your existing hi-fi system. The machine to be described in the remainder of this is built into a 4U (168mm high) 19-inch

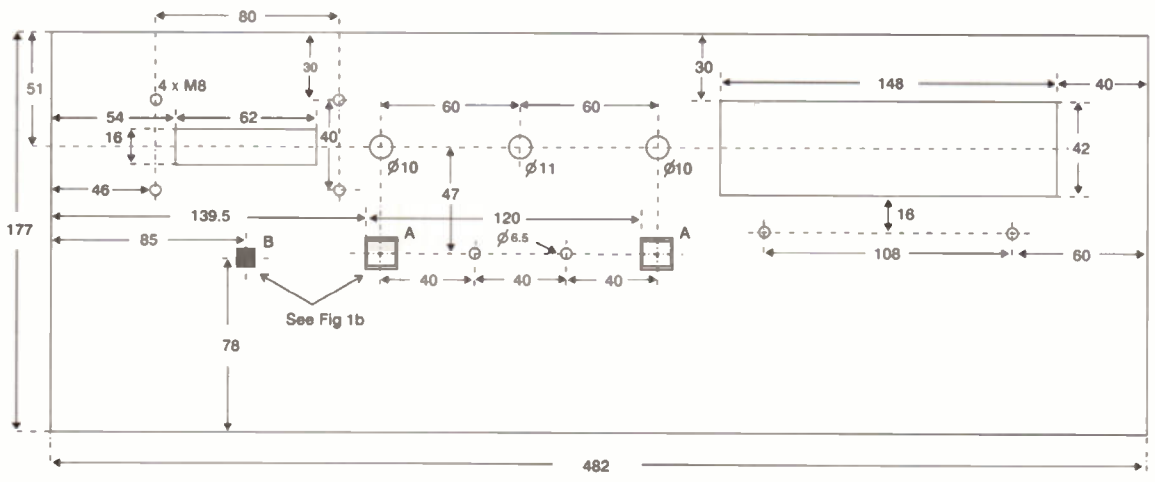


Figure 1a

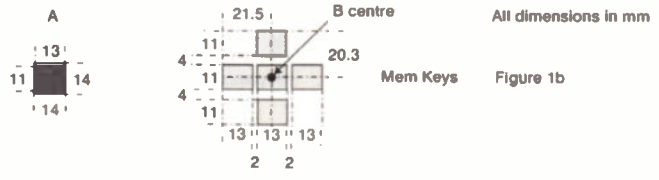


Figure 1a. Front panel cut-out details

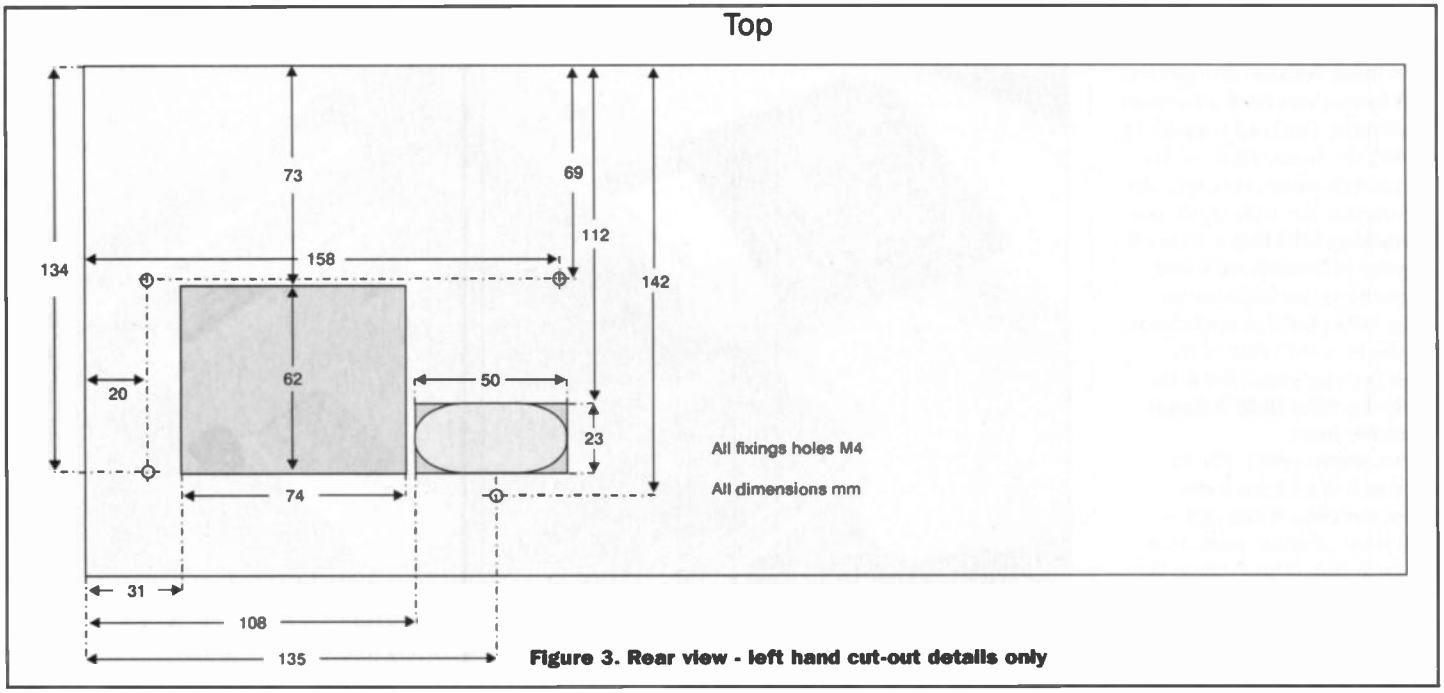


Figure 3. Rear view - left hand cut-out details only

instrument case. It's capable of working, with an external monitor and keyboard, as a regular PC - it will hence produce MP3 files from audio CDs, record music from the soundcard's line input to the hard disk as an MP2 (if using Iomega's fantastic RecordIt program, which is freely downloadable from www.iomega.com) or a previously-captured WAV file. Indeed, it will do any of the tasks usually associated with PCs. It is, for example, capable of playing back regular audio CDs as well as MP3 files (we'll discuss this later). The player's front panel, and control positions, are shown in Figure 2.

In its default mode, the system in question is capable of acting as a self-contained MP3 player - with the appropriate software configuration, track details are displayed on a 16-character, 2-line screen (Maplin order code RB36P). Tracks are selected using a series of keys on a standard PC keyboard - eventually, though, you'll be able to select music tracks with a front-panel keypad. The keypad and display are hard-wired to the parallel port, special software being used to drive them. The keypad function was not available at the time of writing, although the programmers who designed the MP3 player software are currently working on keypad drivers. Note that they should be ready by the time this article is published. An alternative is to use a joystick - some of the DOS MP3 players can be configured to be driven from one of these.

In the self-contained MP3 player mode, the system works under DOS. A boot menu system determines whether DOS or Windows is booted. The default is the DOS-based self-contained player mode, and it will automatically boot in this mode after a user-defined period. In other words, there's no need for keyboard intervention, and you don't have to stare at a monitor screen. The DOS device drivers for the soundcard and CD-ROM are loaded, and a DOS-based MP3 player program starts looking for files in a specified location. If a keyboard and monitor are attached, though, the start-up menu - and its 'non-default' Windows option - can be seen. The latter bypasses the DOS drivers, and Windows can easily be added simply by typing WIN. If you don't want to go into Windows, you don't have to - you might, for example, only want to copy files from a CD-ROM to the hard disk. The prototype unit has a network card, and in Windows mode MP3 (and other types of) files can transferred from other machines on the network. Note that the prototype machine doesn't have a floppy drive, but it doesn't need to - other machines on the author's home network are suitably-equipped, and the floppy drive can be accessed across the network.

Hardware

The hardware includes a stereo headphone amplifier for

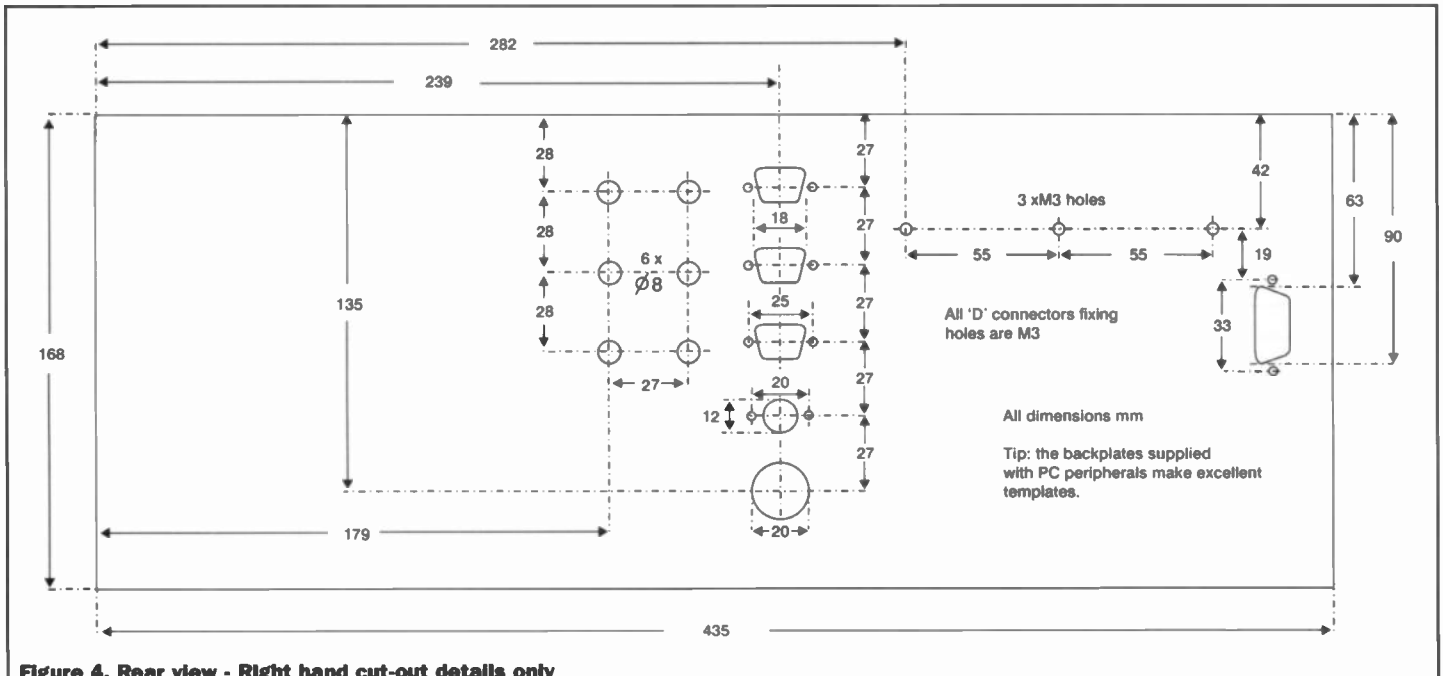
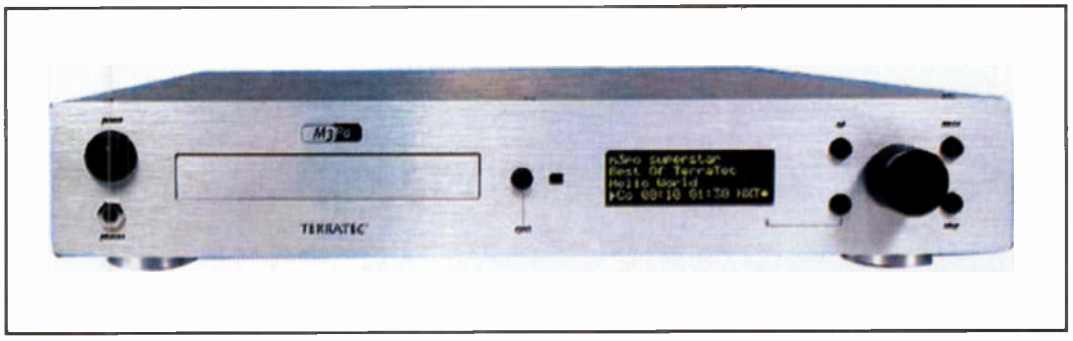


Figure 4. Rear view - Right hand cut-out details only

personal listening, in the form of a circuit based around the TDA2822. Originally, Maplin sold a complete kit around this simple 1W per channel IC, but unfortunately it has since been discontinued. At the time of writing, though, the IC and PCB are still available - all you need is a small handful of capacitors and resistors, which are standard Maplin items. When stocks of the PCB run out, the chip should still be available - fortunately, the circuit is simple enough to be knocked up on a small piece of Veroboard. The kit (and PCB) originally specified a 3.5mm socket, but this has been replaced by a standard 6.3mm (quarter-inch) type. The amplifier's stereo outputs are connected to the sockets via 100Ω resistors, which provide a useful reduction in the amount of background noise as well as limiting the output current. The headphone amplifier is held to the case by its volume control. Mounting and wiring details are given in Figures 16 and 17 respectively. The 12V power requirement is derived from a tag strip wired to one of the unused drive connectors.

Headphone Amplifier

The headphone amplifier, which is shown in Figure 19, to be shown next month has quite a high input impedance (around 47kΩ), and can hence be wired in parallel with the audio output connectors, which are standard phono types located on the rear panel. Note that you can also fit phono inputs, which can be hard-wired to the soundcard. This is worthwhile if you envisage using your PC to record analogue audio to your hard disk for subsequent conversion into an MP3 file. In all cases, we have specified insulated chassis phono sockets (order code JZ05F black/left; JZ06G red/right) to isolate the signal ground from the case metalwork. These sockets may be quite expensive, but they're of the highest possible quality. The headphone amplifier and line output can be fed directly from the PC soundcard, if desired.

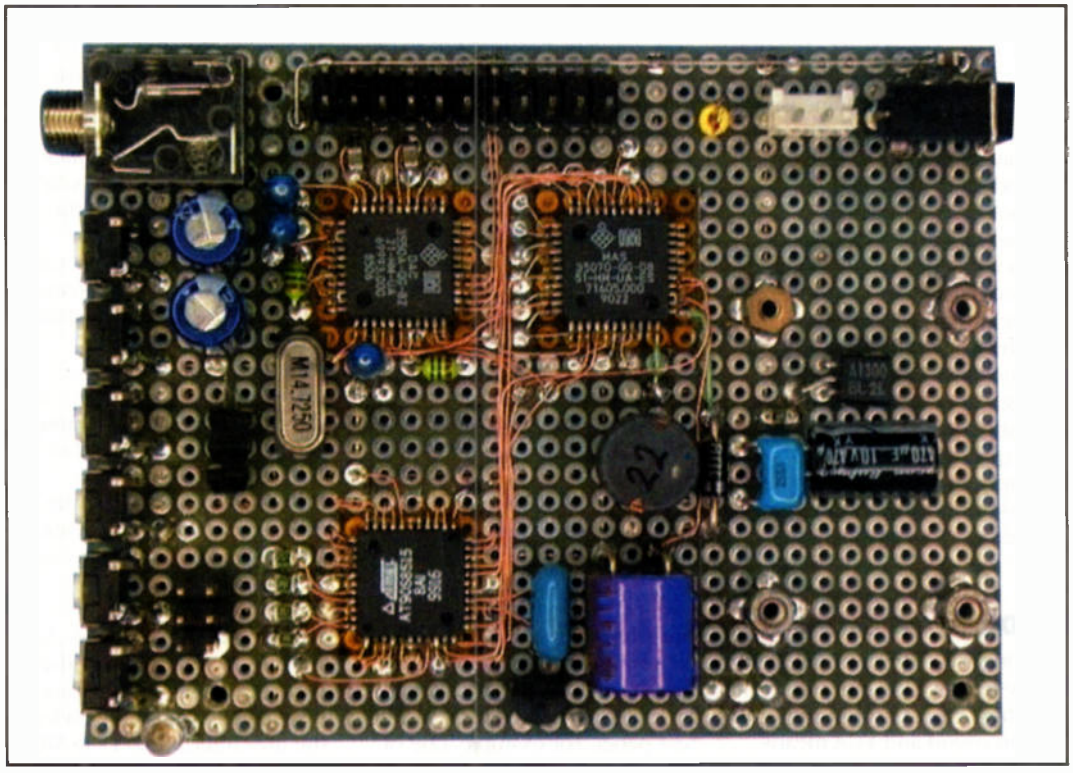


This is Terratec's M3PO - the world's first commercially-available MP3 player for home hi-fi use. The elegantly-styled device, which has a pricetag of approximately £350, will play audio CDs as well as MP3 CD-ROMs.

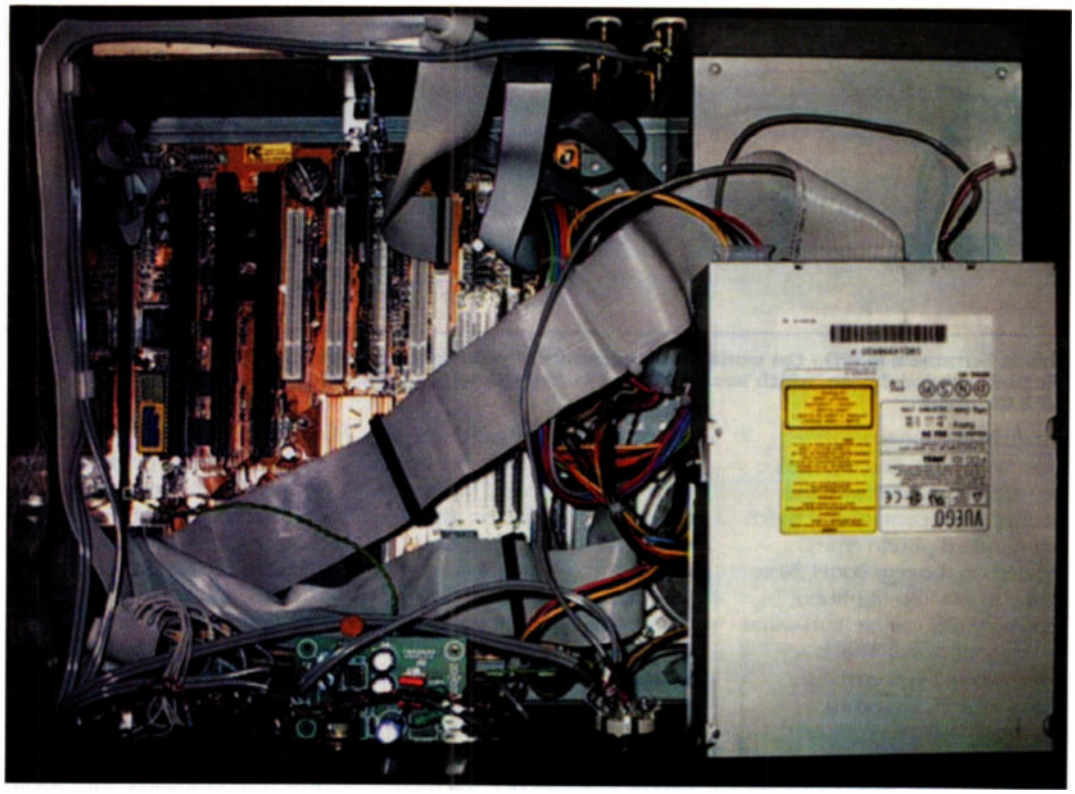
In the prototype, though, we have used a rotary selector switch to feed the output from either the soundcard or the CD-ROM audio connector. The switch is a 4-pole 3-position type, but the switch has been modified to two positions by re-orientating the rotation limit stop. The third position may well be restored, though. There are plans to upgrade the CD-ROM drive with a DVD-ROM drive and Creative MPEG decoder - the device will then have a third role as a DVD player. The switch's third position would be used to route the MPEG decoder's audio output to the phono sockets and headphone amplifier. All audio interconnections are made with screened cable (XR21X). Any exposed braid was covered by heat-shrink sleeving. The switch wiring will be shown in Figure 18 next month. Note that the CD-ROM drive audio was fed to the switch using the original cable supplied with the unit. The connector at the other end of the cable was snipped off, and the wires thus exposed were soldered directly to the switch.

Where possible, we have used standard PC components to facilitate easy and inexpensive upgrading. The prototype's motherboard is a 'baby-AT' form-factor PC Chips M571, which is compatible with Socket 7 processors of 233MHz or less. Although the motherboard is far from cutting-edge, it is still available at computer fairs for between £30 and £40. Currently, the prototype's processor socket is occupied by a Pentium 133, which is more than fast enough for the playback of MP3 files, even under Windows. CD/WAV-to-MP3 conversion is fairly slow, however, although the prototype has a fair amount of memory (128Mb). There are plans to replace the processor with a K6/233, which should yield a welcome increase in speed here. Some motherboards are capable of being operated without their keyboards - in some instances, the BIOS will have an option, part of the power-on self test (POST) configuration, that tells the system to halt if no keyboard is present. The ability to disable this was probably conceived with multimedia kiosks and remote server PCs in mind, but it also has beneficial implications for self-contained MP3 players. After all, who wants to unnecessarily clutter up their hi-fi rack with a keyboard? Although the AMI BIOS fitted to the M571 doesn't have a manual menu option for disabling keyboard presence testing, I'm pleased to report that it will happily get through the POST routine sans keyboard.

Another reason for basing the project around the M571 is that it includes Super VGA graphics and sound on-board. The motherboard is supplied with a standard VGA connector, which



Here's a look inside the Elm personal player. The MP3 decoder chip was obtained from a shop in the Akihabara (Tokyo's equivalent to London's Tottenham Court Road). An Atmel AT90S8535 is used as the system controller, while SmartMedia cards form the basis of storage. The Elm site (http://www2s.biglobe.ne.jp/~elm/reports/mpc) contains a wealth of information, including circuit diagrams and firmware.



Top view of the prototype, with its top case removed. Note how the display/keypad ribbon cable is held to the side of the case with self-adhesive clips.

is mounted on the rear panel (together with the PS/2 mouse and two serial ports). Importantly, the SoundPro HT1869V+ sound system is supplied with DOS drivers that fully emulate a Creative Labs SoundBlaster 16. Support for this industry-standard soundcard is commonplace among DOS-based MP3 players. If you don't have a supported soundcard, you won't hear anything - it's as simple as that! Interestingly, the HT1869V+ is essentially the same CMI8330 chip that forms the basis of the Audio Excel AV310 soundcard. Even the drivers are identical and interchangeable! The AV310 has a TTL-level SP/DIF output, which is derived from pin 45 of the surface-mounted CM8330 'does everything' chip. The output here is 44.1kHz, regardless of the original file's sample rate.

SP/DIF Output

It should thus be possible to obtain a SP/DIF output from the HT1869, although the pin is unconnected to anything on the motherboard. The pin density is very high, and soldering wires directly to the pin is very difficult. If only they had brought out pin 45 to a pad... A suitable TTL-to-SPDIF matching circuit (which will also work with a CD-ROM drive's SP/DIF output) is given in Figure 20, if you're feeling brave! The soundcard also features a joystick/MIDI port, which is available on a series of header pins on the motherboard. The supplied standard 15-pin connector was removed from its mounting bracket, and fitted to the rear panel. This will be shown in Figure 4 next month (the connector can be seen to the right of the drawing). This connector will be an essential fixture if you envisage using a joystick to control the DOS MP3 player - or indeed playing games, when the machine isn't being used for audio purposes! Still on the subject of rear panel ins and outs, you could fit phono sockets (or other connectors) for SP/DIF digital audio input and output. These connectors are already in place on the prototype, although they're not wired up to anything yet! There's nothing wrong with a bit of forward-thinking though - a couple of extra quid spent now is infinitely preferable to complete dissassembly if you decide the connectors are essential later on!

Choice of Case

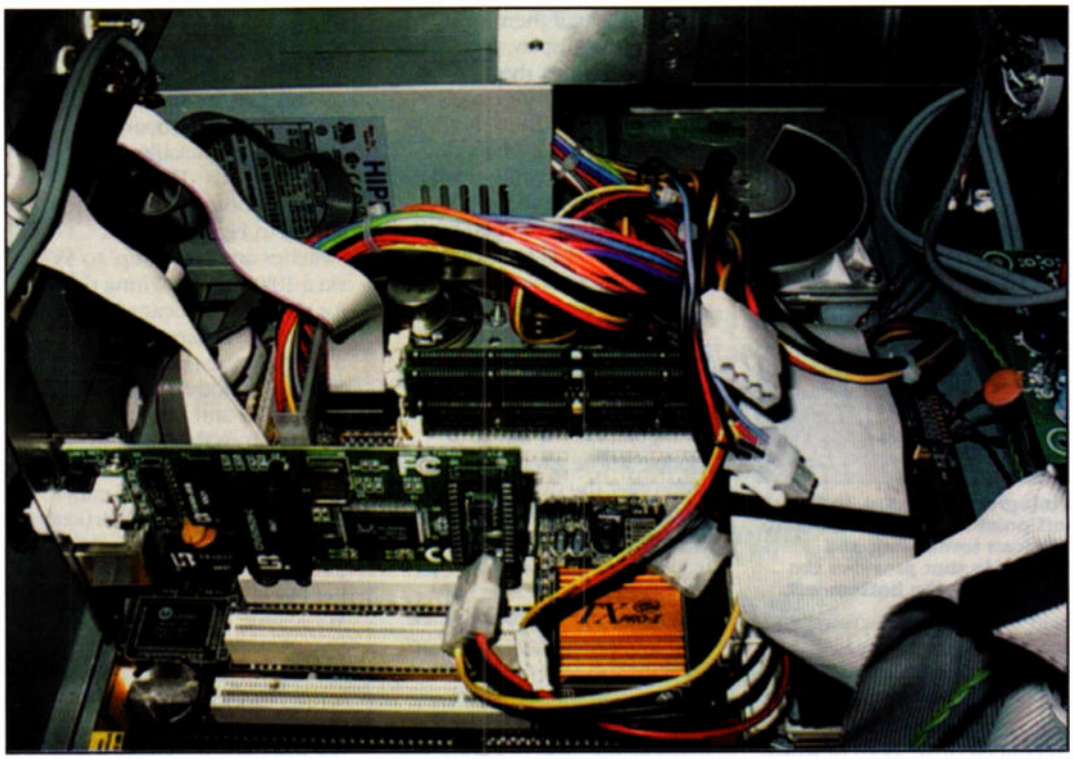
The original idea was to build the system in a lower-profile (2U) high case, because the built-in sound and VGA means that no expansion cards would be needed. There's nothing to stop you from doing this. Note, for example, that Maplin sell a motherboard similar in concept to the M571, but of higher performance. The Commate All-In-One, which features on-board sound and VGA, sells for £69.99. If you're interested in this SiS-based board, which supports Socket 7 processors of up to 450MHz, its order code is QA30H. There might not be room for a CD-ROM drive, but this needn't be a problem if you don't need one. If you do, then no worries - the secondary IDE port could be brought out to an external 'D' connector, to which the CD-ROM could be attached when required. We plumped for the full-sized case simply because it allowed us to make full use of the motherboard's PCI and ISA expansion slots. The case has been designed so that the addition of expansion cards is relatively easy. A 150mm section of 10mm x 10mm wooden dowelling, obtained from a hardware store, was screwed to the rear panel. This will be shown in Figure 12 next month.

This dowelling is used to secure the card mounting brackets, and prevent the cards from working loose or touching each other. Note that if the cards have external connections, appropriately-dimensioned holes will need to be drilled or punched in the rear panel. For example, one of the prototype's PCI slots is occupied by a network card - its BNC socket is made accessible to the outside world through a 20mm hole. Also on the expansion front, there are plans to install a soundcard of superior quality - and SP/DIF digital audio output as standard! The problem is that of drivers - these days, soundcard manufacturers tend not to bother with 'true' DOS drivers. I have, for example, just taken delivery of a VideoLogic Sonic Vortex 2, a fairly inexpensive (£65 RRP) but high-quality PCI soundcard that combines high analogue sound quality with a SP/DIF output. Unfortunately, it will only work within Windows. There are no DOS drivers supplied - VideoLogic (and the chipset maker Aureal) expects you to run DOS games within Windows. I have also had trouble with other high-quality cards in my possession. A Creative Labs AWE64 Gold refused point-blank, thanks to the vagaries of 'plug-and-pray', to install properly under DOS. Meanwhile a Turtle Beach Tropez (one of the first PC-based 'samplers') failed to work in the Soundblaster 16 emulation mode required by DOS-based MP3 players. That said - although the M571's on-board sound is of mediocre quality in hi-fi terms, it should be acceptable for most applications.

Motherboard

Note that any baby AT motherboard will fit into the prototype case - the spacer positioning and clearance (shown in Figures 5 and 8) should accommodate most such boards without modification. If you're planning to specify a high-performance ATX motherboard, then you'll have to cut out a slot in the case's rear panel to accommodate the connector backplate. The motherboard is supported by 10mm insulated spacers - these provide sufficient clearance to accommodate the bottom of the expansion cards' mounting plates without fouling - this will be seen in Figure 12 next month. Before installing the motherboard, fit the six rubber feet to the bottom of the case, as shown in Figure 8.

The M571, and other motherboards of its genre, have a 26-way header plug for the parallel port. The display and front-panel keypad, which form the user interface in DOS MP3 playback mode, are wired to this connector. This will be shown in Figures 14/15 and Table 1. 26-way ribbon cable (XR75S) and a IDC plug of the



Another view of the prototype's interior. The network card and hard disk can both be seen.

corresponding size (FG85G) were used to make the motherboard connection in the prototype. Note that ATX motherboards have the printer port on the backplate. If you're using one of these, the display and keypad will have to be connected via a 25-way 'D' plug (you will need to refer to Figures 14 and 15). The cable could be passed through a hole drilled in the rear panel, and wired to a trailing plug that's mated with the motherboard's parallel socket when the display and keyboard functionality are required. Although this approach is not particularly elegant, it does have the advantage that the display/keypad connector can be removed in Windows mode, and other peripherals (such as printers) attached.

Power Supply

Another 'off-the-shelf' item that has found its way into the prototype is the standard ATX-type power supply, which provides 'soft start' and sleep modes with compatible motherboards. Unlike the older AT power supplies, there's no need to route mains cables and power switches. Modern Socket 7 motherboards will work with ATX supplies, or the older type - they have two sets of connectors. ATX motherboards, meanwhile, require ATX supplies. The M571 motherboard can be switched on or off from the front panel if a suitably-located push button is connected to pins 4 and 5 of connector J1. Pressing the button forces the machine into a 'sleep' mode - holding it down switches the machine off. The same control is used to turn the machine off. Another advantage of the ATX supply here is that the machine can be turned off from within Windows. Note that the reduced height of a 2U case, should you be considering one, may require you to remove the power supply circuitry from its casing - otherwise it might not fit together! The uncased circuit board and fan would then be mounted in the player's cabinet. To avoid noise problems, we would recommend mounting the supply in a separate shielded section of the cabinet.

In the prototype, I specified the JB00A red-buttoned push switch as an on/off power control. The same switches were used for the reset (in this case the black-buttoned variant JB01B) and menu keypad (four black switches surrounding a centrally-located red one). I used Minicon connectors to make such connections to the motherboard. Reset and power switch apart, there are the power/drive activity LEDs, soundcard stereo output and speaker to cater for. Wiring details specific to the prototype's M571 motherboard will be given in Figures 21, 22 and 23 next month. Although the Minicon connectors are of the correct conductor pitch for motherboard connections, the housings are too large if multiple connections span two rows of header pins. In these cases, you might need to file away some of the plastic and orient a pair of connectors back-to-back - one for each row. One of the photographs illustrates the general idea. The Minicon terminals are prepared as shown in Figure 24.

The power supply has several trailing power wires for disk drives of various types. Not all of them are used, and so the connector from one of the redundant ones is cut off and the wires soldered to a 5-way tag board (this will be shown in Figure 9). The power supply wires from the display, switch and power supply can be connected to this tag board, which is held in position by a 10mm M3 screw, shakeproof washer and nut. The position of the tag will be seen in Figure 5. We recommend using the outer two pairs of tags - don't use the central tag, because this is in contact with the metalwork! A PC PSU's drive supply wires are colour-coded as follows: red, 5V; black, ground; yellow, +12V.

To avoid the possibility of the tag strip working loose , we would recommend securing its base with epoxy resin. One can only imagine the damage that could result if the 12V tag was to come into contact with the motherboard logic circuitry... If you're into the belts-and-braces school of hardware construction, you might also want to cover the exposed conductors with heatshrink sleeving. Figure 9 will show how the 50mm speaker is prepared - basically, M3 tags are soldered to the chassis of the device. The speaker can then be attached to the chassis with a 10mm M3 screw, shakeproof washer and nut.

Choice of Hard Drives

Whilst on the subject of drives, I am using a standard 3.5in. hard disk to store the operating system, programs and MP3 files. The prototype's drive had a capacity of 1.2Gb, but there's

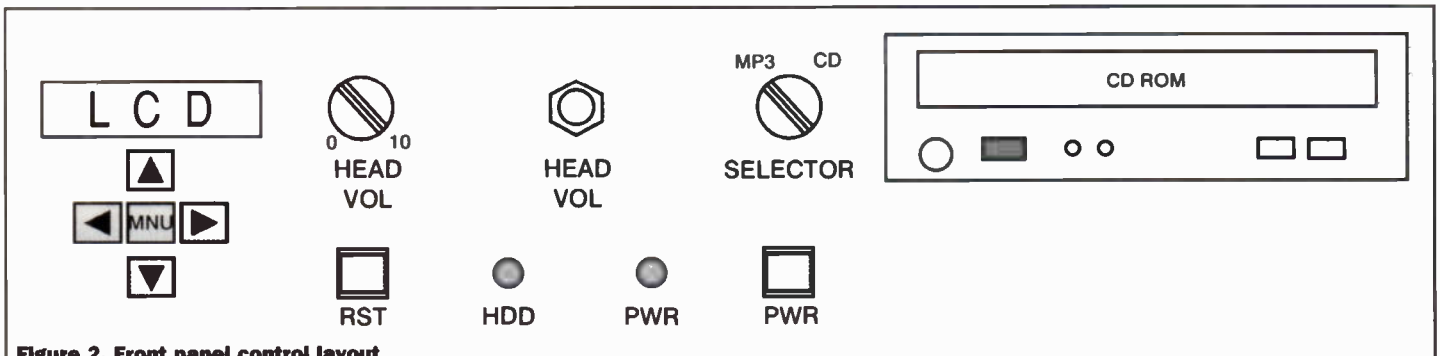
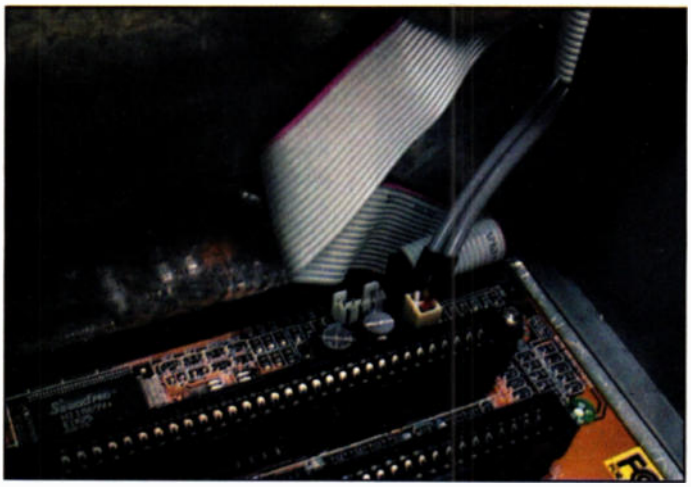


Figure 2. Front panel control layout



The prototype's motherboard has an integral soundcard. In this picture, you can see the audio take-off point referenced in Figure 23 (another excellent use for those Minicon terminals!) and joystick connector. The HT1869/CMI8330 chip that provides the audio functionality can clearly be seen towards the bottom-left.

absolutely no reason why more capacious drives can't be specified. The greater the capacity, the more MP3 files that can be accommodated! It's quite amazing that a compact item of computer equipment could accommodate a music collection that would otherwise fill a room - but that's the wonder of MP3! The drive is mounted on the prototype's chassis base sideways, with its connector end nearest the motherboard - The filing and mounting details will be shown in Figure 5 & 6. To provide some shock resistance, the drive is separated from the chassis by 4mm grommets cut in half.

Above the hard disk is the CD-ROM, which is supported by an aluminium plate secured between the power supply and the front panel. Dimensions of this plate will be given in Figure 7, and mounting details will be shown in Figure 11 - Note, that the power supply is supported at its front end by a pair of cut-down nylon spacers and M3 hardware. The drive is held in by a pair of screws, and can easily and quickly be removed. It will also be quite an easy matter to replace the drive with a CD recorder or DVD-ROM drive, both of which will also support the reading of standard CD-ROMs. Unfortunately, Maplin no longer sells aluminium plate (my sample was a fortunate 'end-of-line' special, bought at the local store). If you can't get hold of any aluminium plate, you could try PCB material as an alternative. The angle brackets could be fashioned from hardware items obtained at a hardware store. A pair of solder tags could be used to support the mounting plate at the front-panel end.

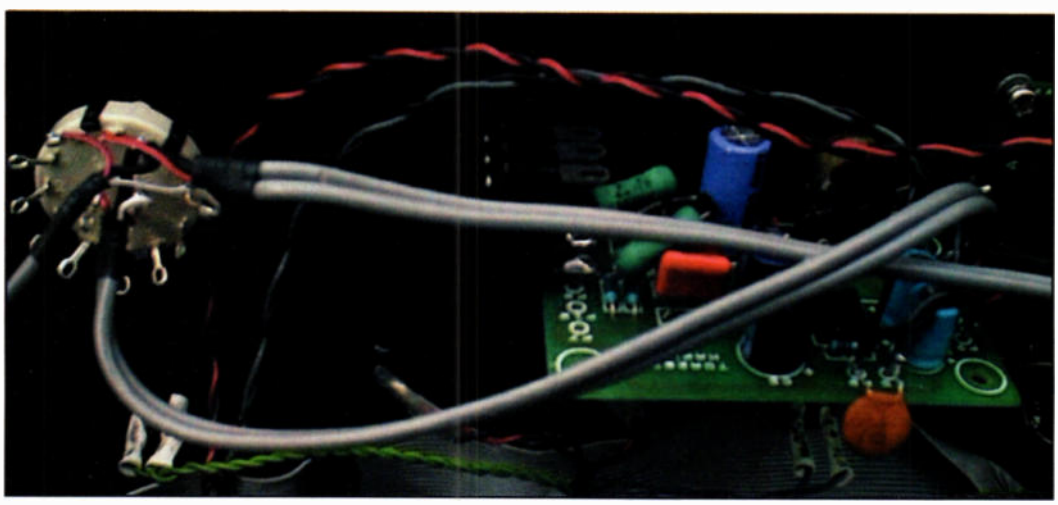
To accommodate the drive, a rectangular hole is prepared in the front panel (refer to Figure 1a). If you don't want to include a CD-ROM - let's say, for example, that files will be copied from a networked PC's CD-ROM drive as required - then there's no need for the cut-out. A smaller rectangular cut-out serves for the LCD screen. Again, if there's no need for the display, there's no need to hack out the corresponding front-panel hole. I prepared these holes by drilling a rectangle-shaped series of holes slightly smaller than the desired shape. The holes were then reamed out with a larger drill bit, and the unwanted section of metal within the rectangle of holes punched out. The cut-out was then neatly finished off to the specified dimensions with needle files. Mounting arrangements for the LCD module will be given in Figure 13. To protect the display, a piece of clear sheet plastic has been epoxied to the inside of the front panel. On the prototype, the plastic was obtained by cutting up an old cassette case with a hot knife (gas stoves are ideal for this sort of thing!)

The smaller rectangular holes for the push buttons (such as the ones of Figure 1b, which are provided for menu access) were initially prepared by drilling holes. Needle files were then used to shape these holes to the required dimensions. Fortunately, the front panel is made from aluminium. The rear panel is steel, and is not quite as easy to work with! Here, the larger holes such as the keyboard connector and will be shown in Figure 4 were made with a sheet metal punch. The power supply fan's aperture, was made by punching out four large holes, and cutting away the interconnecting metal with a hacksaw. The hole thus produced was then filed out to the quoted dimensions. For neatness, a plastic 80mm fan guard (JU26D) could be glued over the hole in the rear panel.

We've already discussed the reset and power buttons, which are wired directly to the motherboard - as are the drive activity and power-on LEDs. The exact wiring details are, of course, specific to your particular motherboard. Not all features are available on all motherboards! The menu buttons, though, are wired as shown in Figure 14. The switches are 'pulled up' to 5V via a 10k resistor. Wiring details for the display, meanwhile, will be given in Figure 15 next month. In the prototype, the 5V and ground rails needed by the display and keypad are derived from the PC power supply via the tag-strip arrangement discussed earlier.

The final stage of construction is, on the face of it, quite difficult. The front panel is held in position by four black M4 screws, which mate with threads incorporated into the bases of the handles. The lower screws cannot be accessed with the front panel in position, because they're obstructed by the motherboard and CD-ROM mounting plate. There is a workaround, though. Before fitting the front panel to the rest of the case, feed the two lower screws through the case metalwork. Position the panel so that the screw threads can be seen from the front. Push the panel down, trapping the screws in position, and mate them with the handle threads. Rotate each handle, until you can feel the threads mate.

Keep rotating the handle, screwing it onto the thread until it's flush with the case and feels rather tight. To ensure that the free end of the handle does not scratch the front panel, we would recommend temporarily wrapping it up in adhesive tape, or covering the front panel with paper. The controls are arranged in such a way that the free end of the handle is not fouled when being rotated. Note, however, that the CD-ROM drive must not be present when attaching or removing the handles, because it protrudes from the front panel. When the lower moorings of the handles are in position, the handles can be aligned vertically and the two top screws fitted. The CD-ROM drive and front panel knobs can then be fitted. Hardware construction is now complete.



Close-up view of the audio amplifier board and CD/soundcard selector switch. Note that the amplifier is securely held to the front panel via the potentiometer, and decoupled by an extra 220nF capacitor wired across the power supply pins. Note also that one of the switch's unused terminals is pressed into service as an earth tag, and that heatshrink sleeving covers exposed coax braid.

Next Month...

All outstanding drawings and software with photos will be included.

Further constructional details with photos will also be included.

An Electrifying CENTURY

THE RISE OF ELECTRONICS 1900 - 2000

In part 3, Gregg Grant brings us to 1950 and the arrival of the computer.

Electronics and Entertainment

One of the outstanding features of the present century has been the way in which the world's population has come to rely on others - indeed entire industries - for its entertainment. In fact the entertainment business has been responsible for a number of important developments in electronics and electrical engineering, achievements for which it is rarely given credit. A good example of this is motion pictures.

By 1926, the public were - to put not too fine a point on it - getting blasé about the 'movies.' Warner Brothers thought that one way to bring the crowds back would be to introduce sound, although it might, they reasoned, be a pretty expensive affair.

Consequently they asked the Western Electric Corporation to develop a system which could synchronise disk recording equipment with a film camera. Western Electric turned to its licensee, the Victor Talking Machine Company, to carry out the recording whilst they concentrated on the motor drives for both the record turntables and the cine projectors.

The system that evolved was one of projectors and turntables powered by the same constant-speed motor arrangement and standard, state-of-the-art public address amplifiers and loudspeakers, a system given the name of Vitaphone.

In October 1927 Al Jolson's 'The Jazz Singer' opened as the first 'Talkie' and became a considerable success. The theatre chains lost no time in approaching Western Electric for the lease of their equipment and the Warner Brothers studio set up its own disc recording studio.

This was but the beginning. In the following year another 'Talkie' arrangement appeared, this time created by Fox Movietone News. A 'Sound-on-Film' system, it used a glowlamp known as an Aeo-light which had an oxide-coated cathode. This device's intensity could be modulated by varying the anode voltage - at audio frequencies - in the range 200 to 400 volts.

The light was located at the rear of the camera and directly against the film there was a light-restricting slit. This orifice passed a very fine beam between the picture and the sprocket holes and the Aeo-light's intensity was such as to expose the negative film used for picture recording. The system was adequate for newsreel work, where pictures and sound were taken together, on the same camera.

Twenty years after the Movietone News system was developed a new technique - magnetic recording - began its climb to supremacy. This technique was the original recording method, hindered initially by the recording medium used, steel tape. But, during the Second World war the Germans developed a magnetic oxide which gave a low-noise performance. In tandem with this achievement came a technique for coating the oxide on to a flexible base, some four inches wide along with the necessary electro-mechanical drive and amplifiers for a complete system.

This equipment was examined by the Allies at the end of the conflict and soon organisations such as the Radio Corporation of America (RCA) began undertaking further development of the system. In 1948, 35 mm film with an oxide coating was developed for sound recording in the film industry. Tests proved that the new medium produced high quality recording with large dynamic range. It also proved more flexible and economical than any of the previous methods attempted.

1927 also saw the opening developments in what would become, perhaps, the most successful form of home entertainment ever - television. Herbert E. Ives and his colleagues at the Bell Telephone Company sent the first television transmission over cable, between Washington and New York. Ives used Nipkow disks for both transmission and reception.

By 1929, the Bell Company had set up its own laboratory and it was one of the first organisations anywhere to attempt to create colour TV. Employing a 50-line system, the Bell engineers transmitted the three primary colours on red, blue and green on three discrete channels initially, but towards the end of the year, they succeeded in transmitting a number of colour signals over a single channel.

Seven years later the British had developed TV to the point where Public Service broadcasting was about to begin, albeit on a trial basis. However, there was a problem - the signal between Central London and the transmitters at Alexandra Palace was carried on a shielded pair cable, on which interference pick-up distorted the signal.

Since video transformers did not exist at this time, another solution had to be found. Alan Blumlein came up with the circuit shown in Figure 1, which he called the Long Tailed Pair. Long since transistorised, this circuit has, since its inception, been one of the most widely used in electronics.

Colour TV of course is based on the principle of colour addition, the idea that any colour can be created by the mixing of the three primary ones, namely red, blue and green. Since there are phosphors capable of emitting - separately - red, blue and green light, almost all colour TV tubes are three-gun types and the most common of these

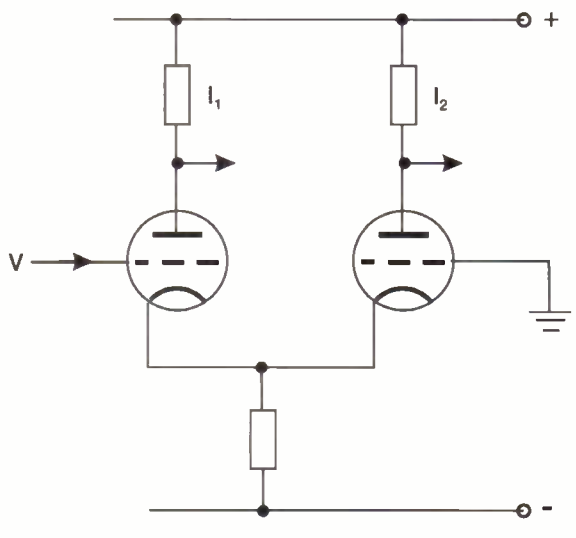


Figure 1: Alan Blumlein's Long Tailed Pair circuit of 1936.

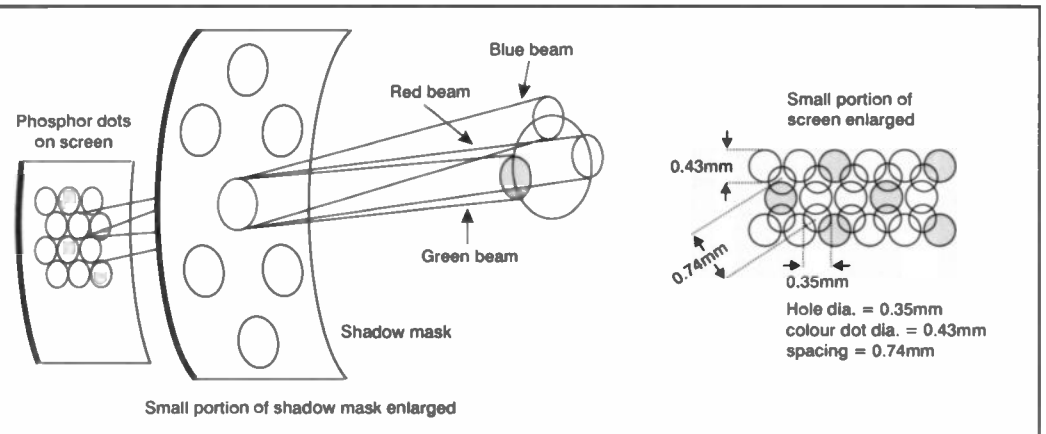


Figure 2: A Modern Shadow-Mask Colour TV Tube: Colour Addition Technique.

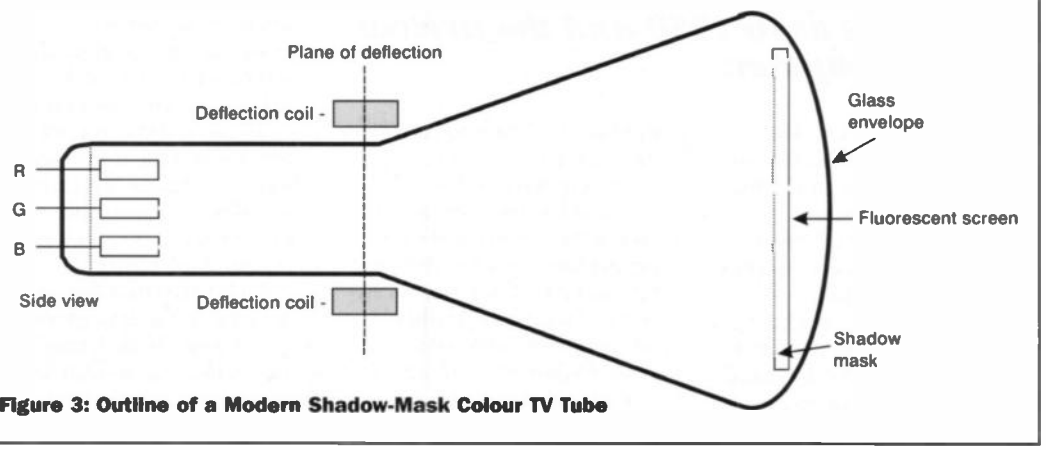


Figure 3: Outline of a Modern Shadow-Mask Colour TV Tube

is the Shadow-Mask tube, shown in Figures 2 and 3.

This type of tube is sensitive to the direction of the three electron beams and the first man to propose such a system was the German inventor W. Flechsig, in 1938. His method involved several hundred turns of very fine wire being accurately aligned with a matching number of groups of three primary colour phosphors. Once again, a concept proved easier to outline than to manufacture.

The modern Shadow Mask tube was proposed by two RCA engineers A. N. Goldsmith and A. C. Schroeder, although making it a technical reality would subsequently prove to be a considerable team effort. Nevertheless, some eleven years after Flechsig's idea was first aired, RCA initiated a crash programme to develop a colour TV tube.

Goldsmith and Schroeder's idea of a hexagonal array of holes in a metallic mask, coupled with phosphor dots and tightly-spaced electron beams acting through a common deflection yoke, was further investigated by their colleague, H. B. Law. An authority on phosphor deposition, Law made the crucial breakthrough - the invention of a device he termed a Lighthouse.

This enabled a photographic process to create light shadows which were almost identical to those of the electron beam, which meant that primary colour phosphors could be deposited in exactly the correct spot. Shortly afterwards, using photographic etching, Law created very small holes in a metal mask and then deposited the three colour-emitting phosphors through them, he slightly shifted the mask for each deposition.

After Law's first tube proved that it could deliver excellent colour pictures, two engineering teams concentrated on further development. The result was the announcement of the single electron-gun tube, at RCA's Princeton Laboratories. Colour TV - and for that matter colour computer graphics - were an established fact.

In 1931 Alan Blumlein filed for a British patent on what he termed Binaural Recording. The title may not a have caught the imagination but the patent certainly did, not simply for itself but also for the 70 claims made within it!

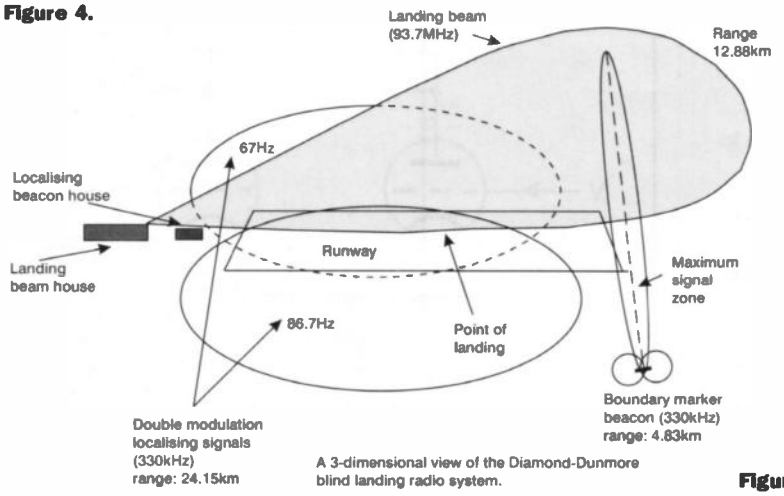
At about the same time, Bell Laboratories in America independently came up with the same idea, they terming it Stereophonic Recording. The Bell team, under their leader Harvey Fletcher, gave a demonstration of their system on the 27th April 1933 at the Academy of Music in Philadelphia.

In Britain meanwhile, Electrical and Musical Industries, (EMI), produced the earliest stereo records. This work was again directed by Blumlein, the end product being stereo 78 rpm recordings. The system nevertheless was some quarter of a century ahead of its time and - almost - the technology of the day!

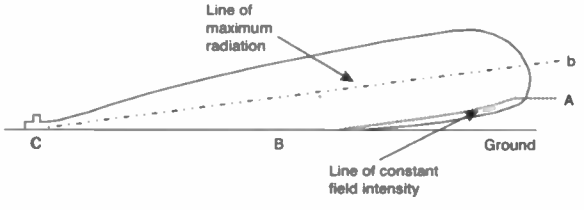
Electronic Navigational Aids

Aircraft development made considerable strides in the opening years of 1920s, among which were aids to more accurate navigation, although many of them would prove of marginal value. Landing too had

Figure 4.



A 3-dimensional view of the Diamond-Dunmore blind landing radio system.



The vertical directive characteristic of the Diamond-Dumnore landing system.

Figure 4: The Diamond-Dunmore blind landing system of 1929.

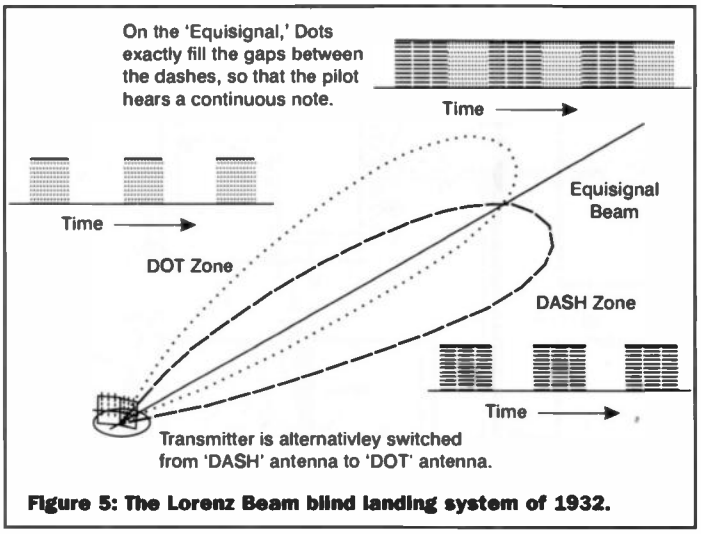


Figure 5: The Lorenz Beam blind landing system of 1932.

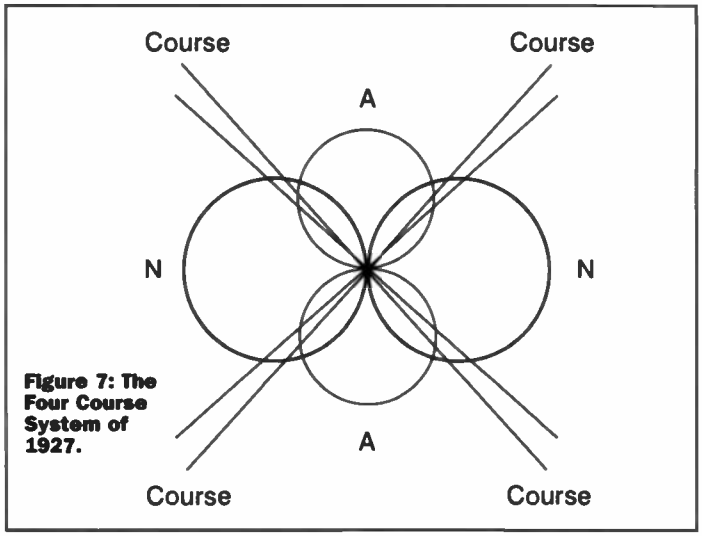


Figure 7: The Four Course System of 1927.

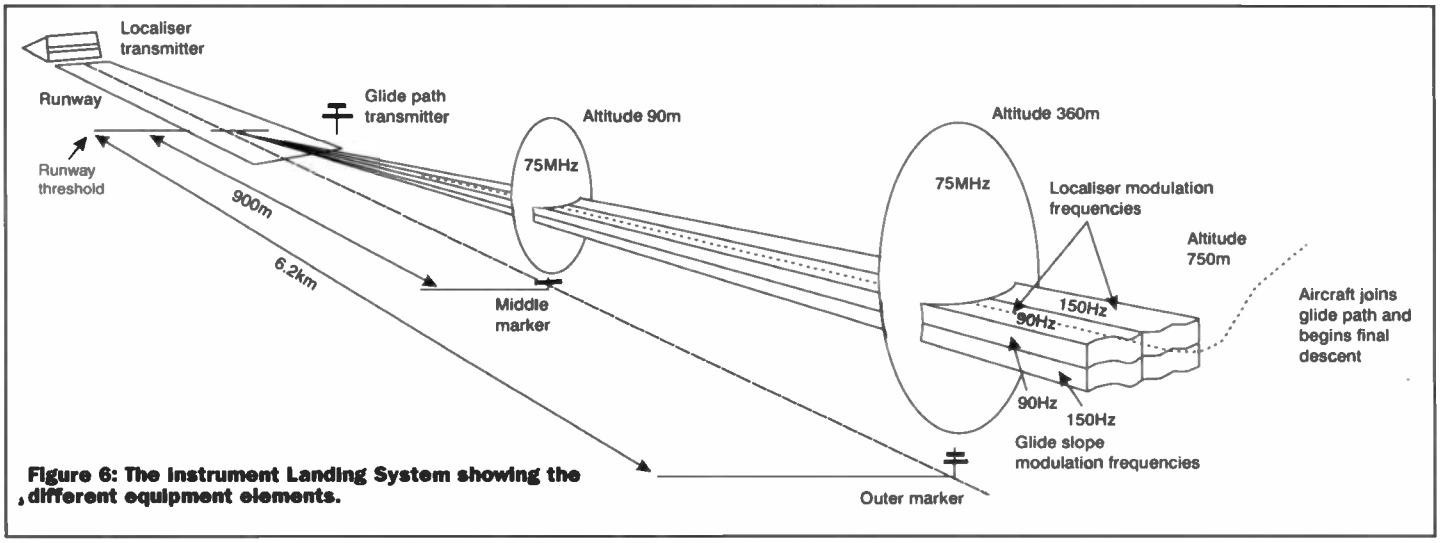


Figure 6: The Instrument Landing System showing the different equipment elements.

long been a vexatious experience, indeed the most critical phase of a flight, from which few of the early pioneers came away unscathed.

In 1919, the American Bureau of Standards began one of the earliest trials to investigate whether radio could be used as an aircraft landing aid. A decade later, the Bureau began further, more detailed, trails using the equi-signal beacon system, shown in Figure 4. The arrangement, designed by the Bureau's engineers H. Diamond and F. W. Dunmore, gave a pilot vertical guidance that enabled him to land in poor visibility.

In Europe too, aircraft navigation and landing problems were beginning to be addressed. In Germany for example, one considered solution was the Lorenz Beam System, shown in Figure 5.

Developed by E. Kramer and R. Elsner, the system consisted of two dipole antenna systems, arranged side by side, the distance between the dipoles being broadly equal to their length.

Two beams were then radiated, pointing in marginally different directions, yet overlapping each other in a narrow band. The transmitter was switched from one system to the other in a repetitive sequence, one antenna system giving a 'dot' signal, the other a 'dash.' Along the centreline, was the dot-dash equi-signal, giving a continuous note along which the pilot flew to ensure a safe landing. Marker beacons were also installed along the runway approach path.

The system was as simple and effective as the Diamond-Dunmore arrangement and capable of further development, as the Germans demonstrated in the Second World War by using it as the basis of a navigational bombing aid. The British solution to the landing problem - installed at Farnborough - was a 'leader cable' arrangement, in place of what we, today, would term the Instrument Landing System (ILS) Localiser equipment.

By 1942 the first operational Landing System - the SCS-51 - had been developed in the United States. Adopted by the American armed forces shortly afterwards this equipment, under the auspices of the

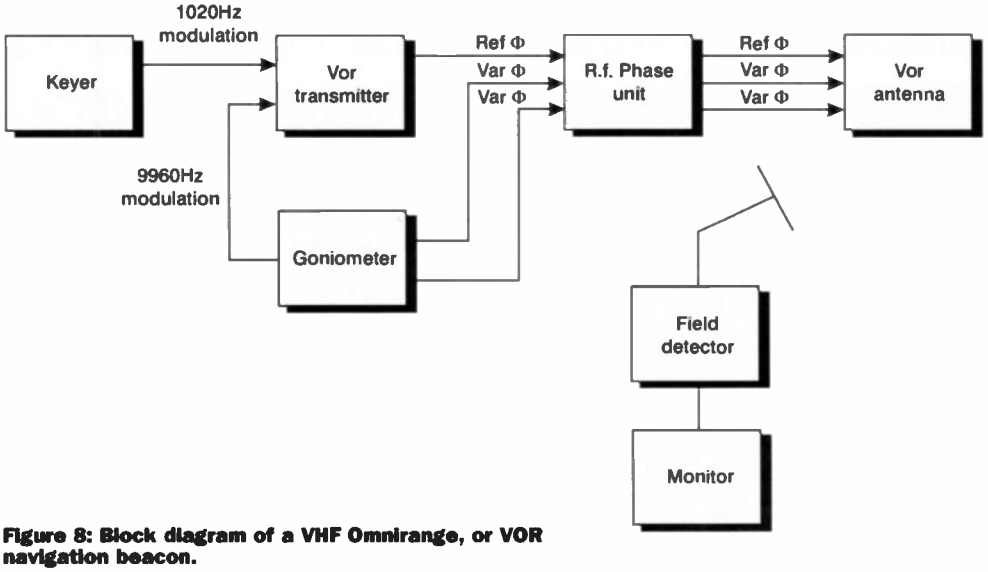


Figure 8: Block diagram of a VHF Omnirange, or VOR navigation beacon.

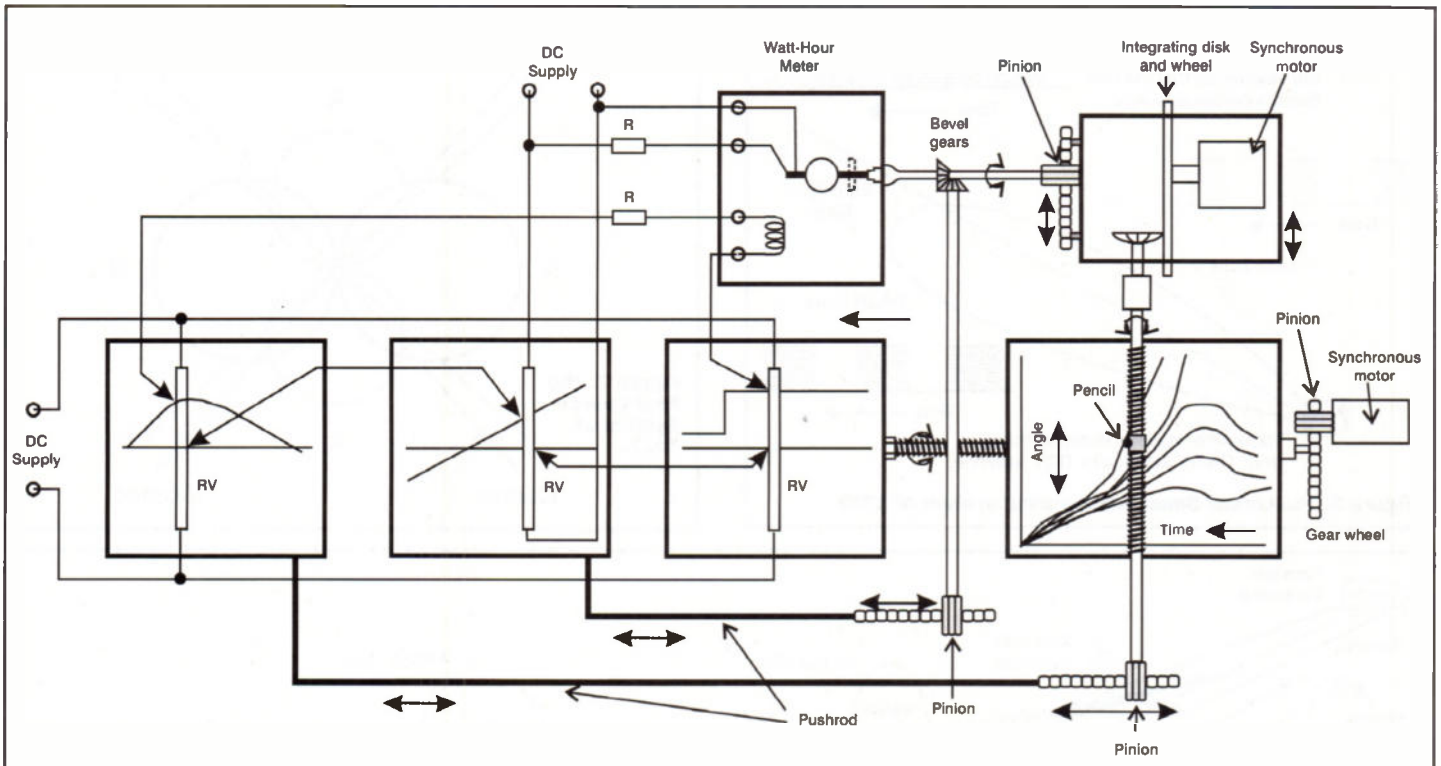


Figure [illegible] Integraph calculator of 1930.

International Civil Aviation Organisation (ICAO) would, from 1947 onwards, become the standard radio landing aid at the world's major airports. Indeed the ILS - shown in Figure 6 - is only now being slowly phased out, after half a century of use.

Aircraft navigational aids received a major boost as a result of World War Two. The earliest such aid was the American Signal Corps Four Course system of 1927, shown in Figure 7.

The equipment consisted of a tone-modulated transmitter, working into two crossed, vertical loop antennas, displaced by 90°. Each loop's field pattern was a figure-of-eight, whose intersection produced four zones of equal field intensities, or courses, broadly 3° wide. By 1936, despite problems with propagation - known as Night Effect - this navigational aid was adopted as the basic navigational system in the United States.

After the rapid progress made between 1940-45, postwar navigational aids moved up into the Very High Frequency, or VHF, band where they were free of propagation problems. Today, the major navigational aid of the civil airlines is the VHF Omnirange, or VOR, beacon shown in Figure 8.

Components, Circuits and a Revolutionary Device

The 22 years between 1926 and 1948 saw the development of a number of useful components, devices and circuits, as shown in Table 1. Undoubtedly the most significant of these was the invention of the Transistor.

The development of the transistor * changed electronics fundamentally. Although the concept had been put forward in the 1930s in Germany by Julius Lilienfeld - the MOSFET concept - and Oskar Heil, who developed the Field Effect concept, it required the determined effort of a small army of researchers to make the concept practical.

The Bell Laboratories team of Shockley, Bardeen and Brattain developed what would become a template for the tiny device and usher in a completely new era in electronic engineering.

The Arbiter of All Our Lives

When it comes to domination, the computer is in a league of its own. The steamship, the internal combustion engine and the turbojet-powered aircraft have all made an impression on our lives, at times a significant one. However, the computer has conquered every aspect of human activity, even to the extent of influencing the hunting and tracking abilities of the South African Bushmen. And it has done so in less than half a century!

Like the transistor before it, the computer had a lengthy gestation. First conceived as an aid to accurate calculation by Charles Babbage, it later became an aid to tide

Component	Inventor and Country	Date
The Tetrode Valve	H.J. Round, Marconi Company. (UK).	1926
A.V.C. Circuitry	H.A. Wheeler, Hazeltine Corp., (USA).	1926
N.F.B. Amplifier	Harold Black, Bells Laboratories (USA).	1927
The Pentode Valve	Tellegen and Hoist, Philips (Holland).	1928
Energy Conserving Circuit	Alan Blumlein EMI, (UK).	1932
Polyethylene Insulation	Imperial Chemical Industries (UK).	1933
Pulse Code Modulation	Alec Reeves, Standard Telephones (France).	1937
Plan Position Indicator	E.G. Bowen, W.B. Lewis, G.W.A. Dummer & E. Franklin (UK).	1940
Satellite Communications	Arthur C. Clarke (Proposed) (UK).	1945
The Transistor	W. Shockley, W. Brattain & J. Bardeen (USA).	1948
The Modem.	Bell Laboratories (USA).	1950

Table 1: Some Component and Circuit Development 1926 - 1950

Computer	Inventor/Developer	Year
Electronic Discrete Variable Automatic Computer	Moore School of Engineering, University of Pennsylvania.	1947
Universal Automatic Computer	Presper Eckert and Professor John Mauchly	1947
Standards Electronics Automatic Computer	U.S. National Bureau of Standards.	1948
Manchester One	F.C. Williams and Tom Kilburn. UMIST (UK).	1948
Electronic Delay Storage Automatic Calculator	Maurice Wilkes, Cambridge University (UK).	1948
IBM 650.	International Business machine Corporation. (USA).	1950

Table 2: Computer Developments 1945 - 1950

prediction for Lord Kelvin before, in the 1920s, reverting to its original role, that of number cruncher.

Dr. Vanevar Bush's work on electrical power failures was stuttering to halt. He and his team were being buried almost under the complexity of the differential equations involved. He decided therefore that the way ahead lay with a machine and so - in 1927 - he and his colleagues designed the Integraph, shown in Figure 9.

By 1930 it was up and running and, in the course of its work,** it became an influential device. Twelve years later, Integraphs were being used by the United States Army's Ordnance Corps to calculate shell trajectories.

Unfortunately, they were beginning to fall behind in this task such was the demand, due to the imminent invasion of Europe by the allied armies. This led to the army turning to the University of Pennsylvania's Moore School of Engineering to provide a solution. The Electronic Numerator, Integrator and Computer, or ENIAC, was about to be born.

ENIAC employed decade ring counters, Eccles-Jordan flip-flop circuits and pentode gates with an input/output system of card readers and punches. It was - in its way - the first general purpose computer.

On the eighth of November 1945 John von Neumann, at that time a member of the Institute for Advanced Study at Princeton, put forward his design ideas for a stored programme computer. These concepts, which would come to be known as the von Neumann Architecture, are still the basis of all modern computers.

In the following year the British computer genius Alan Turing designed the Automatic Computing Engine, or ACE, stored programme machine at the National Physical Laboratory. In the following year the Massachusetts Institute of Technology, the MIT, began work on its Whirlwind computer. Both machines ran their first programmes in the early 1950s.

By the middle of the century, the computer was already an established device, as table two illustrates. Although all of the machines built thus far used valves, the transistor would shortly be developed to the point where it could be used in computing devices. Mankind's newest technological tool was about to become a great deal smaller and - as a result - very much more versatile.

References

* See 'Electronics & Beyond,' No. 115, July 1997, Article 'What's In A Name' No. 5, Page 54.

** See 'Electronics The Maplin Magazine,' No.70, Article 'History of Computers.' October 1993.

FET Principles & CIRCUITS

PART 2

Ray Marston looks at practical JFET circuits in this second episode of this 4-part series.

Last month's opening episode of this 4-part series explained (amongst other things) the basic operating principles of JFETs. These are low-power devices with a very high input resistance and invariably operate in the depletion mode, i.e. they pass maximum current when the gate bias is zero, and the current is reduced ('depleted') by reverse biasing the gate terminal. Most JFETs are n-channel (rather than p-channel) devices; two of the oldest and best known n-channel JFETs are the 2N3819 and the MPF102, which are usually housed in TO92 plastic packages with the connections shown in Figure 1. Figure 2 lists the basic characteristics of these two devices. This month's article looks at basic usage information and applications of JFETs, and all practical circuits shown here are specifically designed around the 2N3819, but will operate equally well when using the MPF102.

Figure 1. Outline and connections of the 2N3819 and MPF102 JFETs.

Parameter	2N3918	MPF102
V_{DS} max (=max drain-to-source voltage)	25V	25
V_{DG} max (=max drain-to-gate voltage)	25V	25V
V_{GS} max (=max gate-to-source voltage)	-25V	- 25V
I_{DSS} (=drain-to-source current with V_{GS} =0V)	2 - 20mA	2 - 20mA
I_{GSS} max (=gate leakage current at 25°C)	2nA	2nA
P_T max (=max power dissipation, in free air)	200mW	200mW

Figure 2. Basic characteristics of the 2N3819 and MPF102 n-channel JFETs.

JFET Biasing.

The JFET can be used as a linear amplifier by reverse biasing its gate relative to its source terminal, thus driving it into the linear region. Three basic JFET biasing techniques are in common use. The simplest of these is the 'self-biasing' system shown in Figure 3, in which the gate is grounded via Rg, and any current flowing in Rs drives the source positive relative to the gate, thus generating reverse bias. Suppose that an I_D of 1mA is wanted, and that a V_{GS} bias of -2V2 is needed to set this condition; the correct bias can obviously be obtained by giving Rs a value of 2k2; if I_D tends to fall for some reason, V_{GS} naturally falls as well and thus makes I_D increase and counter the original change; the bias is thus self-regulating via negative feedback.

In practice, the V_{GS} value needed to set a given I_D varies widely between individual JFETS, and the only sure way of getting a precise I_D value in this system is to make Rs a variable resistor; the system is, however, accurate enough for many applications, and is the most widely used of the three biasing methods.

A more accurate way of biasing the JFET is via the 'offset' system of Figure 4(a), in which divider R1-R2 applies a fixed positive bias to the gate via Rg, and the source voltage equals this voltage minus V_{GS}. If the gate voltage is large relative to V_{GS}, I_D is set mainly by Rs and is not greatly influenced by V_{GS} variations. This system thus enables I_D values to be set with good accuracy and without need for individual component selection. Similar results can be obtained by grounding the gate and taking the bottom of Rs to a large negative voltage, as in Figure 4(b).

The third type of biasing system is shown in Figure 5, in which constant-current generator Q2 sets the I_D, irrespective of the JFET characteristics. This system gives excellent biasing stability, but at the expense of increased circuit complexity and cost.

In the three biasing systems described, Rg can have any value up to 10M, the top limit being imposed by the volt drop across Rg caused by gate leakage currents, which may upset the gate bias.

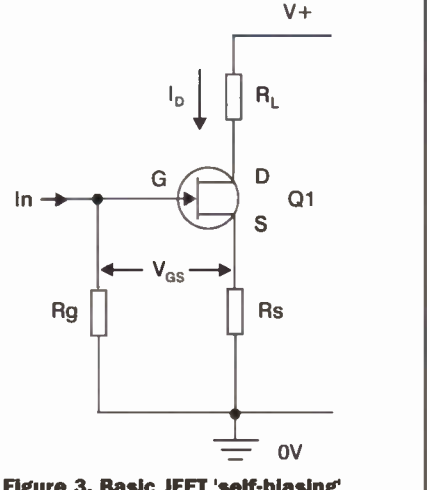


Figure 3. Basic JFET 'self-biasing' system.

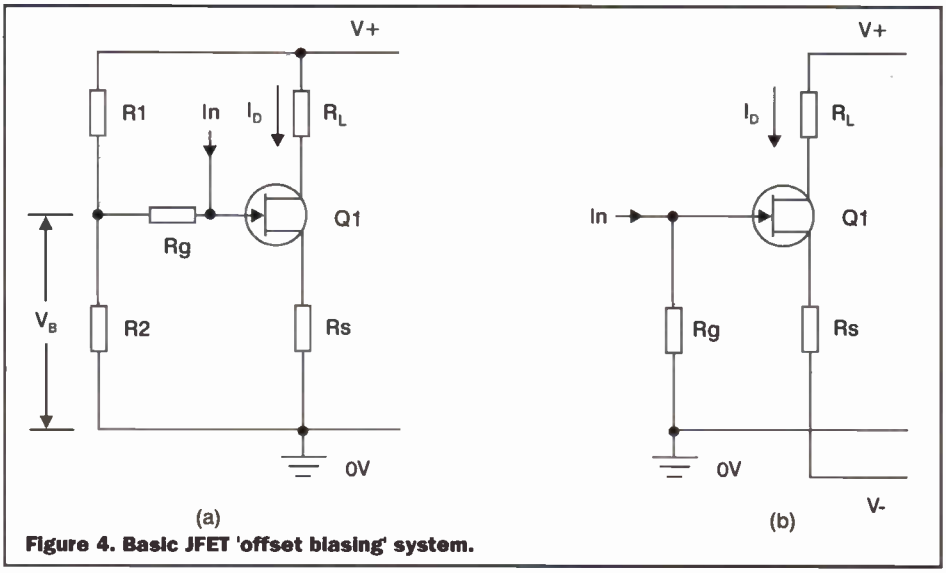


Figure 4. Basic JFET 'offset biasing' system.

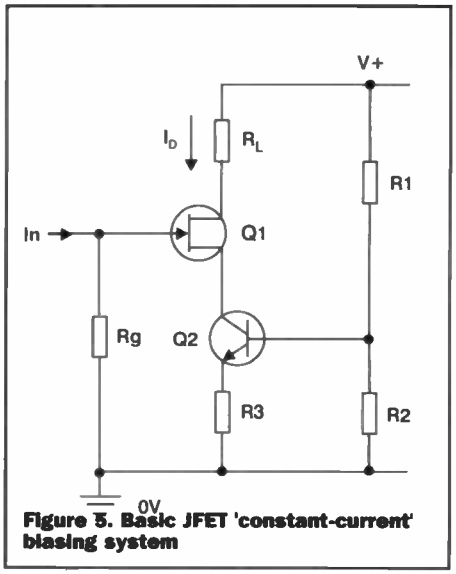


Figure 5. Basic JFET 'constant-current' biasing system

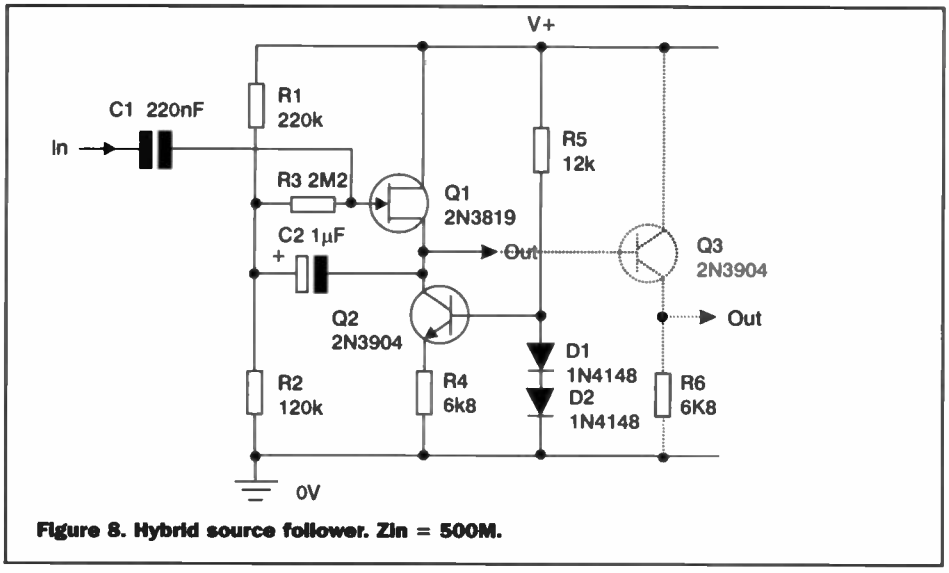


Figure 8. Hybrid source follower. Zin = 500M.

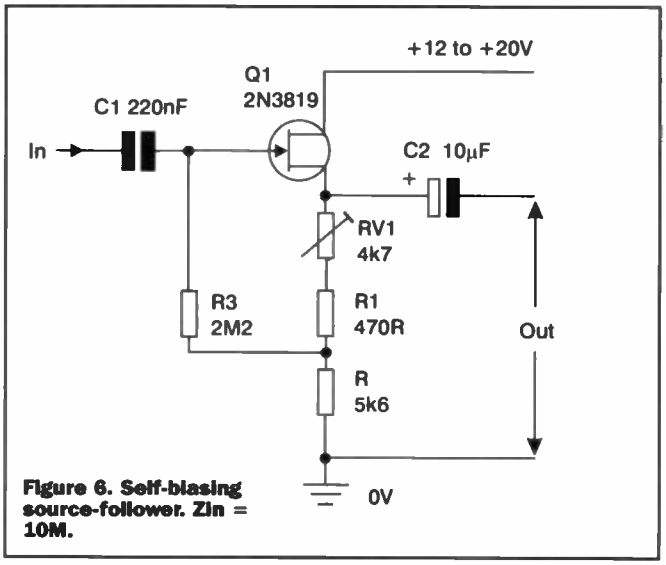


Figure 6. Self-biasing source-follower. Zin = 10M.

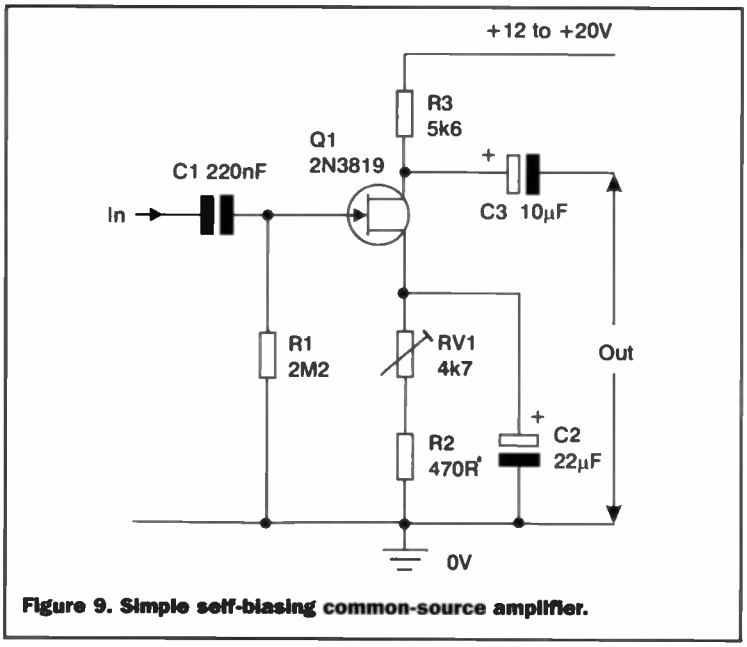


Figure 9. Simple self-biasing common-source amplifier.

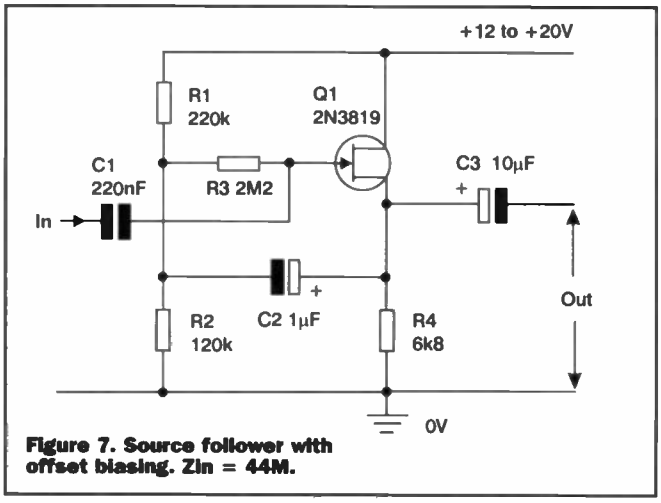


Figure 7. Source follower with offset biasing. Zin = 44M.

Source Follower Circuits.

When used as linear amplifiers, JFETs are usually used in either the source follower (common drain) or common-source modes. The source follower gives a very high input impedance and near-unity voltage gain (hence the alternative title of 'voltage follower'). Figure 6 shows a simple self-biasing (via RV1) source follower; RV1 is used to set a quiescent R2 volt-drop of 5V6. The circuit's actual input-to-output voltage gain is 0.95. A degree of bootstrapping is applied to R3 and increases its effective impedance; the circuit's actual input impedance is 10M shunted by 10pF, i.e., it is 10M at very low frequencies, falling to 1M0 at about 16kHz and 100k at 160kHz, etc.

Figure 7 shows a source follower with offset gate biasing. Overall voltage gain is about 0.95. C2 is a bootstrapping capacitor and raises the input impedance to 44MΩ, shunted by 10pF.

Figure 8 shows a hybrid (JFET plus bipolar) source follower. Offset biasing is applied via R1-R2, and constant-current generator Q2 acts as a very-high-impedance source load, giving the circuit an overall voltage gain of 0.99. C2 bootstraps R3's effective impedance up to 1000M, which is shunted by the JFET's gate impedance; the input impedance of the complete circuit is 500M, shunted by 10pF. Note than if the high effective value of input impedance of this circuit is to be maintained, the output must either be taken to external loads via an additional emitter follower stage (as shown dotted in the diagram) or must be taken only to fairly high impedance loads.

Common Source Amplifiers.

Figure 9 shows a simple self-biasing common source amplifier; RV1 is used to set a quiescent 5V6 across R3. The RV1-R2 biasing network is AC - decoupled via C2, and the circuit gives a voltage gain of 21dB (= x12), and has a ±3dB frequency response that spans 15Hz to 250kHz and an input impedance of 2M2 shunted by 50pF (this high shunt value is due to Miller feedback, which multiplies the JFET's effective gate-to-drain capacitance by the circuit's x12 Av value).

Figure 10 shows a simple self-biasing headphone amplifier that can be used with headphone impedances of 1k or greater. It has a built-in volume control (RV1), has an input impedance of 2M2, and can use any supply in the 9V to 18V range.

Figure 11 shows a self-biasing add-on pre-amplifier that gives a voltage gain in excess of 20dB, has a bandwidth that extends beyond 100kHz, and has an input impedance of 2M2. It can be used with any

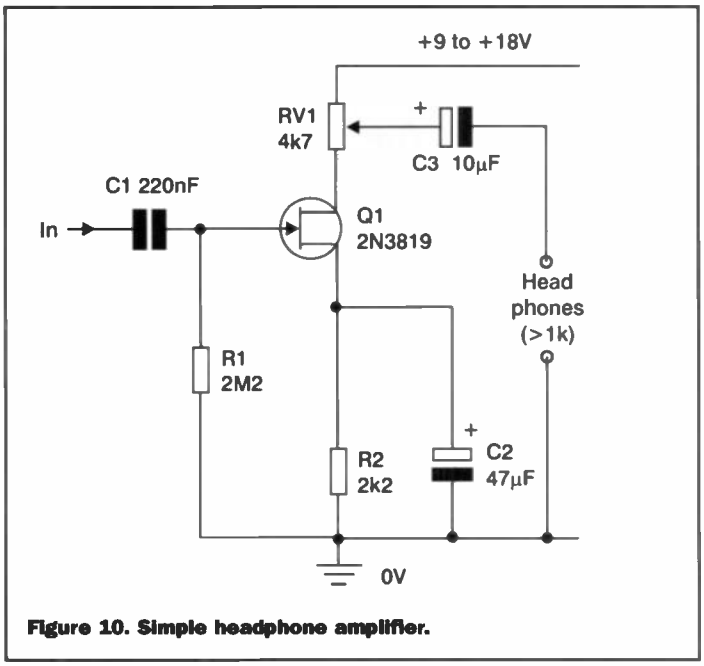


Figure 10. Simple headphone amplifier.

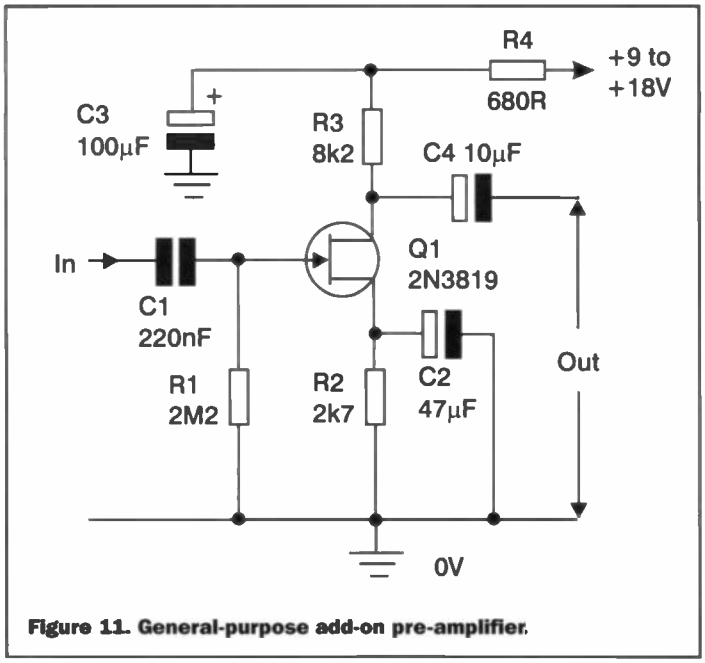


Figure 11. General-purpose add-on pre-amplifier.

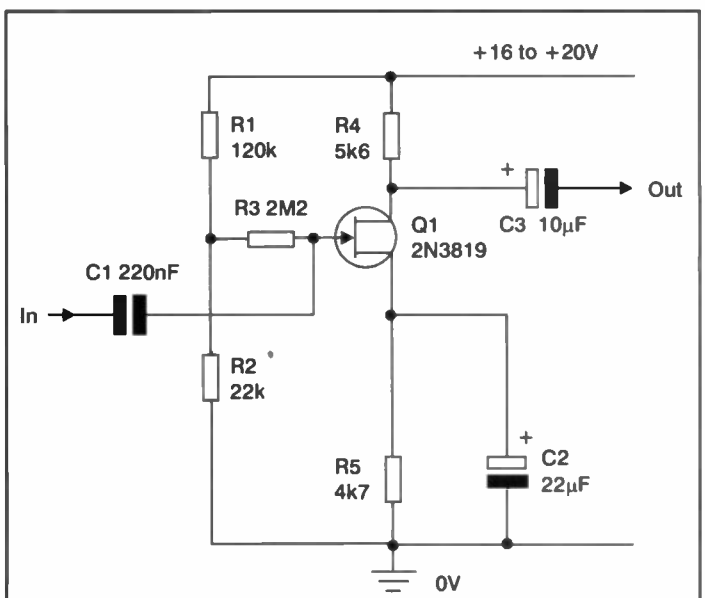


Figure 12. Common-source amplifier with offset gate biasing.

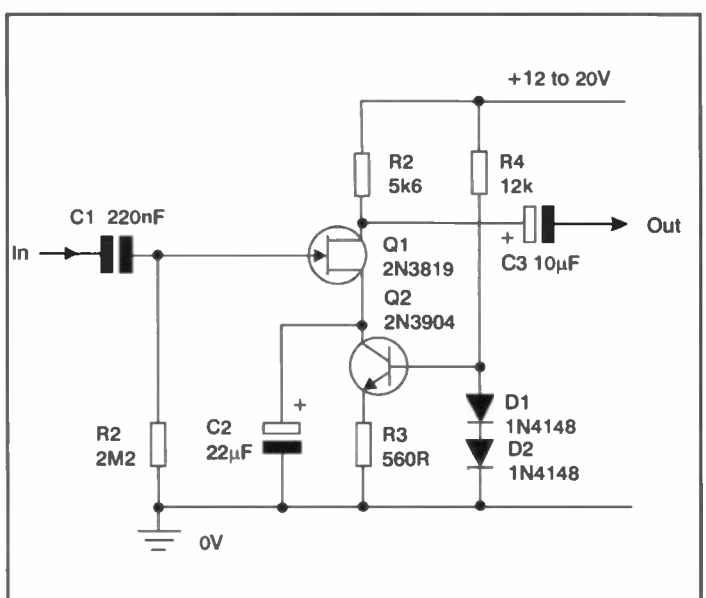


Figure 13. 'Hybrid' common-source amplifier.

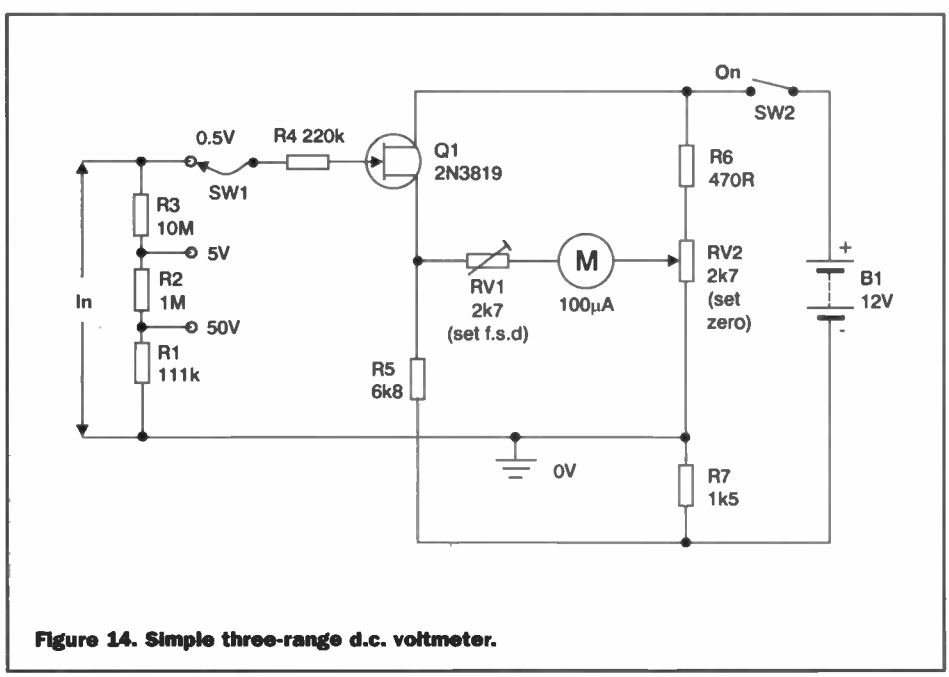


Figure 14. Simple three-range d.c. voltmeter.

amplifier that can provide a 9V to 18V power source.

JFET common source amplifiers can, when very high biasing accuracy is needed, be designed using either the 'offset' or 'constant-current' biasing technique. Figures 12 and 13 show circuits of these types. Note that the 'offset' circuit of Figure 12 can be used with supplies in the range 16V to 20V only, while the hybrid circuit of Figure 13 can be used with any supply in the 12V to 20V range. Both circuits give a voltage gain of 21dB, a ±3dB bandwidth of 15Hz to 250kHz, and an input impedance of 2M2.

DC Voltmeters

Figure 14 shows a JFET used to make a very simple and basic 3-range DC voltmeter with a maximum FSD sensitivity of 0.5V and an input impedance of 11M1. Here, R6-RV2 and R7 form a potential divider across the 12V supply and, if the R7-RV2 junction is used as the circuit's zero-voltage point, sets the top of R6 at +8V and the bottom of R7 at -4V.

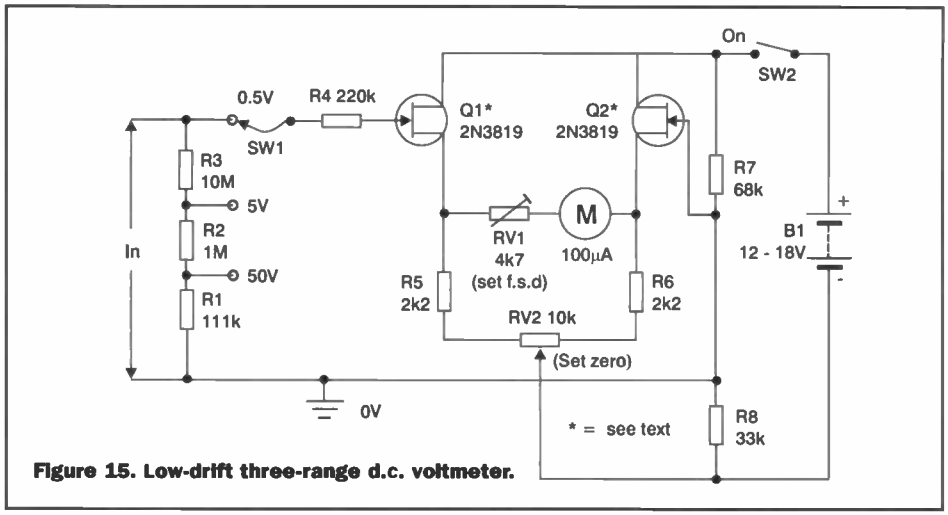


Figure 15. Low-drift three-range d.c. voltmeter.

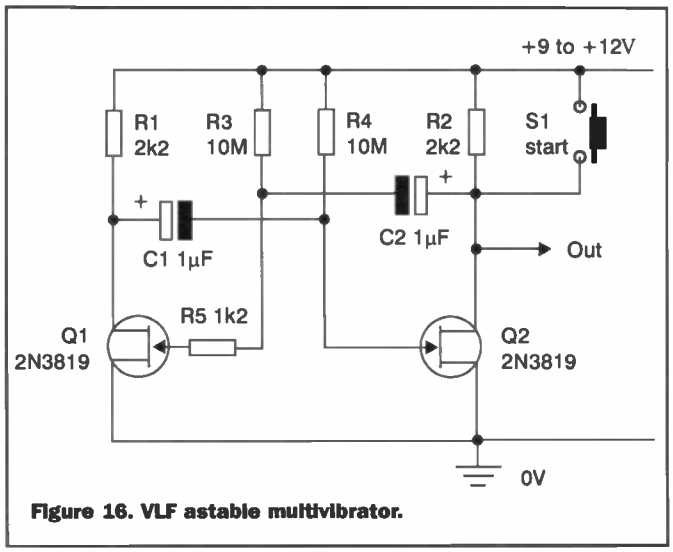


Figure 16. VLF astable multivibrator.

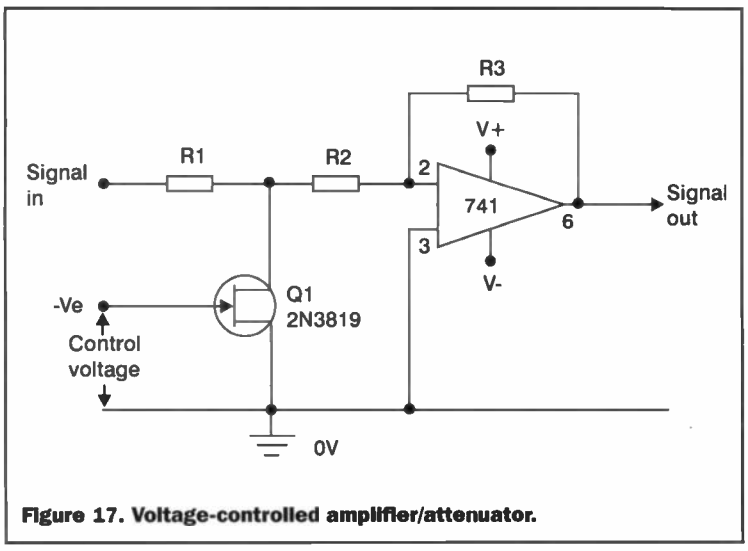


Figure 17. Voltage-controlled amplifier/attenuator.

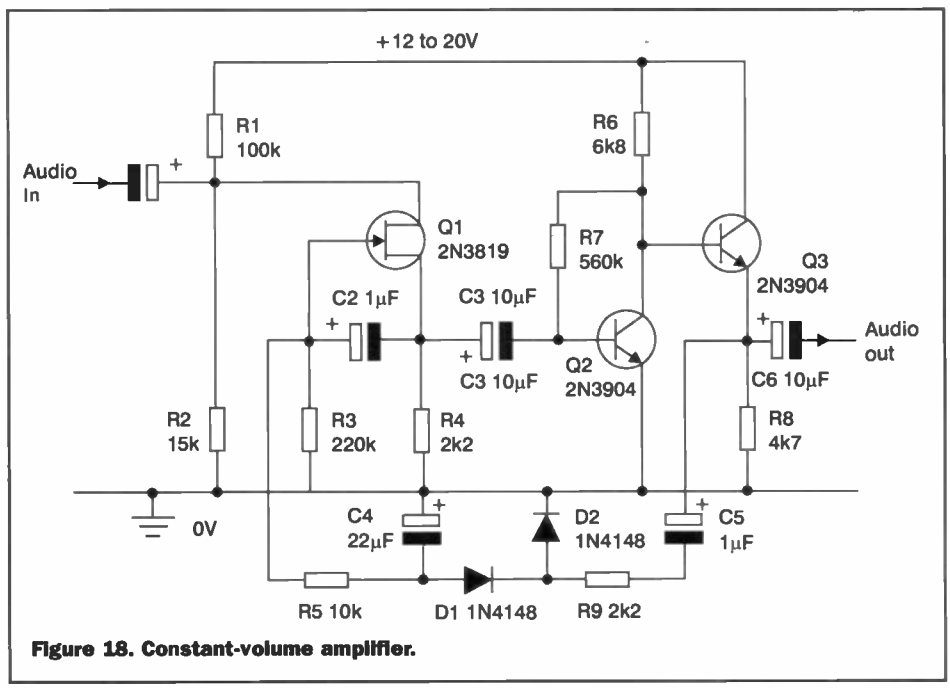


Figure 18. Constant-volume amplifier.

periods are controlled by C1-R4 and C2-R3, and R3 and R4 can have values up to 10M. With the values shown, the circuit cycles at a rate of once per 20 seconds, i.e. at a frequency of 0.05Hz; start button S1 must be held closed for at least one second to initiate the astable action.

Figure 17 shows, in basic form, how a JFET and a 741 op-amp can be used to make a voltage-controlled amplifier/attenuator. The op-amp is used in the inverting mode, with its voltage gain set by the R2/R3 ratio, and R1 and the JFET are used as a voltage-controlled input attenuator. When a large negative control voltage is fed to Q1 gate the JFET acts like a near-infinite resistance and causes zero signal attenuation, so the circuit gives high overall gain, but when the gate bias is zero the FET acts like a low resistance and causes Q1 is used as a source follower, with its gate grounded via the R1 to R4 network and is offset biased by taking its source to -4V via R5; it consumes about 1mA of drain current.

In Figure 14, R6-RV2 and Q1-R5 act as a Wheatstone bridge network, and RV2 is adjusted so that the bridge is balanced and zero current flows in the meter in the absence of an input voltage at Q1 gate. Any voltage applied to Q1 gate then drives the bridge out of balance by a proportional amount, which can be read directly on the meter. R1 to R3 form a range multiplier network that, when RV1 is correctly adjusted, gives f.s.d. ranges of 0.5V, 5V, and 50V. R4 protects Q1's gate against damage if excessive input voltage is applied to the circuit.

To use the Figure 14 circuit, first trim RV2 to give zero meter reading in the absence of an input voltage, and then connect an accurate 0.5V DC to the input and trim RV1 to give a precise full-scale meter reading. Repeat these adjustments until consistent zero and full-scale readings are obtained; the unit is then ready for use. In practice, this very simple circuit tends to drift with variations in supply voltage and temperature, and fairly frequent trimming of the zero control is needed. Drift can be greatly reduced by using a Zener-stabilised 12V supply.

Figure 15 shows an improved low-drift version of the JFET voltmeter. Q1 and Q2 are wired as a differential amplifier, so any drift occurring on one side of the circuit is automatically countered by a similar drift on the other side, and good stability is obtained. The circuit uses the 'bridge' principle, with Q1-R5 forming one side of the bridge and Q2-R6 forming the other. Q1 and Q2 should ideally be a matched pair of JFETs, with IDSS values matched within 10%. The circuit is set up in the same way as that of Figure 14.

Miscellaneous JFET Circuits

To conclude this month's article, Figures 16 to 19 show a miscellaneous collection of useful JFET circuits. The Figure 16 design is that of a very-low-frequency (VLF) astable or free-running multivibrator; its on and off

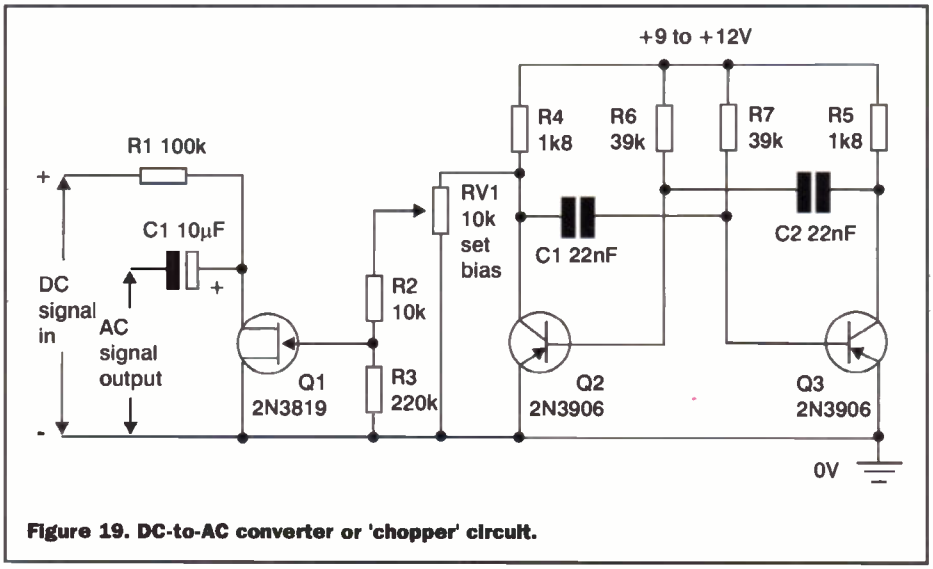


Figure 19. DC-to-AC converter or 'chopper' circuit.

heavy signal attenuation, so the circuit gives an overall signal loss. Intermediate values of signal attenuation and overall gain or loss can be obtained by varying the control voltage value.

Figure 18 shows how this voltage-controlled attenuator technique can be used to make a 'constant volume' amplifier that produces an output signal level change of only 7.5dB when the input signal level is varied over a 40dB range (from 3mV to 300mV rms). The circuit can accept input signal levels up to a maximum of 500mV rms. Q1 and R4 are wired in series to form a voltage-controlled attenuator that controls the input signal level to common emitter amplifier Q2, which has its output buffered via emitter follower Q3. Q3's output is used to generate (via C5-R9-D1-D2-C4-R5) a DC control voltage that is fed back to Q1's gate, thus forming a DC negative-feedback loop that automatically adjusts the overall voltage gain so that the output signal level tends to remain constant as the input signal level is varied, as follows.

When a very small input signal is applied to the circuit, Q3's output signal is also small, so negligible DC control voltage is fed to Q1's gate; Q1 thus acts as a low resistance under this condition, so almost the full input signal is applied to Q2 base, and the circuit gives high overall gain. When a large input signal is applied to the circuit, Q3's output signal tends to be large, so a large DC. negative control voltage is fed to Q1's gate; Q1 thus acts as a high resistance under this condition, so only a small part of the input signal is fed to Q2's base, and the circuit gives low overall gain. Thus, the output level stays fairly constant over a wide range of input signal levels; this characteristic is useful in cassette recorders, intercoms, and telephone amplifiers, etc.

Finally, Figure 19 shows a JFET used to make a DC-to-AC converter or 'chopper' that produces a squarewave output with a peak amplitude equal to that of the DC input voltage. In this case Q1 acts like an electronic switch that is wired in series with R1 and is gated on and off at a 1kHz rate via the Q2-Q3 astable circuit, thus giving the DC-to-AC conversion. Note that Q1's gate-drive signal amplitude can be varied via RV1; if too large a drive is used, Q1's gate-to-source junction starts to avalanche, causing a small spike voltage to break through the drain and give an output even when no DC input is present. To prevent this, connect a DC input and then trim RV1 until the output is just on the verge of decreasing; once set up in his way, the circuit can be reliably used to chop voltages as small as a fraction of a millivolt.

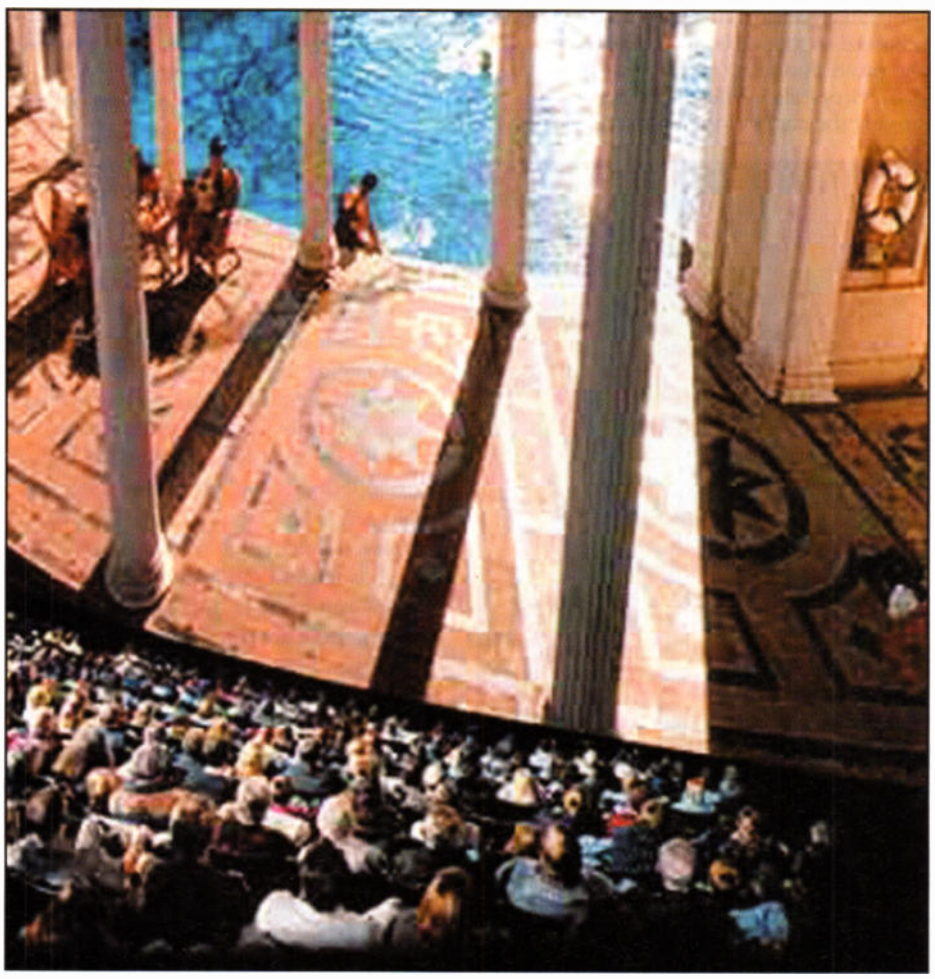
TECHNOLOGY WATCH

With Martin Pipe

The End of Film?

For some time now, cinemagoers have thrilled to the benefits of digital surround sound. In the early 1990s, three rival systems started making their presence felt. Quite literally, because all three systems specify dedicated subwoofer speakers. The systems are Dolby Digital, DTS (Dynamic Theater Sound) and SDDS (Sony Dynamic Digital Sound). The first two are known as '5.1' systems - they offer a discrete centre (dialogue and on-screen effects), two surround (ambient effects) and two front (stereo) channels in addition to the sub. SDDS is a '7.1' system - the two other channels, which drive more surround speakers, are employed to enhance ambience. The first two systems can be replicated in the home, thanks to digital surround decoders, multi-channel amplifiers and DVD players. It's amusing to note that some top-end home cinema set-ups sound noticeably better than some cinema installations. Although the MPEG2-based DVD format is capable of delivering pleasing results, particularly through a big-screen 16:9 TV, it falls dramatically short of the picture quality offered by cinema screens. Your local picture palace's sound system may be digital - but those impressive pictures are derived from good old-fashioned photographic emulsion. How much more analogue can you get?

Still photography is, of course, going digital - slowly but surely. Digital cameras and colour inkjet printers are falling in price, and increasing in performance. Today's high-end enthusiast cameras have image sensors with resolutions of over 2.5 million pixels. Soon, they will begin to approach the resolution of APS, and possibly 35mm, film. Traditional film will perhaps only appeal to professionals, who won't better the resolution of their medium- and large-format cameras for some time to come. Most purist camera shops now offer a range of digital models alongside their existing goodies. Even the real photographic snobs are beginning to convert - my college photography lecturer admits to possessing a scanner, printer and Adobe Photoshop. Within a couple of years, digital cameras will have progressed to the point where even he would consider one. The advantages - low cost, instant preview, Internet-friendliness, manipulation potential and cheap A4-size prints.



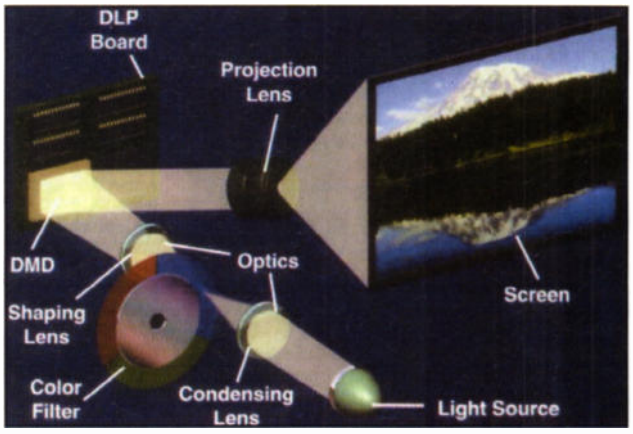
It will be some time before digital will offer the resolution needed by large screens, such as this Iwerks installation at Hearst Castle, California

Digital Cinemas

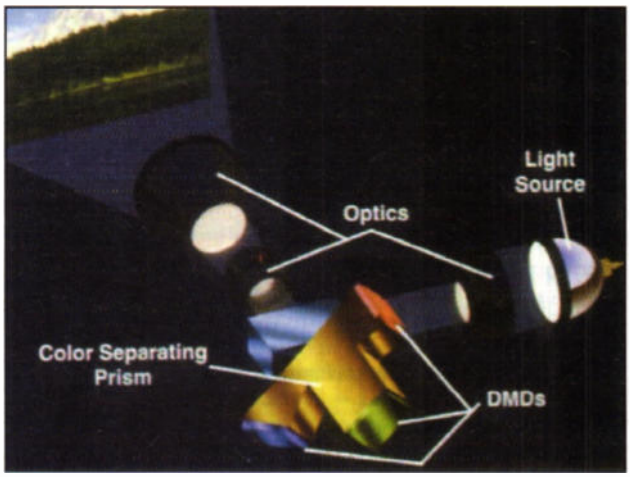
Digital imaging could soon be making in-roads into cinematography - the last bastion of film. George Lucas' Star Wars saga is rightly considered to have been one of cinema's most pioneering contributions. Not only did the original 1977 film revive the flagging science fiction genre and introduce ground-breaking special-effects, but it was the first film on general release to make use of the analogue Dolby Stereo surround system. Last year saw the release of the long-awaited Episode One 'prequel'. This, too, was pioneering in at least two areas of technology. Not only did it prominently feature a 'synthespian' character that didn't simply exist outside the CGI domain (Jar Jar Binks, love him or hate him!), but it was the first movie to be screened digitally to a public audience- no celluloid to be seen anywhere. Last June, digital projection was employed to show Episode One in four cinemas across the Atlantic. Two of the 'theaters' were in New Jersey, while the others were in California. Not that the Americans get it all their own way - the latest Bond film, The World is Not Enough, received its premiere at a digital cinema in London. George Lucas doesn't get it all his way, either. The first digital screening of a movie was Shakespeare in Love, at a NAB convention.

At the four American Star Wars cinemas, the traditional optical projector was replaced with a specially-built high-resolution widescreen DLP (Digital Light Processing) unit from Texas Instruments. Further information on the underlying technology can be obtained from www.ti.com/dlp/. The unit wasn't much bigger than the data projectors used in conference rooms and lecture theatres. I can imagine the projectionist being quite happy, because he's suddenly got a lot more space in his booth! The TI projector's lens was bigger than that of a standard data projection, being approximately 18 inches long and 4 inches in diameter. It stretched

The DTS 6AD digital surround decoder for cinemas. Here, the movie soundtrack is stored on CD-ROMs, and synchronised with a timecode track found on the film. The prototype digital systems must have similar synchronisation arrangements, because the audio and video streams are stored on separate hard disk arrays



How a single-DMD DLP projector works

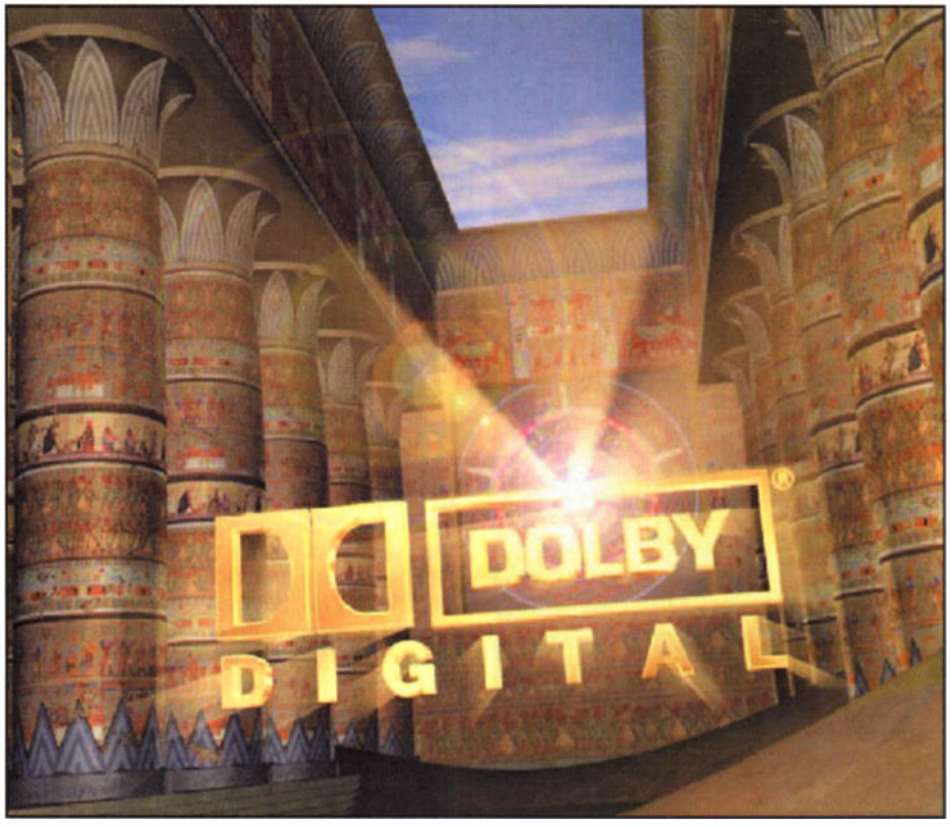


How a triple-DMD DLP projector works

the picture horizontally to give the cinematic aspect ratio. Another difference was the light source, which was rather more powerful than the type fitted to data projectors because of the larger room it has to serve. The resolution of the TI projector was a non-interlaced 1800 x 1200, and its picture was refreshed at the same 24 frames per second of conventional projectors. This isn't quite as good as a release film print, which has an effective resolution of at least 3000 x 1800 pixels - and a superior contrast range to boot. On the other hand digital images are rock-steady, with no shifting caused by mechanical intolerances; what's more, there's no film grain to worry about

Lesser-specified DLP projectors have been available for around four years now. You'll find them in conference rooms and - ironically enough - high-end home cinema installations. They're much more efficient at transmitting light than LCD screens, meaning brighter pictures from lower-powered lamps. LCDs also suffer from a 'honeycomb' pattern produced by the individual pixels. DLP projectors don't have this problem, which would be obvious on cinema screens! At the heart of all DLP projectors is a display chip known as a DMD (Digital Micromirror Device), which is built up of countless microscopic (16μm) 'micromirrors', arranged in a matrix. The DMD chip at the heart of the Star Wars prototype projector, for example, contained over two million. The position of each individually-addressable micromirror can be adjusted so that its light is reflected towards the projection lens (on) or away from it (off). Greyscale is effected by accurately varying the angle of the mirror. Lower-cost DLP projectors employ one DMD, using a RGB filter to provide colour. Professional projectors, including the Star Wars prototype, employ a total of three DMDs - one for each primary colour. Both types are shown in the accompanying diagrams.

One of the New Jersey sites (Paramus) didn't use the TI projector. This site was instead served by an off-the-shelf model from Hughes-JVC Technology (a wholly-owned subsidiary of Japanese giant JVC). This unit, installed by CineComm Digital Cinema, was much larger than the TI unit - visitors to the projection booth described its size as equivalent to "three (American) fridges". For its display, Hughes-JVC developed a technology known as 'Image Light Amplifier'. Here, the images are displayed onto a high-resolution LCD panel, which is used to modulate the light source (a 7kW xenon arc lamp). Unlike the TI system, there are separate lenses, light sources and LCD panels for the red, green and blue elements of the picture. They're combined on the screen to produce a colour picture. Unfortunately, the system needs to be set up so that the three pictures are in correct alignment - otherwise you'll get colour fringing. Installers of the early colour video projectors, which contained three tubes, had to go through this 'convergence' procedure. In this case the (interlaced) display had a resolution of 1920 x 1080, and was refreshed at the US TV rate of 30 frames per second.



The Dolby Digital surround-sound system is popular in cinemas and home installations alike

Even today's highest-resolution (XGA, or 1024x768) data projectors, such as this Digital Projection model, are not good enough for cinematic presentations. The TI prototype used for the Star Wars presentations was similar in physical appearance, though

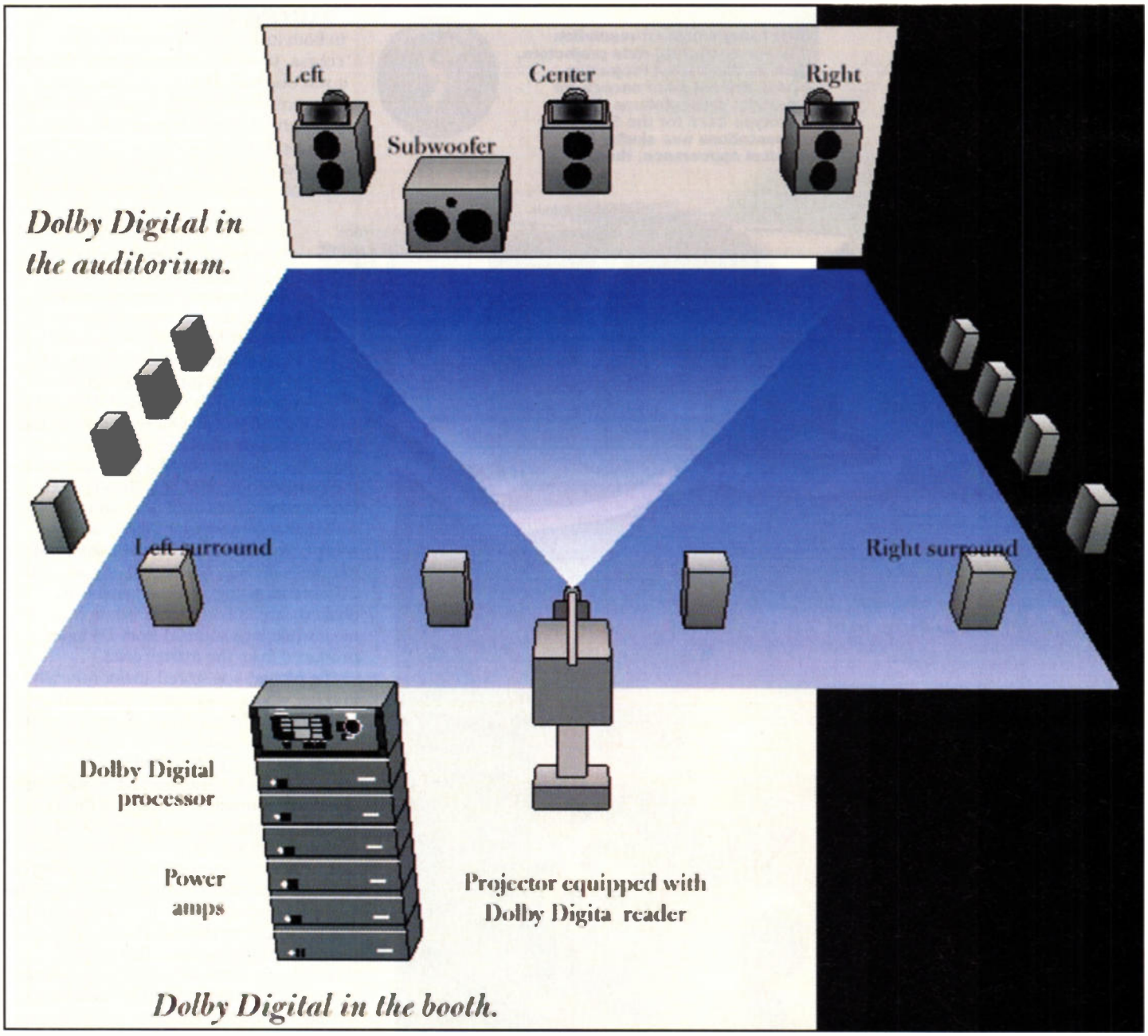
Star Wars Episode One - the first movie to be digitally-screened for the benefit of a fee-paying audience

Storage

In both instances the movie was, of course, stored by digital means - although it was originally derived from an optical print, presumably using some kind of high-resolution telecine machine. Built into a flight-cased rack of electronics was a Pluto Hyperspace disk array. This unit was directly connected to the TI projector via a fibre-optic link. The JVC/Hughes projector, meanwhile, was connected indirectly to the Hyperspace via RGB/sync - an intermediate Panasonic HDTV converter was responsible for converting the digitally-stored movie into analogue means. The Pluto drive array consisted of twenty 18Gb SCSI hard disks, giving a total of 360Gb. Our projectionist had better become computer-literate, or he might find himself out of a job... Apparently, the picture content of Star Wars Episode One occupied 300Gb of this - and that's with digital compression. To ensure an acceptable picture quality, the compression rate was only 4:1 (compare that with MPEG-2 TV broadcasting!). The original NAB Shakespeare in Love demonstration, meanwhile, was sourced from D5 tapes produced from the master print.

The picture was stored anamorphically - in other words, horizontally-squeezed (widescreen TV broadcasting uses the same approach). To obtain the correct 2.39:1 aspect ratio, the picture had to be correspondingly unsequeezed. Stretching was done optically in the case of the TI system, and through a combination of optical and electronic (i.e. the Panasonic converter) in the case of the JVC-Hughes. A separate rack of electronics stored the 24-bit Dolby EX-encoded surround sound, which was fed into the cinema's existing THX-compliant sound system. This was timecode-synchronised to the video using an interface between the video and audio storage units. The DTS Cinema system, currently found in over 15,000 cinemas worldwide, works along similar lines. In the case of DTS, though, the sound is stored on several CD-ROMs and the timecode derived from a special track on the optical print.

Some moviegoers appeared to be quite impressed, certainly with the TI system. Others compared the experience to "watching a big TV set". One viewer reported a bright, uniformly-focused screen with no 'hot-spots'. Colour reproduction was said to be 'amazing', although pixellation was occasionally noticed. There was also a bleached appearance to some scenes (notably those shot in the Tatooine desert). A technician explained that the film-to-video transfer was responsible. The Paramus attendees weren't quite as impressed, apparently. They reported an inferior contrast range relative to film, muted colour, motion artifacts and the same occasional bleaching that plagued the TI. It is not known, however, whether the average attendee understood the full implications of what they had just seen. Traditionally, movies are filmed using expensive 35mm or 70mm cameras, which cost thousands of dollars a day to rent (apparently, the studios



How the speakers in a typical cinema - in this case a Dolby Digital one - are arranged. Existing speaker set-ups can be retained following the move to digital

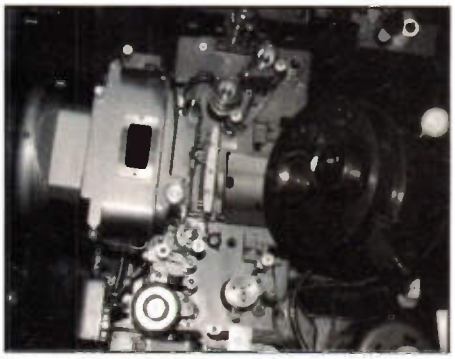
can't actually buy them). Where computers are used to provide graphic sequences, they're printed to film using a special film recorder. The film stock is developed, and then physically edited by adding or removing sections, and title sequences spliced on. An accurately-synchronised soundtrack is then added, resulting in a master copy. This process is then followed by duplication, in which multiple copies ('release prints') are churned out for cinemas worldwide.

Film Problems

There are two problems here - longevity and cost. If you catch a movie towards the end of its run at the local cinema, scratches and other nasties - the result of running the film through the projector on numerous occasions over a six-week run - are only too apparent. In practical terms, a digital movie would never wear out. Modern hard disks have mean-time-to-failure specifications measured in the tens of thousands of hours! Those cinema release prints are exceptionally expensive, costing up to three thousand dollars each (most movies span several reels). They're also quite expensive to distribute, weighing 60 pounds each. If the movie was to be stored digitally, the possibility of virtual distribution is opened up.

Chances are that within ten years, you might start seeing satellite dishes on top of your local Odeon. Satellite would be the obvious choice for distribution, because of the large bandwidth available. Remember that 300Gb is quite an amount of data! Fibre optic networks of the guaranteed capacity required aren't yet sufficiently widespread, and a collection of delicate disk drives would be just as expensive to distribute as canisters of film! The studios would book transponders, and simultaneously transfer the movie to all of the cinemas (in a given region) that paid to show it. Chances are that the receiving process would be an overnight one, conducted automatically. Satellite distribution speeds up the release of a movie - according to one industry source, a movie could be finished on Thursday and in the cinemas by Friday! The movie data would be encrypted and 'fingerprinted' to reduce the risk of piracy. Note that satellite links and electronic displays pave the way for big-screen high-resolution coverage of live events, such as football matches and tennis. I'm sure that the opportunities are not lost on Mr. Murdoch and those of his ilk.

Without the need to produce optical prints, there would be no need to work with film at all. Movies could be produced entirely in the electronic domain - all the way from high-definition digital movie camera, through editing, effects and soundstage, all the way to cinema projection screen. Movie studios like the idea, because it would save them a considerable amount of time and money in the long run! George Lucas, it is said, already has plans for all-digital movie production. It would take some time, however, for the world's cinemas to upgrade their projection



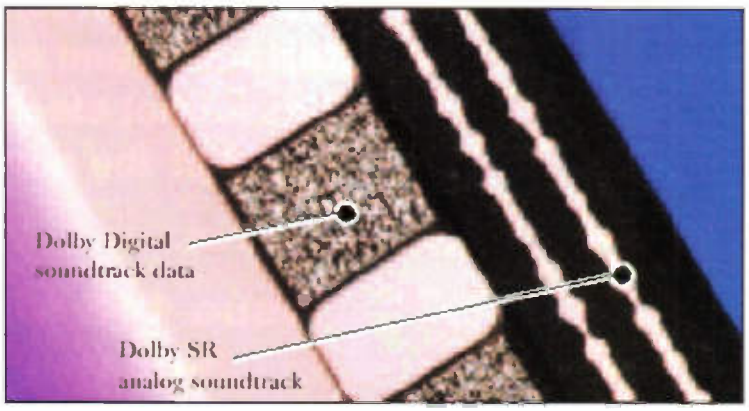
Close-up view of a traditional cinema projector - this one is a Cinemeccannica Victoria 8, capable of handling 35mm and 70mm film and featuring interchangeable lenses for different widescreen formats (such as 1:1.85 and Cinemascope)

Films usually span several reels. These are loaded, in advance, onto platters like these. Continuity is thereby provided during the presentation. Such hassles are a thing of the past in the brave new world of digital projection

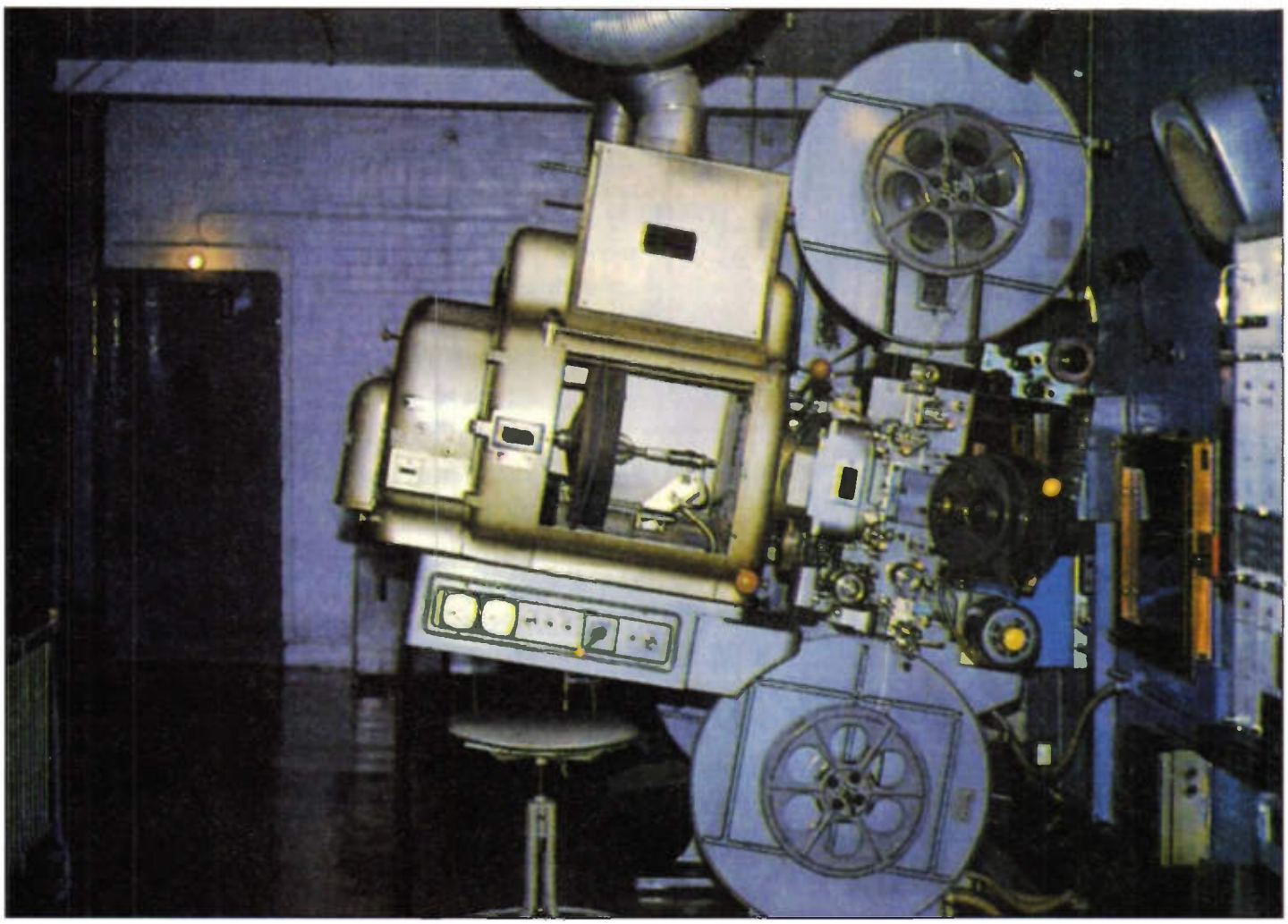
equipment. Digital projection equipment has an estimated price in the region of $80,000 - twice that of a film projector. The same screen, speakers and amplifiers could be used, though. In any case, the cinemas would appreciate the benefits. No longer would managers have to worry about a popular blockbuster's release print failing to arrive on time. But could digital mean the end of smaller independent cinemas without the money to invest in new projectors? Who knows...

One thing's for sure. Computers and movies are already hopelessly intertwined. There are many examples other than Star Wars' Jar Jar Binks. One thinks of the computer-generated extras on board Titanic, the digital compositing techniques used in Forrest Gump, the T1000 of Terminator 2, Jurassic Park's dinosaurs and of course entire computer-animated epics like Toy Story and Antz. With digital distibution/projection, the connection is brought several stages further. This is undoubtedly the direction in which 21st-century movies are headed. Ironically, home cinema enthusiasts already have a high-quality digital video source, in the form of DVD. Presently, the discs are derived from an optical print - but this could change very soon...

Martin Pipe welcomes comments and ideas. E-mail him as:martin@webshop.demon.co.uk Or look out for him online! His ICQ ID is: 15482544



How film was modified to accommodate Dolby Digital multi-channel audio - its crammed into the space between the spocket holes. Analogue stereo has been provided as a back-up



Inside the viewing room of a typical cinema. Think of all the room that that would be released if its owners were to switch to TI's digital projectors!

Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering, side cutters, pliers, wire strippers, and screwdriver). Test gear not required and no setting-up needed.

Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

Average. Some skill in construction or more extensive setting-up required.

Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

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