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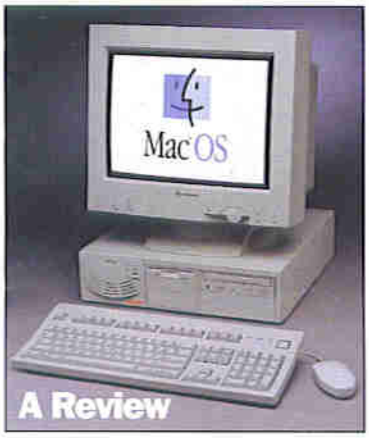
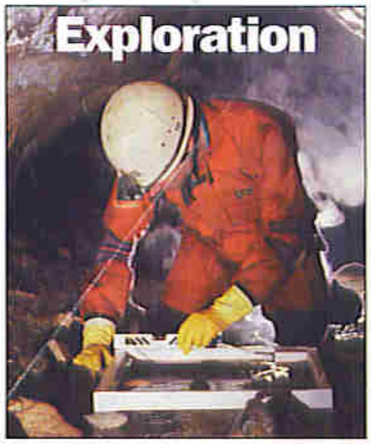
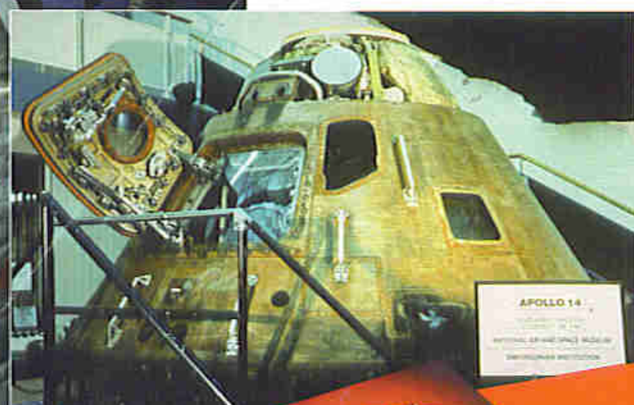


A Review

Cave Radio & Electronics



Exploration



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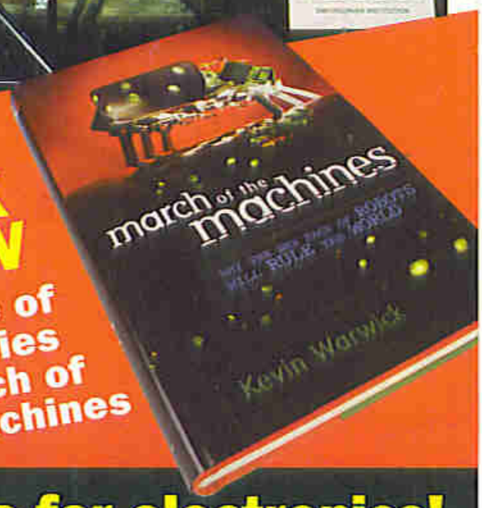

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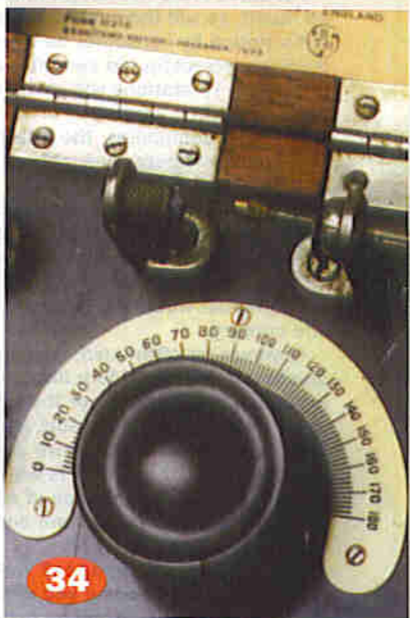

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ELECTRONICS and Beyond

Information Overload – Some would say it's almost here! Just what are we going to do with 400 TV digital channels and hundreds of digital radio stations, let alone a rapidly expanding Internet system and some areas of printed information?

For sure, there will not be enough advertising support to go round, so will the cushioning effect of sponsorship or subscription by consumer be enough to keep them going? It will be interesting to see after a few years what the total number of TV stations will settle down to after consumers have given their verdict.

For most companies, the Internet is an extension of their PR machine effectively supplying information for free and it has given the chance for smaller companies to be heard out there. The Internet could be regarded as the modern-day encyclopedia of information but with a wide ranging acceptability of taste, bias and impartiality. Being global and universally accessible, it must incorporate subjects and opinions that would not necessarily be seen or read in any one country.

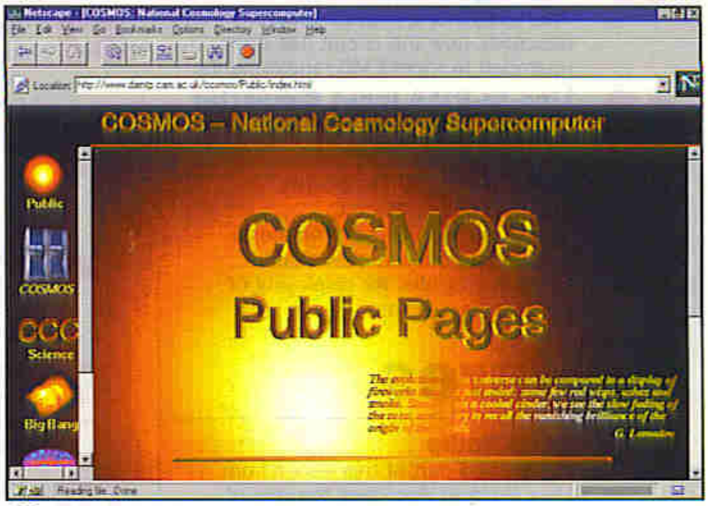
However, as often said, we can always 'switch off' the electronic versions. More difficult to switch off is the unsolicited printed mail or the telephone/fax. Most of us by now must only give a passing glance at junk mail before it goes into the bin. Here, there is a physical act of doing something about it, which is why many companies out there reckon it is the best chance of catching our attention. This also applies to the telephone and again a response mechanism is required to say 'No'.

What is all this leading to? Well, if you find the subject fascinating or infuriating you might just be interested in a series of articles that will be appearing in future months of Electronics and Beyond.

Paul Freeman-Sear, Publishing Manager

Britain's Best Magazine for the Electronics Enthusiast

NEWS REPORT



Supercomputer Installed to Support UK Cosmology Research

UK scientists investigating the history of the universe have installed a new supercomputer at Cambridge University to support their research. The Silicon Graphics Origin2000 supercomputer, valued at £2 million, has been named COSMOS.

COSMOS will be owned and used by a nationwide group of cosmologists, the UK Computational Cosmology Consortium (UK-CCC). Members of the Consortium say that COSMOS represents a vital step in maintaining and enhancing the UK's high international standing in this competitive field of research.

The new computer will enable UK theorists to model the history of the universe from the first fractions of a second after the Big Bang right through to the present day, some ten billion years later.

Professor Stephen Hawking, principal investigator of the UK-CCC, told *Electronics and Beyond*, "The COSMOS will enable us to calculate what our theories of the early universe predict and test them against the new observational results that are now coming in".

For further details, check: **www.damtp.cam.ac.uk/cosmos.**

Contact: University of Cambridge, Tel: (01223) 332300.

CD-ROM Speeding Hype

CD-ROM drives are getting faster, but industry analysts say consumers should beware of marketing hype. According to analyst house Disk/Trend, the speed race that is going on between the CD-ROM drive vendors is more for the benefit of the PC makers than consumers. With an 8x drive transferring data at about 1,200 kilobytes per second, most experts say that's plenty, even for video playback.

Contact: Disk/Trend, Tel: +1 415 961 6209.

Cisco Establishes Development Centre in Israel

Cisco Systems has opened a development centre in Israel to support its engineering facilities in San Jose, California. One of its first priorities will be to support Cisco's push into gigabit switching and routing technology.

According to IDC, the IT market in Israel is growing as quickly as IT markets in Europe and throughout the world. IT spending in Israel totalled over $2 billion in 1996 and is expected to grow in the next three years at an annual rate of 14·9%.

By 2000, total IT spending in Israel is expected to surpass $3·5 billion. In comparison, global IT markets are expected to grow at an average annual rate of just more than 10% for the next three years.

For further details, check: www.cisco.com and www.idc.com.

Contact: Cisco, Tel: (0181) 756 8000.

Virtual Journey into a Circuit Board

Our modern lives rely on electronic circuit boards. But integrated circuits, the silicon chips which form the most vital component of electronic circuits are tiny, typically 5mm². How then, can we begin to imagine what these vital components look like?

The answer is to use virtual reality to shrink us down until the semiconductor appears more massive than a cathedral. Philips Semiconductors recently commissioned VR Solutions to do just that.

VR Solutions's models can be viewed in minute details – at the highest resolution, the hexagonal structure of the silicon itself seems to stretch on for miles.

For further details, check: www.sense8.ch/vrsolns/wel_e.htm.

Contact: VR Solutions, Tel: (0161) 745 7384.

Test-drive a PC at Software Warehouse

Following an exclusive deal with Software Warehouse, leading direct UK PC manufacturer, Viglen, is giving its customers the opportunity of a hands-on trial of a Viglen PC. Consumers are now able to visit any of Software Warehouse's eight stores, located throughout the UK, and get the same touch and feel opportunity as visiting the high street.

For further details, check: www.viglen.co.uk.

Contact: Viglen, Tel: (0181) 758 7000.

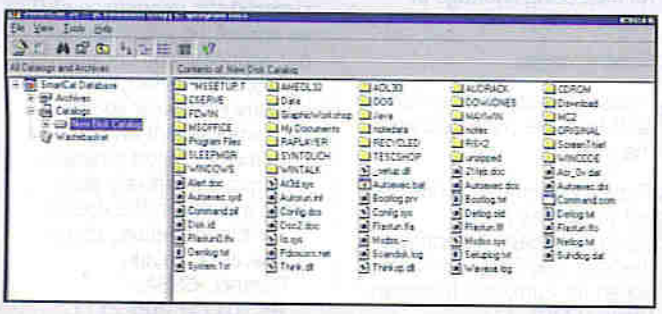
SmartCat Simplifies Data Management

A 32-bit file/media cataloguing and archiving utility launched this month makes it easy to archive, organise and subsequently find all your important data. SmartCat 97 from Oakley Data Services is tightly integrated into Windows Explorer and has the familiar Windows 95/NT4 look and feel for ease of use.

Priced at £25, SmartCat 97's cataloguing capabilities allow you to keep track of floppies and CDs including analysis of the internals of zip files and zip-based self-extractors. Powerful searching facilities allow you to track down that missing file wherever it is, by name, date or size.

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

Contact: Oakley Data Services, (01889) 565064.



Motor IC Selectable Up to 8-Step

The 25-pin IMT 901 from Nanotec is an IC driver for bipolar constant-current controlled stepper motors. With a voltage supply from 12 to 40V DC, the phase current can be set using fixed resistors up to 2·5A per phase. An innovation is the 2-bit selectable full/half/quarter/eight-step switch giving quasi-sinusoidal output signals.

Contact: Nanotec, Tel: +49 81 21 972 100.

NEWS BYTES

Compaq Celebrates Ten Years in Scotland with 200 More Jobs

Celebrating ten successful years of manufacturing in Scotland, Compaq announced 200 jobs to the manufacturing and customer service operations in Erskine, near Glasgow. The announcement builds on more than 260 positions created in 1996 and takes the workforce in Erskine to over 2,000 employees.

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

Contact: Compaq, Tel: (0181) 332 3000.

Europe's First Tree Mast

Orange has announced a range of new initiatives to improve the quality and breadth of its network coverage as well as a new experimental transmitter mast that looks like a tree.

The experimental tree-shaped telecommunications mast is situated near Cockermouth in the Borough of Allerdale, Cumbria, on the edge of the Lake District National Park. The design of the 'tree' is based upon a conifer, taking into consideration the types of real trees in the area. The 'tree' has been given the Latin nickname *Loquentes per arbores* – talking through the trees.

Orange will invest over £200 million in its network during 1997. By the end of 1997, we will have more than 3,300 sites that will further improve the service provided to our customers. It plans to cover 96% of the UK population by the end of 1997.

For further details, check: www.orange.co.uk.

Contact: Orange, Tel: (0800) 801080.

Power Amplifier Provides Stereo Solution

Expanding its line of audio power amplifiers, Texas Instruments has announced a 1·5W single-chip stereo audio solution. The new amplifier provides two 1·5W bridge-tied load (BTL) channels, a 600mW single-ended (SE) stereo line output and a stereo input MUX.

This device, designated the TPA0102, is capable of delivering greater than 1·5W of continuous RMS power per channel (BTL) into a 4W load. If single-ended drive is required, the TPA0102 provides 600mW of output power per channel.

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

Contact: Texas Instruments, Tel: (01784) 212000.

NEWS BYTES

Bromcom makes PC for Every Teacher a Reality

Bromcom's wireless administration network for schools wNET, will now be available with Microsoft Windows CE. The addition of Windows CE brings a new dimension to Bromcom's wireless network (wNET), already in use by over 10,000 teaching staff across the UK. The announcement gives teachers portable access to a familiar range of software packages such as Microsoft Pocket Word, Excel and Internet Explorer.

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

Contact: Bromcom, Tel: (0181) 461 3737.

CD-ROM Dictionary for Scientists, Students and Technologists

Liris Interactive has announced what it claims to be an indispensable source of information for scientists, students and technology enthusiasts alike, in the form of the Larousse Dictionary of Science and Technology, on a CD-ROM.

This unique CD features over 50,000 entries under 50 searchable subject headings, including such diverse areas as architecture, computer science, ecology, image technology, medicine and space. Also included are details of chemical structures, mathematical formulae and over 450 colour diagrams.

The Larousse Dictionary of Science and Technology is available immediately, priced £49.99.

For further details, contact: www.liris.com.

Contact: Liris Interactive, Tel: (01908) 575600.

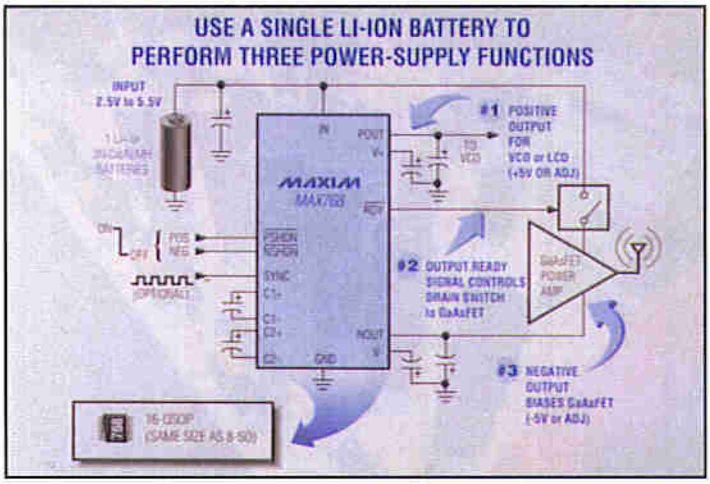
VLSI Launches Gigabit Silicon

VLSI has announced the industry's first commercially available gigabit Ethernet-class silicon for high-speed data networking applications. Available now, the VNS67500 will relieve networking traffic bottlenecks caused by the rapid increase in the transmission of large data and graphics files on corporate-based local area networks (LANs) and Intranets.

Utilising Media Access Controller (MAC) technology from Packet Engines, VLSI's offering will give users the ability to move large files (voice, data, graphics and video) over networks at the speed of one gigabit, or one billion bits, per second. The MAC defines protocols that control the way computer equipment communicates over an Ethernet link.

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

Contact: VLSI, Tel: (01908) 667595.



Maxim Devices Pump Action

The MAX768 is a small, low-noise, dual-output charge pump with a power-ready indicator. The device does three important jobs from a 3·6V lithium-ion battery: it biases a GaAsFET power amplifier, powers an LCD or voltage controlled oscillator and protects the GaAsFET by controlling the drain switch until the negative bias is within regulation.

Contact: Maxim, Tel: (0118) 930 3388.

Freespirit PC Card Provides Ultimate in Connectivity

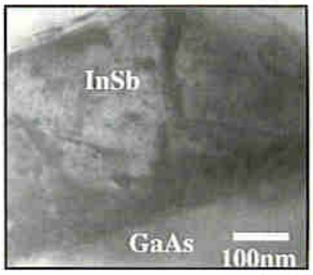
The Portable Add-ons' FreeSpirit PC Card modem is reckoned to be the first 33·6k-bps PC Card modem solution with GSM capabilities. Launched this month, it is certainly the first modem to combine high-speed fax/data communication via both a digital mobile phone and a conventional telephone line.

Portable Add-ons has also announced a 33·6k-bps version of the Portable Add-ons' Euromodem and free 33·6k-bps software upgrades for users of existing Portable Add-ons' 28·8k-bps modem products.

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

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

Chip-making Process Developed at Cornell



Researchers at Cornell University have developed a new process for making semiconductors that could result in lower manufacturing costs and new classes of chips.

The key to the new process is the creation of a universal substrate, or base, on which many different types of semiconductors can be built. With a universal substrate, there are no compatibility issues between the film deposited and the supporting substrate.

The result will be faster, more powerful chips that can be used for everything from PCs to fibre-optic telecommunications.

For further details, check: www.cornell.edu.

Contact: Cornell University, Tel: +1 607 255 3651.

Application Sharing Protocol Clears Road to Standard

An application-sharing protocol jointly submitted by Microsoft and PictureTel, has successfully cleared the fully determined stage by the International Telecommunications Union's Study Group 16.

The technology, previously known as T.SHARE and now titled T.128, enables any number of conference participants at geographically dispersed locations to view and jointly use off-the-shelf PC and workstation applications, regardless of the type of data networks or computing platforms they use.

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

Contact: PictureTel, Tel: (01753) 723000.

Survey Reveals Skill Capabilities Concerns

CSSA, the UK trade association for the software, IT services and information industries has released the findings of a survey of its 530 members. The survey was conducted in March by e-mail, and carries strong messages for a future government.

Key findings include:

- An increasing shortage of skilled staff.
- Soaring wages.
- A possible exodus of skilled IT staff from the public sector to the private.
- The suggestion that conditions will worsen as more companies begin to address the Year 2000 problem and to adjust for European Monetary Union (EMU).
- New university graduate recruits lack interpersonal skills and have a weak understanding of business issues.
- 85% of those surveyed look to increase their export focus over the next three years.

Respondents to the survey stressed the importance of IT as one of the key shapers in our economy and society. They highlighted the fact that the IT industry is a major source of new employment and provides the crucial support structures underpinning virtually every other industry in the country.

For further details, check: www.cssa.co.uk.

Contact: CSSA, Tel: (0171) 405 2171.

Photo 1. Radio location. Setting up the underground transmission loop. Unless this is perfectly level, the results will be innaccurate.

Cave RADIO AND ELECTRONICS

PART 2

Exploration

by Mike Bedford

September 29th, 1946 was a fine autumn day in the Yorkshire Dales, and caver George Cornes sat down on a limestone boulder on Casterton Fell whilst his three compatriots investigated a newly discovered pothole.

Although the day was perfectly still, George's attention was drawn to the grass at his feet which was thrashing around wildly. It soon became clear that it was a blast of air from underground which was agitating the clump of grass and within minutes, George had dug away the grass with his hands to reveal a 100 foot shaft. A couple of weeks later, George Cornes and a party of eight cavers made the first descent of that pitch and discovered a cave containing some of the most impressive stalactite and stalagmite formations ever found in Britain. Exploration of this cave continues to the present day. It now runs to over 70km of passages lying under the three counties of North Yorkshire, Lancashire and Cumbria. The name of the cave system is the Lancaster Hole / Ease Gill System, alternatively referred to as the Three Counties System.

For a caver or potholer, our introductory account of the discovery of Lancaster Hole is the stuff that dreams are made out of. For today, over half a century of extensive cave exploration later, the possibility of stumbling across a discovery like this is very remote indeed. Nevertheless, the idea of discovering a new cave, of setting foot where nobody has ever been before, is an appealing one for most cavers. But how do you go about finding a new cave, of finding an extension to a known cave, or of finding an unknown link between two previously unconnected caves? Traditionally, this has involved a knowledge of the geology and hydrology of caves, lots of hard work plus,

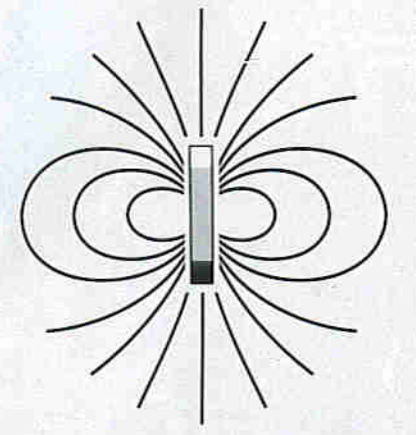


Figure 1. Magnetic lines of force surrounding a bar magnet or the loop antenna of a low frequency induction transmitter.

of course, a good measure of luck. But in recent years, cave detection and cave exploration have become decidedly high-tech. Some techniques are well established and have resulted in many new discoveries. Other techniques are very much at the experimental stage but no less fascinating for that. In this article, the second in our series on the application of electronics and computing to caving, we'll look at how technology is now being used in cave exploration.

Radio-location

On the lower slopes of Ingleborough in the Yorkshire Dales, a massive chasm breaks the monotony of the surrounding moorland. This hole in the ground is called Gaping Gill and must be the most famous pothole in the UK. A significant stream – Fell Beck – pours over the edge of the pothole to disappear among the boulders which make up the floor of a huge cave chamber 360 feet below. But the water doesn't disappear forever – it reappears over a mile away from the mouth of Beck Head Stream Cave, part of the Ingleborough Cave system. This much had been known for a long time, but until fourteen years ago, cavers had never made a through-trip. For many years, the quest for a link between these two caves was one of the major challenges in British caving. And the ultimate discovery of that elusive link was one of the first success stories for electronics in cave exploration – let's investigate.

One thing was clear – if cavers were to pass from Gaping Gill to Ingleborough Cave, they certainly wouldn't follow the waters of Fell Beck through the impenetrable slots in the floor. So, how do you go about finding a passable link? Clearly, the areas to scrutinise for previously unnoticed side-passages would be those parts of Gaping Gill which came closest to Ingleborough Cave. And if you have maps of the two cave systems, then this should be comparatively straightforward. Unfortunately, this is not always the case – especially if the maps were created using conventional surveying techniques. The snag is that both the cave systems run to many miles of passages, yet, because of cumulative errors, maps become increasingly inaccurate as the distance from the entrance increases. Using radio-location, however, underground locations can be pinpointed on the surface, thereby providing a means of correcting conventionally produced surveys. In fact, a radio-location exercise carried out by Bob Mackin of Lancaster University paved the way to the historic through trip by cave divers on 28th May 1983.

Last month, when we looked at cave communication, we saw how low frequency induction is used to communicate through solid rock. Unlike 'real' radio, which would require a huge antenna, induction radio makes use of a small loop and generates a localised magnetic field. Figure 1 is one much beloved of school physics teachers. It shows the magnetic lines of force which surround a bar magnet or, for that matter, the loop antenna of a low frequency induction transmitter. The classic diagram is only a two-dimensional representation but, of course, the lines of force also come out of the plane of the paper, as shown in the Figure 2. The only other bit of necessary background information which we need to cover concerns the directional properties of the loop antenna which is used to receive an induction signal. Maximum signal strength is obtained when the lines of force pass through the plane of the loop at right angles and a null is obtained when the lines of force are in the same plane as the loop. Loops in these two configurations are shown in the diagram.

The predictable field pattern generated by an induction transmitter and the highly directional nature of the receiving loop give us a means of determining the surface position and depth of an underground transmitter. Radio-location makes use of a transmitter which generates a periodic bleep. Frequently, transmitters intended for voice communication are pressed into service for radio-location, although more accurate results are obtained using much lower frequency transmitters, typically in the range 800Hz to 3kHz. In operation, the underground loop is accurately levelled, the transmitter is turned on and the surface party then sets about locating it. The first step is to locate ground-zero, the position directly above the underground loop. This is illustrated in the plan view of a cave which is shown in Figure 3. You'll notice that the lines of force now appear to be straight lines radiating from ground-zero. The surface party moves to the approximate location and checks that a signal can be heard with the receiving loop held vertically. Now, the loop is rotated around its vertical axis until a null is obtained. The plane of the loop is now pointing towards ground-zero. This procedure is repeated from at least one other position and ground-zero is found by triangulation. If necessary, the exercise can be repeated closer to the estimated position to get a more accurate result. And as a final check, a loop at ground-zero can be freely rotated around its vertical axis and no signal will be heard. Ground-zero is now marked and a start is made on measuring the depth.

This is illustrated in the side view of a cave which is reproduced in Figure 4. The procedure makes use of the classic shape of the magnetic lines of force. If you walk away from ground-zero and point the face of the antenna towards ground-zero, a signal will be detected. However, if you angle the loop backwards, you'll eventually find a null. This is when the angle of the antenna to the ground matches the angle at which the field lines leave the ground. Knowing this angle and the distance from ground-zero, the depth can be determined by plugging these figures into the appropriate formula. As a rule of thumb, however, it is much easier to find a point at which the null is at 45°. The depth is then approximately 1·8 times the distance from ground-zero.

Let's now return to the Gaping Gill to Ingleborough Cave link-up. The combined survey of the two systems following radio location (with a section of the old survey shown for comparison) is shown in Figure 5. The known extremities of the two cave systems are much closer than previously thought – as little as 1·2m horizontally and 3·4m vertically – and it shows exactly where a link passage may be found. In fact, a flooded section of Ingleborough Cave passes right under the Gaping Gill system, but it's much easier to dig in a non-flooded section of passage. It's not surprising, therefore, that a 'handshake connection' between the two caves followed within a month and despite horrendously tight, wet and cold conditions in the vicinity of the link-up area, cave divers Geoff Yeadon and Geoff Crossley had made the historic through-trip within another four months.

Cave Surveying

We've just seen how the use of surveys was a major factor in bringing about a link-up between two caves in the Yorkshire Dales. More generally, though, cave surveying is a

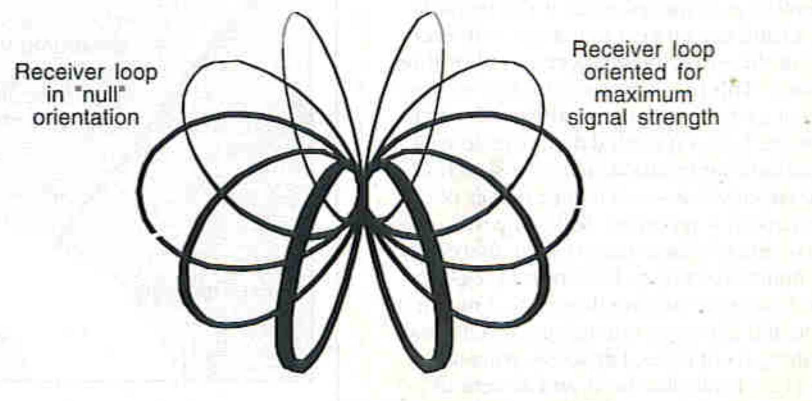


Figure 2. The magnetic lines of force represented in 3D.

Photo 2. Radio location. Finding ground-zero by triangulation.

Photo 3. Radio location. Determining depth by measuring the angle at which the lines of force leave the ground.

vital part of cave exploration – if you can't map where you've already been, further exploration will be a very hit and miss affair. But radio-location isn't the only area in which electronics is coming to the fore in surveying. Even if we forget about radio-location, electronic equipment is increasingly becoming part of the cave surveyors armoury, and the use of software for processing the results is now indispensable.

In the main, cave surveyors make use of three instruments – a tape measure, a compass and a inclinometer (which measures the angle of rise or dip), otherwise known as just a clino. To survey a cave from the entrance, one member of the team proceeds into the cave as far as the first bend and positions some sort of 'target' – an LED, perhaps – in the centre of the passage. Now, another member of the team takes a compass and a inclinometer reading on the target from the entrance, and then measures the distance from the entrance to the target. These figures are recorded in a waterproof notebook and the first leg of the survey is now complete. The first team member now moves as far as the second bend and the process continues with each leg of the survey being represented by three figures. This provides a 'centre line' survey, but at each survey station, the width of the passage is also recorded and, occasionally, additional information such as a sketch of the passage's cross-section or details of formations is recorded. Following the surveying of a large cave system, there may be figures relating to hundreds of legs, so the process of turning these into a map is a long and laborious one using conventional drafting techniques. Obviously, software tools are invaluable here, and all serious cave surveys now involve the use of specialist cave surveying software.

But the use of software can do far more than just turning figures into a graphical form – it can also provide accuracy estimates and even ways of handling errors. We mentioned earlier that it is the accumulation of errors which limits the accuracy of cave surveys. So, if the inherent accuracy of a length measurement is ±25mm, then after 10 legs, we would only be able to quote the overall distance traversed to an accuracy of ±250mm. The same applies to the compass and inclinometer measurements. If the cave consists of a long passage with no junctions, there's no way to counter this problem except, of course, by using radio-location.

However, what if the cave being surveyed is a complicated one? If you look at the Gaping Gill survey, for example, you'll see that the passages contain many junctions and loops. So, having fully surveyed such a system, you'll find that some survey stations have been approached via multiple paths. Clearly, therefore, you'll end up with multiple estimates regarding the location of these stations. The difference between these results is referred to as a 'closure error' and can give a measure of accuracy. If the difference in the position of a particular station calculated over two different paths is very small, then this will give you a high degree of confidence in its position.

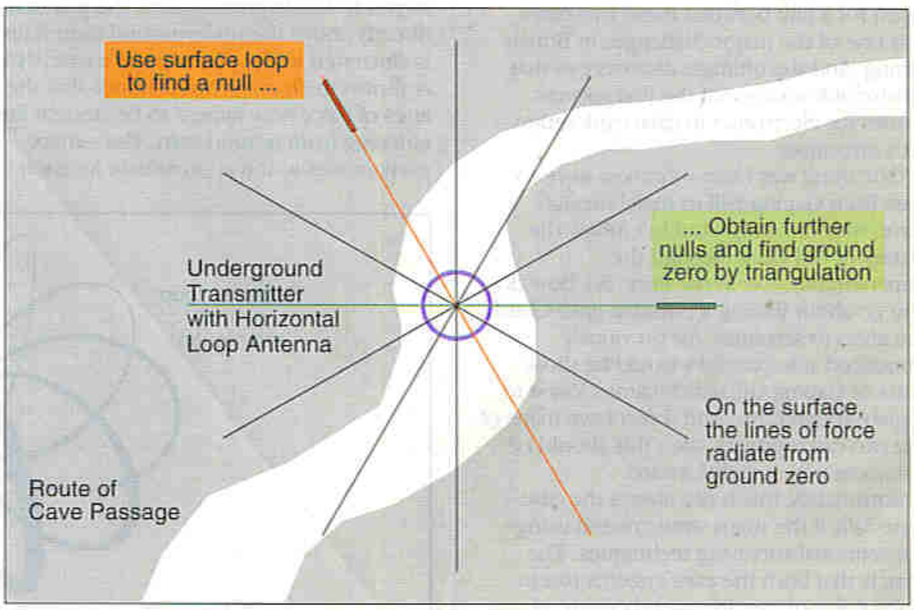


Figure 3. Locating ground-zero in the plan view of a cave.

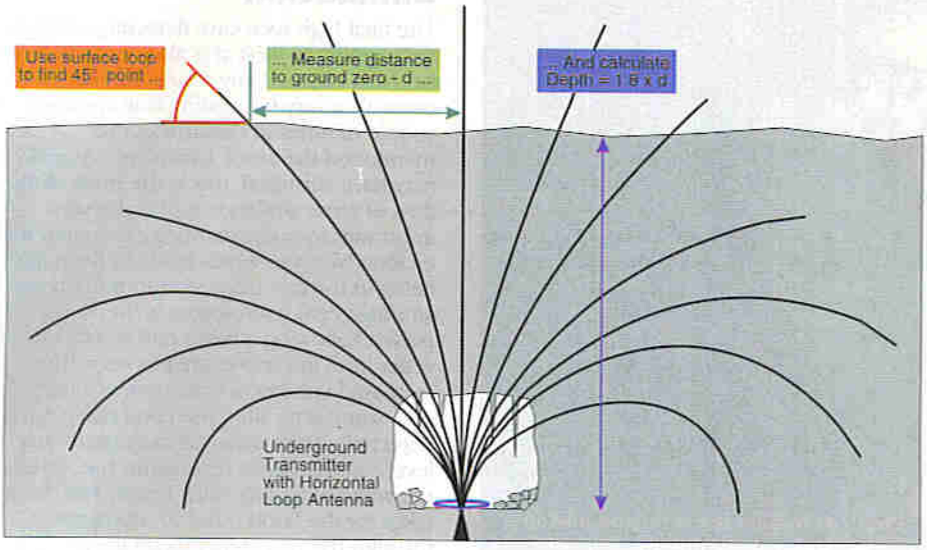


Figure 4. Measuring ground-zero on the side view of a cave.

valuable tool for determining the location of cave entrances in poorly-mapped areas, it is no good whatsoever for underground work. But whereas a satellite-based UHF system can't be used in a cave, what about a terrestrial-based LF system working on the same principle of time-of-flight measurements? No such system has yet been demonstrated and the engineering challenges are not to be underestimated. However, in principle, the system seems straightforward and workable – here's how it might work. Prior to entering the cave, the survey party sets up a couple of surface transmitters on the ground above the cave system at known positions. A small hand-held TUPS (Terrestrial Underground Positioning System) receiver is now clipped to the belt and the party proceed into the cave. Specific measurements don't have to be made. Instead, the integrated processor regularly determines the survey party's position and writes it to memory. At the end of the survey trip, the data is downloaded to a desktop PC for processing and plotting.

Frequently, though, this closure error can be quite significant. In such a case, which result do you use? In reality, neither position will be exactly correct, and survey software uses statistical techniques such as 'least squares fit' to work out the most likely position from estimates of the accuracy of each path.

Despite major advances in the way in which survey data is processed, the actual nitty gritty of surveying has changed little over recent years. However, modern electronic equipment may even displace the traditional compass, inclinometer and tape measure. The most obvious alternative approach is to use the electronic equivalents of these three basic instruments, indeed, the electronic tape measure is now a relatively common piece of equipment. The major advantage which electronic instruments offer is that they can be interfaced directly to laptop computers or data loggers, thereby eliminating transcription errors. Of course, a standard laptop isn't exactly cave-proof, but a number of manufacturers now produce, rugged, waterproof, hand-held computers which would be eminently suitable for this sort of application. However, electronics versions of the compass, inclinometer and tape measure, whilst offering some potential benefits over their traditional counterparts, are not exactly state-of-the-art. Let's take a quick look at a rather more esoteric alternative which has recently been discussed in the caving press.

The concept of GPS – Global Positioning Satellite – is now a familiar one and with hand-held receivers costing less than £200, it's becoming an affordable technology. Furthermore, it can achieve an accuracy of 25m and this is set to be reduced to 5m when the US military discontinues its deliberate degradation of the service. For the cave surveyor, however, the snag is that the system relies on being able to receive the UHF radio signals which are transmitted by the satellites. And as we saw last month, when we considered why conventional radio is inappropriate for surface-to-cave communication, UHF signals are effectively absorbed by rock. So, although GPS is a

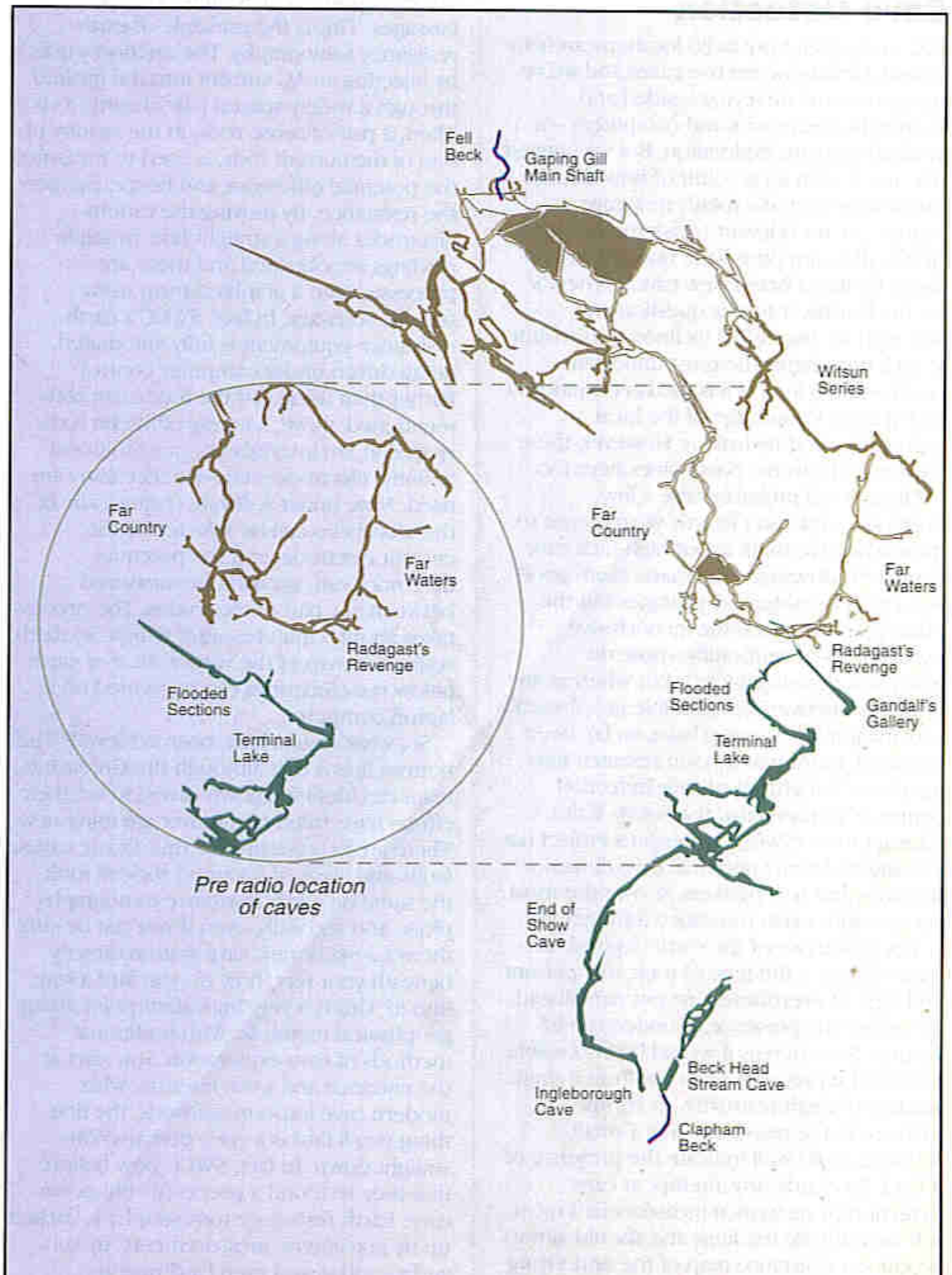


Figure 5. Combined survey of Gaping Gill to Ingleborough Cave.

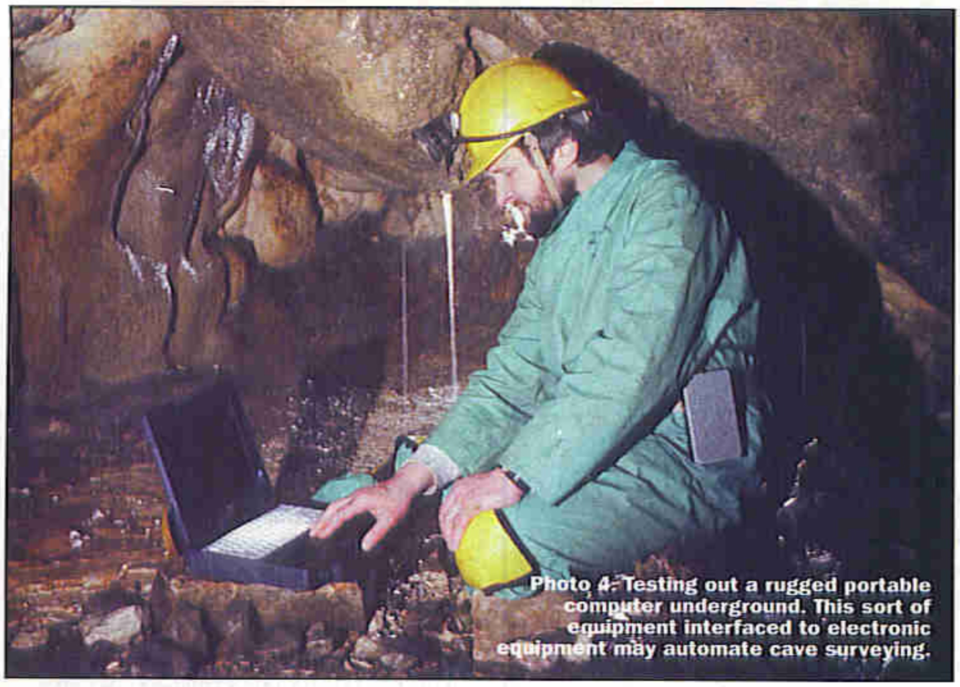


Photo 4: Testing out a rugged portable computer underground. This sort of equipment interfaced to electronic equipment may automate cave surveying.

Cave Detection

OK, we've seen how radio location can help to find a link between two caves and we've seen how cave surveying – aided and abetted by electronics and computers – is invaluable in cave exploration. But we opened this article with an account of how George Cornes discovered a totally new cave system. So, it's relevant to ask the question "If you discount pure luck, how do you go about finding a brand new cave?". There's no single answer to this question and although we might feel inclined to discount it, luck is probably the most important commodity, so long as it is used in conjunction with a good knowledge of the local topography and hydrology. However, there are some electronic possibilities here too.

Photo 5 will probably raise a few eyebrows – this isn't exactly what comes to mind when we think about high-tech cave detection. Dowsing enthusiasts claim good success in locating cave passages but the photograph shows some inconclusive experiments at verification (note the electronic dowsing welly!). But whereas any hopes of discovering a possible geophysical explanation for dowsing have, so far, been thwarted, more mainstream research into geophysical methods of cave detection continue. In particular, the South Wales Caving Club's (SWCC) Greensites Project has investigated many potential cave detection schemes and has, perhaps, shown the most success with earth resistance tomography.

The resistance of the earth depends on many factors – the type of rock, the amount and type of overburden, recent rainfall and, of course, the presence of underground cavities. So, whereas it would be impossible to infer the presence of a cave from a single reading of earth resistivity, an abrupt increase in the resistivity over a small distance could well indicate the presence of a void. So clearly, any attempt at cave detection by resistance measurement must rely on multiple readings and should aim to produce a resistance map of the underlying rock. With experience, such a resistance map might be interpreted in terms of underground features such as caves passages. This is the principle of earth resistance tomography. The method works by injecting an AC current into the ground through a widely-spaced pair of earth rods. Then, a pair of sense rods, in the vicinity of one of the current rods, is used to measure the potential difference and hence, deduce the resistance. By moving the various electrodes along a straight line, multiple readings are obtained and these are processed into a graphical form using suitable software. In fact, SWCC's earth resistance equipment is fully automated, being driven under computer control. Rather than using just the four earth rods mentioned above, an array of fifteen rods spaced at 5m intervals plus an additional 'infinity' electrode some distance away are used. Now, under software control, any of the electrodes can be selected as the current electrode, and the potential difference can, similarly, be measured between any pair of electrodes. The process takes about 5 minutes, after which, an earth resistance map of the vertical slice of earth below the electrodes can be plotted on a laptop computer.

So, what results have been achieved? The bottom line is that although the Greensites team can identify known caves, so far, their efforts have failed to discover anything new. There are two reasons for this. Firstly, caves, faults and areas of fractured rock all look the same on earth resistance tomography plots. And secondly, even if you can be sure there's a major new cave system directly beneath your feet, how do you find a way into it? This is a very important point about geophysical methods. With traditional methods of cave exploration, you start at the entrance and work inwards. With modern cave location methods, the first thing you'll find is a void, perhaps 50m straight down. In fact, SWCC now believe that they've found a previously unknown cave. Earth resistance tomography is backed up by gravimetric measurements, by sub-surface radar, and even by dowsing. However, all attempts at finding a way into this new cave have, so far, been unfruitful.

Cave Detection by Simulation

The final high tech cave detecting scheme we're going to look at is also one which, so far, hasn't reaped any results although it's certainly a very interesting new approach. A couple of times in this article, I've mentioned the word 'hydrology'. As you may have surmised, this is the study of the flow of water underground and is very important to understanding caves since it is erosion by water which brought them into being in the first place. A common phrase amongst cave hydrologists is the 'flood pulse'. Following a heavy rain storm, the water level in surface streams rises. This increased volume of water enters a cave and, some time later, the flood pulse can be detected – once again, as increased water level – at the cave's resurgence (i.e., where the water makes its exit). Exactly how long it takes for the flood pulse to propagate through the cave depends on the properties of the passage. If the passage is phreatic (i.e., totally flooded), then the flood pulse will immediately appear at the other end, since water is incompressible. If, on the other hand, the passage is vadose (i.e., with water flowing in the bottom only), then the flood pulse will appear some time later, depending on the length of the passage and the flow rate. In complicated caves with junctions and multiple paths, a single flood pulse can be detected as multiple pulses at the resurgence, each pulse representing a different path. In a way, the shape of the flood pulses could be thought of as a fingerprint of a particular cave. John Wilkock of Staffordshire University is currently carrying out research into the computer simulation of flood pulses, and the ultimate aim is to produce a system which could assist in finding new cave passages. The screen shot, Photo 6, shows this model – written in Microsoft Excel – in action.

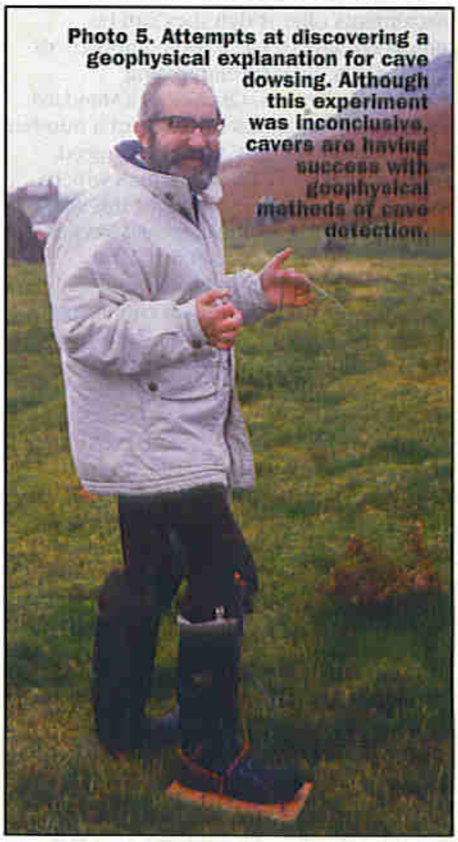


Photo 5. Attempts at discovering a geophysical explanation for cave dowsing. Although this experiment was inconclusive, cavers are having success with geophysical methods of cave detection.

Imagine that you have just carried out some measurements on the propagation of a flood pulse passing through a known cave. You then carry out a computer simulation and find that you get a quite different result. How do you explain this? Well, it could mean that the simulation is flawed, but for the sake of argument, let's assume that you've previously verified the model on other caves, and it's only these results which are anomalous. One obvious explanation is that there are cave passages through which some of the water is flowing which you don't know about. And at this point, the cave explorer gets excited. What will make him more excited, however, is to know where that missing passage is, and to do that, another element is needed. Working backwards from hydrology results to the cave topology is out of the question, but what may be possible is to automatically alter the cave topology being simulated until the simulation output matches the real world results. In theory, you'd then know exactly where to start digging to get your name in lights as the discoverer of Simulation Grotto.

No Substitute for Hard Work

Despite this being an electronics magazine, and despite the pride we might take in our technology, I really can't leave you with the impression that electronics and computing provide the universal panacea in cave exploration. Certainly, electronics can give a helping hand, but new discoveries still don't come easily. In the main, breakthroughs continue to be the result of dedicated cavers spending countless days digging earth and boulders out of tiny passages, of cave divers battling against almost zero visibility, and of cave surveyors taking literally thousands of compass and inclinometer readings. No, cave exploration will never be easy, indeed, it is surely the sense of challenges which makes potholing so fascinating to its enthusiasts. I for one wouldn't substitute my lamp and helmet for a virtual reality headset, even if electronics meant that I could explore a virtual cave without ever getting my feet wet.

Don't Forget

As I said last month, if you're not an experienced caver, don't even think about going underground unless you're in the company of someone who is. If you want to find like-minded people who can show you the ropes, try making contact with the Cave Radio & Electronics Group (CREG) of the British Cave Research Association (BCRA). The Group's twice-yearly field meetings could provide a safe introduction to caving and would allow you to see cave electronics in action. CREG also publishes a quarterly journal which contains a broad mix of practical and theoretic articles. For details and an application form, send an SAE to Bill Purvis, 35 Chapel Road, Penketh, Warrington, WA5 2NG. Also, check out the CREG Web site at
`http://www.sat.dundee.ac.uk/~arb/creg`.

And if it's the general and computing aspects of cave surveying which appeal to you, take a look at the Web site of the closely related Cave Surveying Group at
`http://www.sat.dundee.ac.uk/~arb/surveying`
or contact:
Andy Atkinson at 22 Tyne Road, Bishopston, Bristol, BS7 8EE, enclosing an SAE.

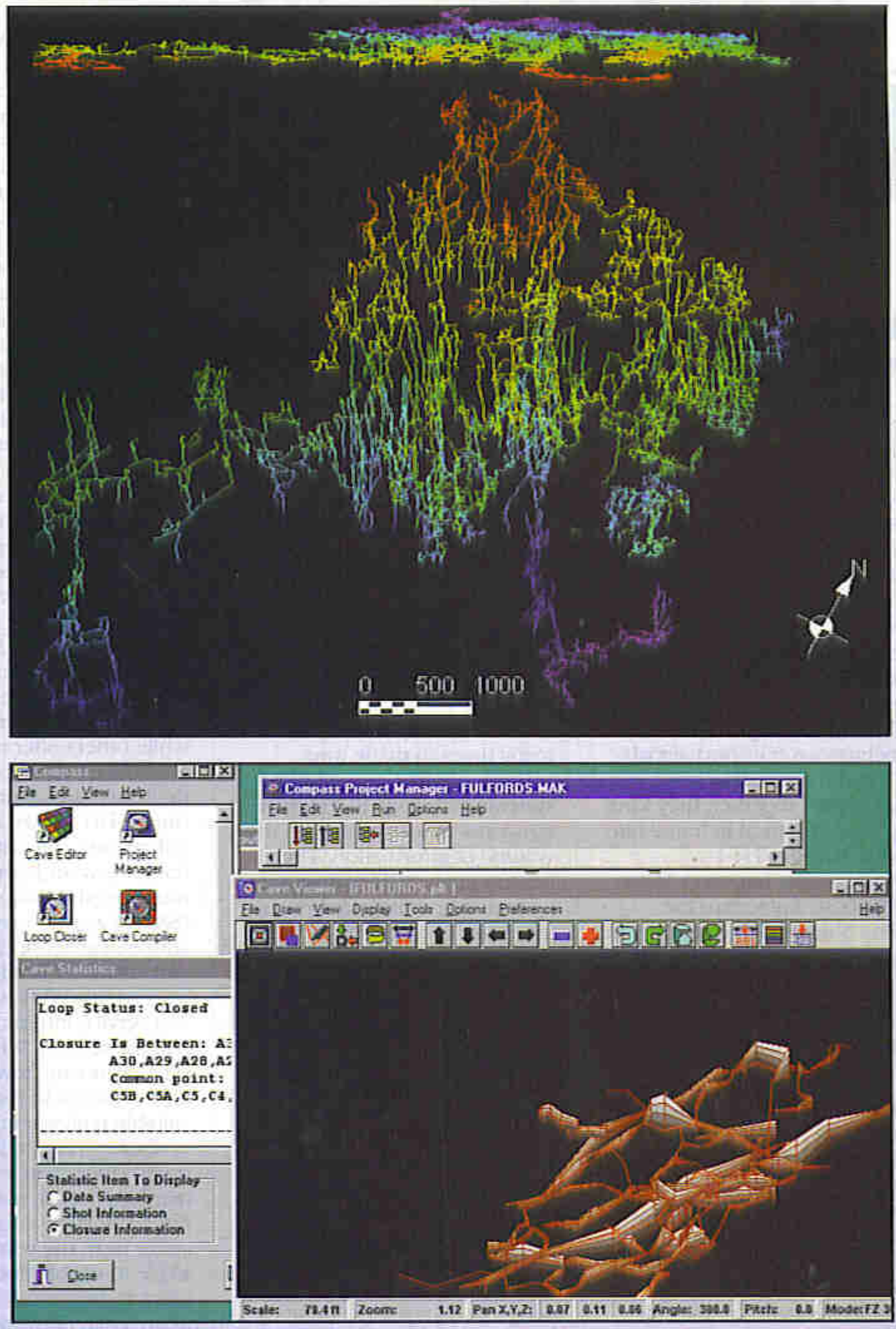


Photo 6. Example of state-of-the-art PC cave surveying software.

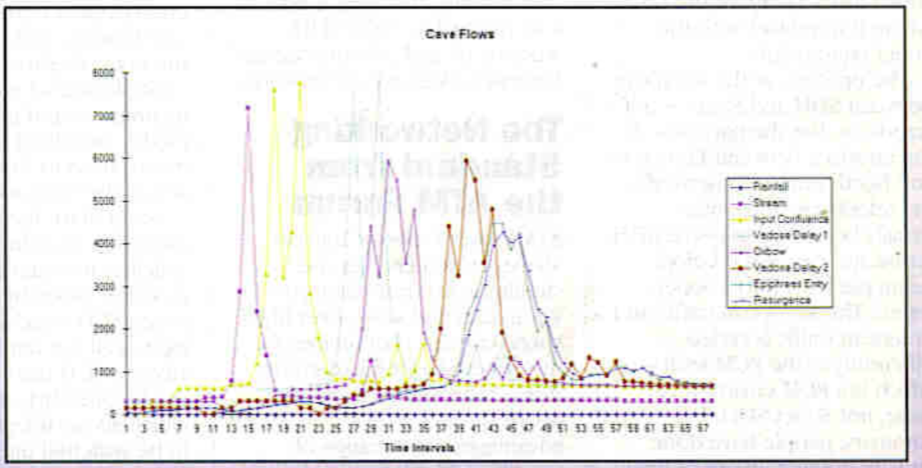


Photo 7. John Wilkock of Staffordshire University is currently carrying out research into the computer simulation of flood pulses, and the ultimate aim is to produce a system which could assist in finding new cave passages. This screenshot shows this model – written in Microsoft Excel – in action.

SDH/Sonet INTERWORKING

by Frank Booty

High-speed Technologies

SDH and Sonet are transmission standards for high-speed digital telecommunications networks. The ITU-T produced SDH (Synchronous Digital Hierarchy) while ANSI drew up Sonet (synchronous optical network). Sonet is a standards subset of SDH, which is a worldwide standard, including Sonet mappings. Sonet allows North American transmission rates to be mapped into a bearer called STS-1 (51·84M-bps, synchronous transport signal).

When three STS-1s are multiplexed together, they form an STS-3, identical in frame rate and format to STM-1 (Synchronous Transport Mode-1, the basic frame rate for SDH). Slight differences exist in pointer processing, and some overheads, but basically they are interworkable, e.g., Nortel multiplexers can map the SDH VC4 (carrying 140M-bps) into an STC-3C to carry over Sonet; everyone's STM-16 (2·5G-bps) can carry STM-1 or STS-3 tributaries as both operate at exactly 155M-bps, with the same basic framing; and various crossconnects exist to interconnect between the two (e.g., AT&T and DSC).

Internationally, circuits are SDH, as Sonet is a subset. Examples are TAT12, TAT13, and CANTAT across the Atlantic, which takes SDH into the US, where it interfaces with the Sonet equipment.

The problem at the interface between SDH and Sonet is not standards, but the payloads. At the interface between European and North American networks, the telephony traffic must usually be taken out of the SDH frame and processed before being put back into a Sonet frame. The European traffic and American traffic is coded differently at the PCM level – which is a PDH environment issue, not Sonet/SDH. In summary, people have done and are doing it, in/out of their labs. Advantages are extreme reliability (traffic routed around outages in milliseconds) and high speeds (up to 2·488G-bps with 10G-bps coming).

The biggest 'problem' of SDH is too much network management. With PDH, management was limited. SDH was specifically designed to provide extensive management bandwidth to the next generation of systems. The 155M-bit carries 140M-bit of telephony traffic, with about 15M-bit left over for management data and framing. Some load. Technologists have used up the various capabilities to ensure every last detail of network activity is reported many times in many ways.

Consequently, operational systems with large SDH/Sonet networks cannot cope with the volume of information. There are too many SDH management systems presenting too much information on too many screens. Overload.

SDH is lower cost than the previous PDH. The rule in transmission is four times the capacity for twice the cost. So, the cost of bandwidth has been halving every five years, e.g., 2·5G-bit systems are twice the cost of 565M-bit, but offer four times the capacity. An add-drop multiplexer will replace two line systems. One-for-one, costs may be higher, but if SDH/Sonet network topologies are adopted, capital and operating costs are significantly reduced. In the UK, this is the reason Energis can undercut BT and Mercury and still make a profit – its network is 100% SDH, whereas BT and Mercury operate higher-cost legacy PDH networks.

The Networking Standard from the ATM Forum

ATM (Asynchronous Transfer Mode), which enables the simultaneous transmission of voice, data and video over high-speed circuits, is optimised for the Sonet/SDH infrastructure. While suffering the same disadvantages, ATM's advantages are its range of speeds and integrated technology. SDH enthusiasts believe ATM is an essential technology, and that the two are not competitive. While SDH provides the bulk low-cost bit haul capability, it is essentially a static network providing point-to-point bandwidth. The bandwidth can be altered rapidly to preprogrammed backups to aid restoration, or slowly to provision new capacity. SDH is not designed to react to real-time capacity demands. Where a customer has a dedicated continuous requirement for bandwidth, SDH is the preferred medium. ATM sits on top (and hence, adds to the cost), but provides dynamic bandwidth allocation to allow multiple users to share the capacity, thus reducing the cost. The ability to provide a wide range of speeds on demand is a clear advantage in many customer applications.

Hitherto unprecedented speed and reliability are now possible as service providers roll out Sonet and SDH on their backbones. Some carriers offer or trial ATM services built on these high-speed transports while others offer native Sonet/SDH services such as dedicated lines or redundant rings. SDH, Sonet, and ATM differ from data services like frame relay and switched multimegabit data service (SMDS) as they serve as both address carrier infrastructure and customer services.

Currently, ATM is configured as a service interface, like SMDS and frame relay. While ATM is seen as moving towards carrier infrastructure in the long term, suitable equipment is still not available (three to five years out?). Huge switch nodes are needed for that, and these do not seem to be economic and suffer from the compromises made to enable both data and voice to be carried. ATM is seen as an 'edge network service interface' for the next few years.

Transmission covers the means by which data is encoded and transported across the network, and aspects like the network data rates, multiplexing schemes, encoding techniques, and transmission media. Switching involves the means used to route the data across the network.

Sonet/SDH does not apply directly to switches, but specifies the interfaces between switches linked by optical fibre. Sonet/SDH switches do not exist, well not until 1997 anyway. SDH incorporates a mode called byte synchronous, which allows telephony traffic to be switched directly from the SDH or Sonet signal within the switch. Nortel will release SDH byte synchronous interfaces on the DMS100 range of switches next spring. Sonet versions are now being verified. Other switch suppliers are busy too.

Such interfaces will come under favourable scrutiny, particularly as they should result in significant cost reductions. Consider replacing 63 2M-bit interfaces with one SDH interface: less interfaces, less cabinets, less transmission multiplexing. Significant.

ATM switches, central office counterparts, or LAN switches can be fitted with Sonet/SDH interfaces.

Sonet transmissions start at 51·84M-bps while SDH starts at 155M-bps. Sonet/SDH is offered at 155, 622M-bps, and 2·488G-bps. Typically, Sonet/SDH backbones are deployed at 2·5G-bps to ensure capacity.

10G-bps systems are possible. Standards are not the issue. It's possible, for example, to use four 2·5G-bps lines, utilising a four-for-one multiplexer, involving time division multiplexing (TDM) or wave division multiplexing (WDM). 10G-bps lines are 'almost' deployable, and can be expected in the Spring in the UK with both TDM and WDM techniques competing for supremacy.

SDH evolved from the PDH transport mechanism – plesiochronous or partially synchronised digital hierarchy. PDH uses time division multiplexing to transmit asynchronous traffic such as that found on E1/E3 (2·048/34M-bps) lines. STM is used for SDH. STM-1 is the basic unit of SDH at 155M-bit. STM-4 is 622M-bit, STM-16 is 2·5G-bit. Sonet is based on STS at 51M-bit. An STS-3 = an STM-1. In the optical domain, an STS is referred as an OC (OC-3, etc.). Both Sonet and SDH evolved from PDH. SDH evolved from European PDH at 2M-bit, 8M-bit, 34M-bit and 140M-bit. Sonet evolved from ANSI PDH at 1·5M-bit, 6M-bit and 45M-bit. More importantly, SDH is designed to encompass all traffic frames, allowing it to carry ANSI or ETSI PDH. Sonet is the subset which deals with ANSI only.

Key features of SDH/Sonet are:

- Interworking at the optical level allowing mid-span meets optically between operators.
- Significant added capability for network management information.
- Flexibility to aid provisioning and circuit restoration.

Traffic running on Sonet/SDH is automatically rerouted within milliseconds of cable fracture or other outage. Users are unaware when there is an outage. Few carriers will discuss network uptime (there are 150+ carriers in the UK alone, most of whom use/are about to use SDH), although it's said 99·99% is the figure. Worldwide, public network operators are about to deploy/are deploying SDH on their backbones.

Many PNOs are offering services to corporate users, e.g., AT&T, BT, Colt Telecommunications, Energis Communications, MFS Datanet, Nynex, and Sprint. According to Alistair Henderson, Head of Network Strategy at Energis, there are 800+ 2·5G-bps systems deployed in Energis today. Energis handles the BBC's output with diverse routed 2·5G-bps lines, the printing needs of Mirror Group Newspapers, and traffic for Thomas Cook and Boots.

In Europe, SDH-based services are available from alternative carriers in Germany and Sweden, as well as the UK. Last year, Swedish PTT Telia installed some 2,000 SDH add-and-drop multiplexers, compared to 1,000 in the previous year. Most PTTs do not divulge details of SDH deployment (it's internal development and strategic information). But the ability to offer SDH to customers provides clues to the status of deployment – deemed 'widespread but patchy'.

If transmitting traffic on SDH at 155M-bps or Sonet at 155M-bps, the cost is the same. Tributary cards operating at 2 or 1·5M-bps cost the same. There's potential complexity with a greater variety of cards, e.g., with a more complex multiplexer in the middle. While there's justification for a small price increase on the multiplexer card, there is no justification for any major pricing differential.

Given the volume of SDH deployed worldwide versus Sonet in North America, and Sonet's smaller basic unit, SDH should be lower priced. But market conditions, nondisclosure of prices, and deals, have decreed otherwise.

Now, according to Henderson, who is Chairman of the PNOIG (Public Network Operators Interconnect Group), a 50M-bps SDH variant for radio low-cost optic systems in Europe is to be introduced, i.e., Sonet is to be adopted into SDH. The possibility of SDH linking to customer premise equipment at 50M-bps is an open option.

Meanwhile, the PNOIG's Transport Interest Group subcommittee is addressing the SDH interconnect issue, where the volume of interconnect traffic between operators is rising steadily. Interconnection at 155M-bps and 2·5G-bps is being addressed.

How Will SDH/Sonet be Put to Use?

Standards bodies originally defined the transmission mediums for broadband ISDN, with ATM serving as the layer 2 protocol on the OSI stack. Coupling the two should produce the oft-touted high-speed switched public networks, carrying data, voice, video, and multimedia. Not yet, of course.

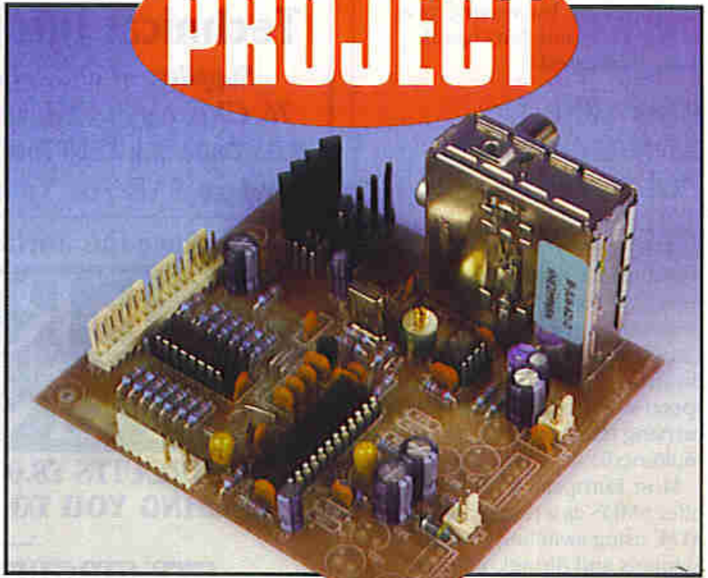
Most European PTTs now offer SMDS as a precursor to ATM, using switches built by Siemens and Alcatel. Telecom Finland has had the most mature ATM service. Deutsche Telekom has the closest thing to switched ATM service, while the UK's SuperJANET academic network interconnects 15 sites with SDH circuits. The German PTT, as with Sweden and Switzerland, has gone part way to offering ATM switched virtual circuits. The problem? Fraud. Time for another subcommittee.

With WDM, it is possible to get 16 2·5G-bps streams per fibre. Soon, it will be 40, with 100 said to be feasible. Capacity is not an issue. As bandwidth increases and more and more vital services are added, the concept of SDH/Sonet rings falling down increases. Rings are very reliable, but as traffic increases, there is a distinct possibility of breaks. Enter now triplicated systems. Energis is setting up a third route from London to Birmingham with live traffic expected next spring.

A SDH/Sonet ring contains dual circuits. If one circuit is cut, the traffic reverses and flows in the opposite direction on the same ring, avoiding the cut altogether. If the ring is broken in two places, the traffic is automatically rerouted onto the second circuit.

It is also possible to buy point-to-point services: local services comprise circuits linking a site to the nearest switch; long distance services are similar to standard leased lines. A connection is bought between two points but traffic is sent over multiple rings within the public network. So, although the user is not buying Sonet/SDH rings, all the benefits accrue associated with rings within the long distance portion of the carrier network. However, high reliability networking is better achieved through utilising local access rings. ELECTRONICS

PROJECT



FEATURES

- Video and UHF TV signal outputs
- European PAL and American NTSC standard selectable
- Six binary TTL compatible inputs provide 64 different colours
- Analogue Red, Green and Blue inputs
- TTL compatible Sync and Blanking inputs
- Crystal controlled oscillator
- On-board voltage regulator

PROJECT RATING 3

Kit Available
Order as LU74R
Price £25.49

PAL COLOUR ENCODER

Design by Chris Barlow
Text by Tony Bricknell

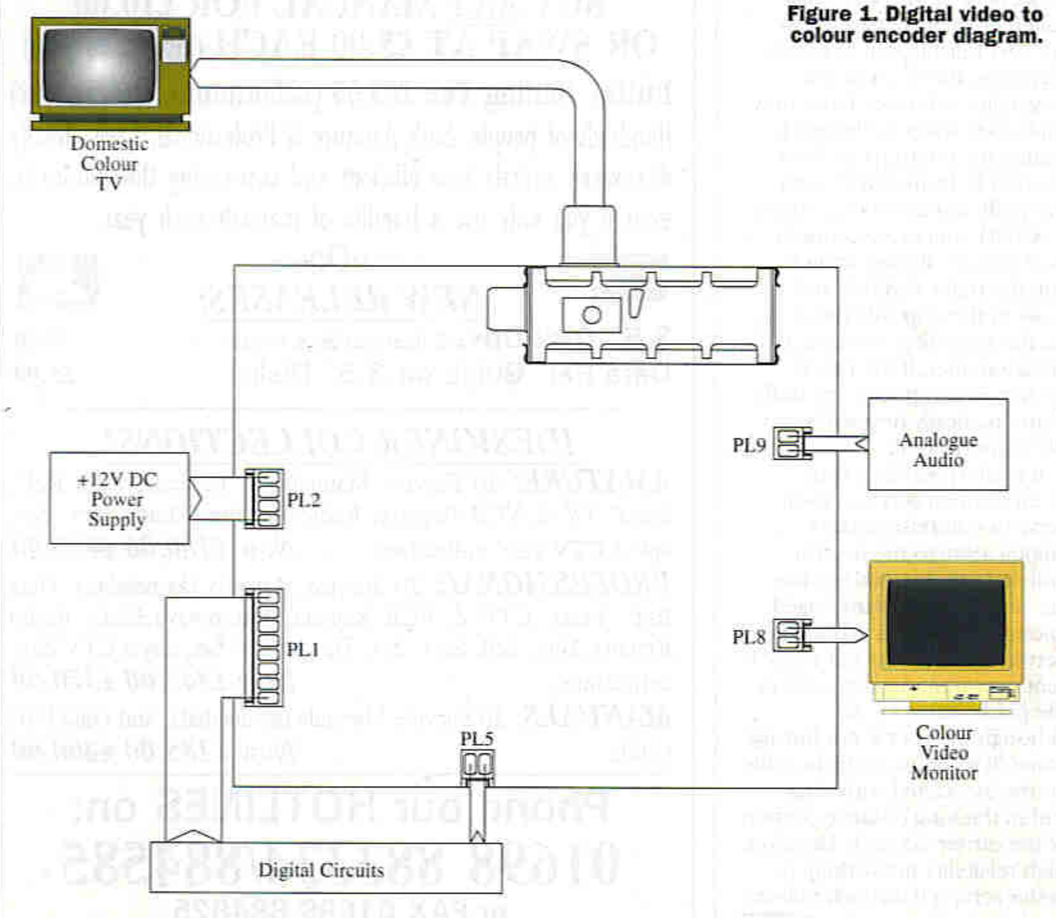


Figure 1. Digital video to colour encoder diagram.

General Description

The PAL colour encoder module is a building block used to convert either analogue RGB or digital RGB signals into colour video, see Figures 1 and 2. The project, as supplied, provides two outputs – direct video for a monitor and modulated RF for domestic colour televisions. In addition, the project incorporates a 6MHz sub-carrier for the modulated RF sound channel, allowing the user to feed line-level audio, along with the video, through to a television.

In addition, by fitment of optional components, the project will also provide Y and C (S-Video) signal outputs as well as fully buffered RGB outputs.

At the heart of the unit is the Sony CXA1645P, an encoder IC that converts analogue RGB signals into a composite video signal, and is suitable for both PAL and NTSC (with certain component changes) systems. The device requires composite sync pulses, sub-carrier and RGB signals and will produce composite video output, separate luminance and chroma components, and clamped RGB outputs. The IC features 75Ω drivers, a band pass filter, delay line, R-Y and B-Y modulator circuits, PAL alternating line circuit, and burst flag generator circuit, see Figure 3. Table 1 gives all the electrical characteristics of the CXA1645P.

(100% colour bar input, 1Vpk-pk)

Supply voltage	5VDC
Operating current	31mA typical
Power dissipation	1·25W max.
Operating temperature	-20°C to +75°C
RGB output	0·71V$_{p-p}$
Output sync	0·29V$_{p-p}$
Y and CV output:	
R = 100%	0·21V$_{p-p}$
G = 100%	0·42V$_{p-p}$
B = 100%	0·08V$_{p-p}$
Y White (100%)	0·71V$_{p-p}$
C and CV output:	
R chroma ratio	3·16
R phase	104°
G chroma ration	2·95
G phase	241°
B chroma ratio	2·24
B phase	347°
Burst level	0·25V$_{p-p}$
Burst width	2·75µs
Bust position	0·6µs
Sub carrier input	0·4V to 5V sine or pulse

Table 1. Electrical characteristics of the Sony CXA1645P chip.

Application Hints

The circuits used to drive the encoder can be very diverse, from computer displays and arcade games to video pattern

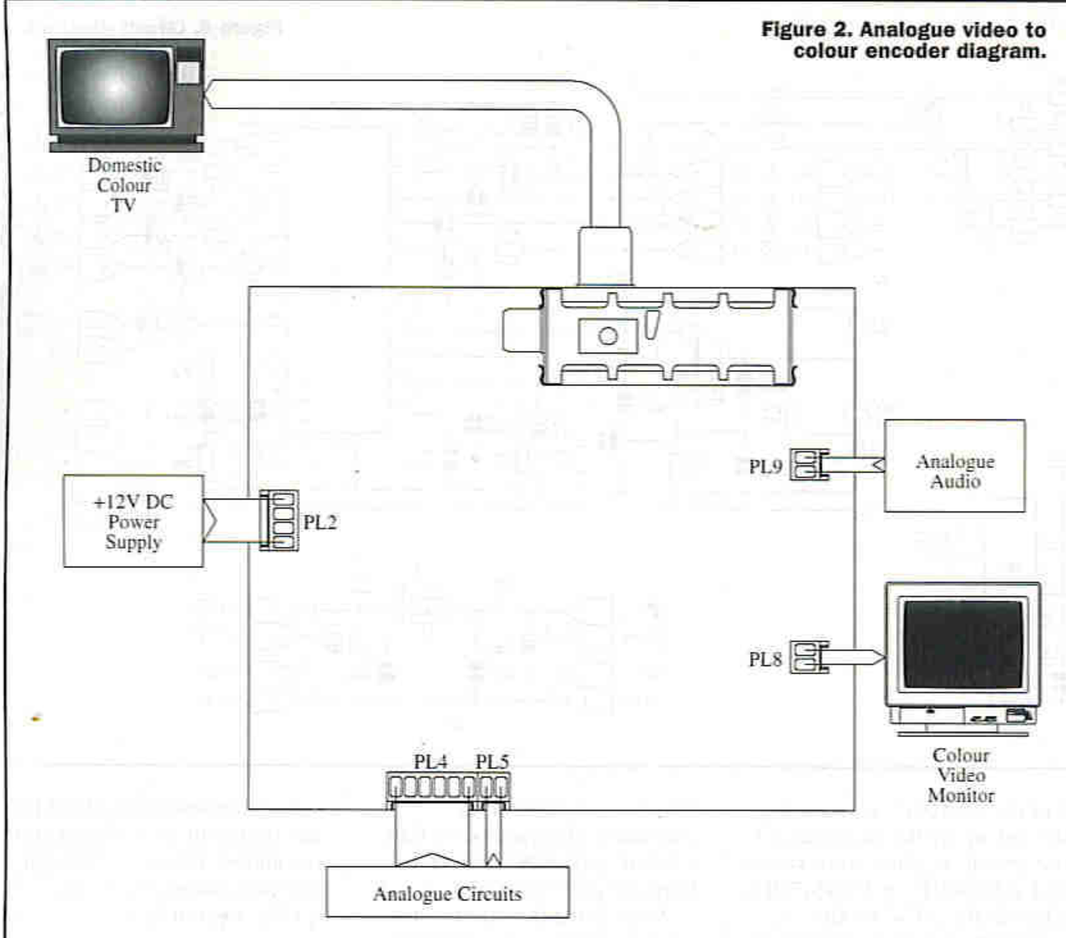


Figure 2. Analogue video to colour encoder diagram.

test generators. However, all these devices must provide the following signals:

1. Composite sync (TTL level, negative logic)
2. Composite blanking (TTL level, only applicable if using digital inputs)
3. Red, green and blue (either TTL level, 2 bits per primary colour *or* $1V_{pp}$ analogue)

The exact timing relationship of composite sync and blanking is quite involved, therefore a good working knowledge of video techniques is essential. Suitable books on this subject can by found in the "Books – TV & Video" section of the current Maplin catalogue. In addition, Maplin stock a Universal Sync Generator for PAL and NTSC standards, the Philips SAA1043 (order as UK85G).

The six bit binary colour data inputs are organised as two bits per primary colour and gamma correction is applied by the CXA1645P to the resultant luminance and chrominance levels. Each of the equally spaced intensity levels (for each primary colour) is combined with those of the other primary colours. This produces 64 output colours comprising a wide range of saturated and desaturated colours, black, white and two levels of grey.

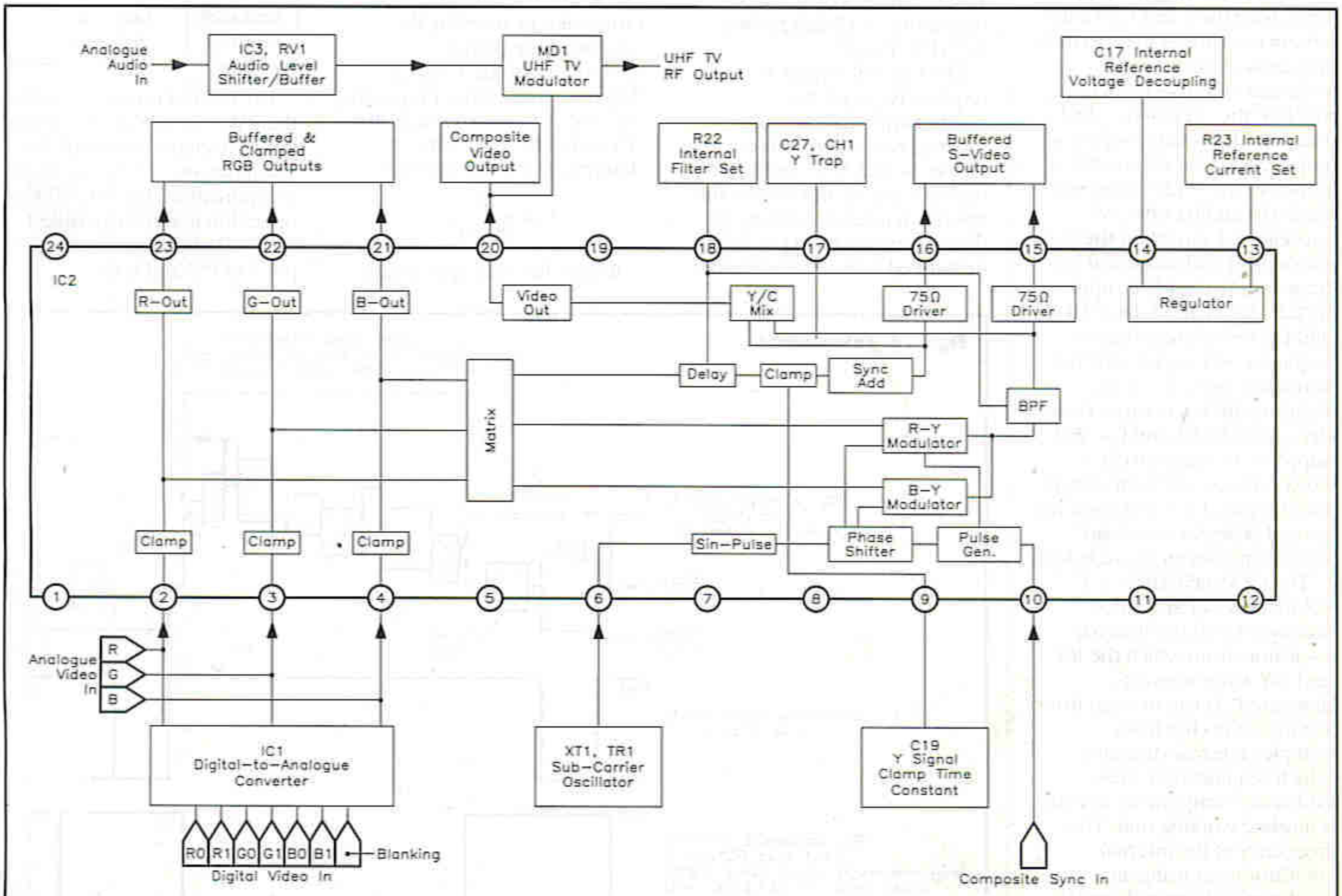


Figure 3. Block diagram.

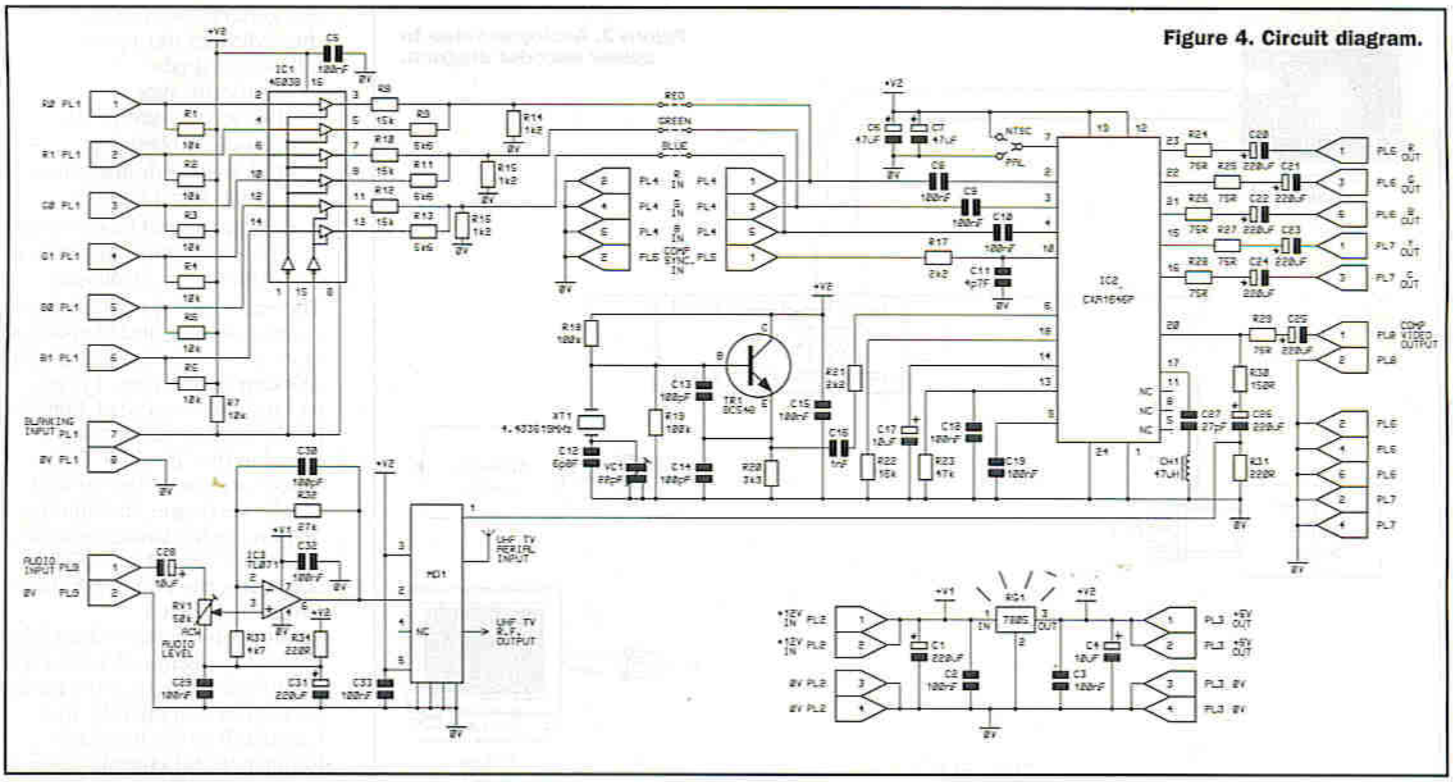


Figure 4. Circuit diagram.

Circuit Description

In addition to the block diagram shown in Figure 3, the circuit diagram shown in Figure 4 should assist you when following the circuit description or fault finding on the completed unit.

Any DC entering the unit must have the correct polarity, otherwise damage may occur to the semiconductors and polarised components. The 12 volts for the circuit is applied to PL2 with the positive supply on pins 1/2, and the 0V ground to pins 3/4. The +12V supply rail feeds the audio buffer, with capacitor C1 providing the main decoupling and additional high frequency decoupling supplied by C2. The RF modulator MD1 and the remaining circuitry require a +5V supply which is generated using a voltage regulator RG1, its output being decoupled by C3 and C4. This supply is also taken to PL3, however the maximum current load on pins 1/2 of PL3 must not exceed 500mA as overload damage may start to occur in RG1.

The CXA1645P (IC2) is a colour encoder and video summer which has internal oscillators from which the R-Y and B-Y waveforms are generated. As can be seen from Figure 3, the chip has a complex internal structure which requires only a few additional components to make a finished working unit. The frequency of the internal oscillator is set using an oscillator built around crystal XT1, trimmer capacitor VC1 and transistor TR1, and input to pin 6 of the CXA1645. When using the PAL mode the frequency of the crystal oscillator must be set to 4·433619MHz, or 3·579545MHz when in the NTSC mode.

The internal filter adjustment, pin 18, of the CXA1645 must be connected to 0V through a 16kΩ resistor for PAL mode operation, or a 20kΩ resistor for NTSC mode.

The internal regulator requires two external components: C17 decouples the internal voltage reference on pin 14 and R23, connected between pin 13 and 0V, sets the internal reference current; In this application pin 13 is also decoupled by a 100nF capacitor.

The Y signal clamp time constant is determined by C19, a 100nF capacitor connected between pin 9 and 0V.

When using the composite output of IC2, a capacitor and inductor (C27 and CH1) connected in series between pin 17 and 0V will reduce the cross colour caused by the sub-carrier frequency component of the Y signal. When the sub-carrier frequency is f_0, the values of the capacitor (*C*) and inductor (*L*) are determined by the equation

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

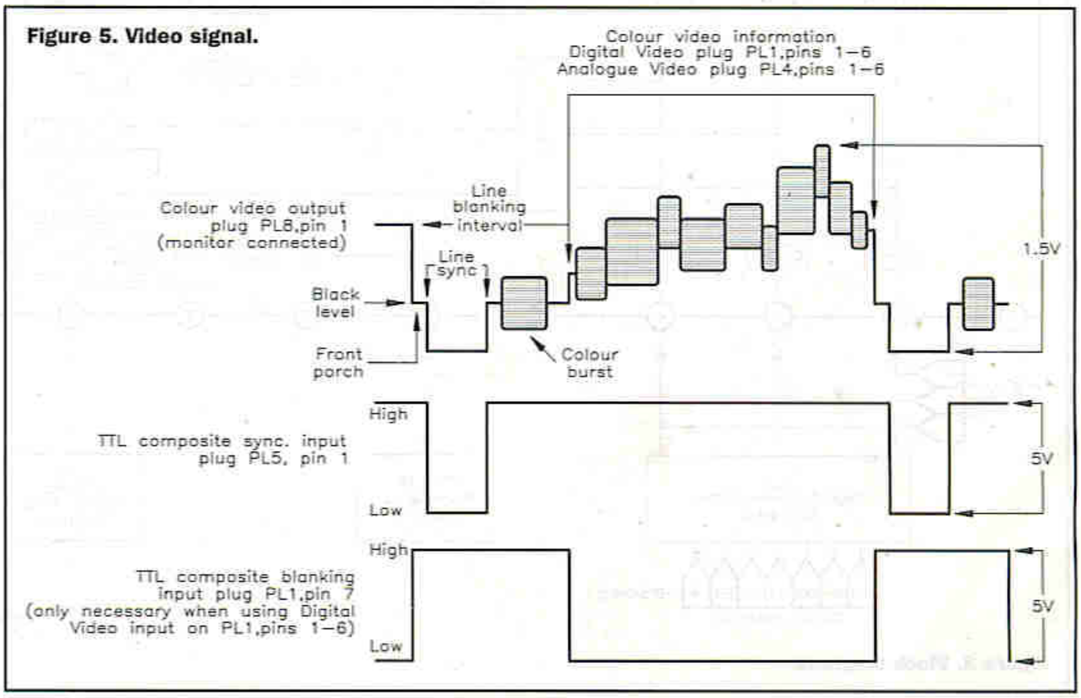
When choosing appropriate values, consideration should be given to both cross colour and resolution. Relations between inductor values and image quality are as follows:

Inductor value	Small ↔ Large
Cross colour	Large ↔ Small
Resolution	High ↔ Low

Pin 7 of IC2 is used to select the PAL/NTSC mode and should be connected to either 0V for PAL mode or +5V for NTSC. A component list for PAL/NTSC operation is shown in Table 2.

Pin 10 of IC2 is connected to pin 1 of PL5 and is the

Figure 5. Video signal.



Component	PAL	NTSC
XT1	4·433619MHz	3·579545MHz
R22	16kΩ	20kΩ
C27	27pF	27pF
CH1	68µH	47µF
IC2, Pin 7	0V	+5V

Table 2. Component list for PAL/NTSC operation.

composite sync input requiring a negative TTL logic signal, see Figure 5. For PAL operation the field sync must include line sync information.

To aid connection to digital circuits, the 6-bit digital input also has a composite blanking input which must be high during sync and colour burst unless all the colour inputs are low at this time.

The digital colour inputs are as follows:

RED *R0 = PL1 pin 1*
RED *R1 = PL1 pin 2*
GREEN *G0 = PL1 pin 3*
GREEN *G1 = PL1 pin 4*
BLUE *B0 = PL1 pin 5*
BLUE *B1 = PL1 pin 6*

There are two binary bits per primary colour and these inputs are TTL compatible. A table showing 18 out of the 64 possible colours is given in Table 3.

In addition to the digital inputs, separate analogue RGB inputs are provided on PL4 as follows:

Analogue RED
Signal = PL4 pin 1
Return = PL4 pin 2

Analogue GREEN
Signal = PL4 pin 3
Return = PL4 pin 4

Analogue BLUE
Signal = PL4 pin 5
Return = PL4 pin 6

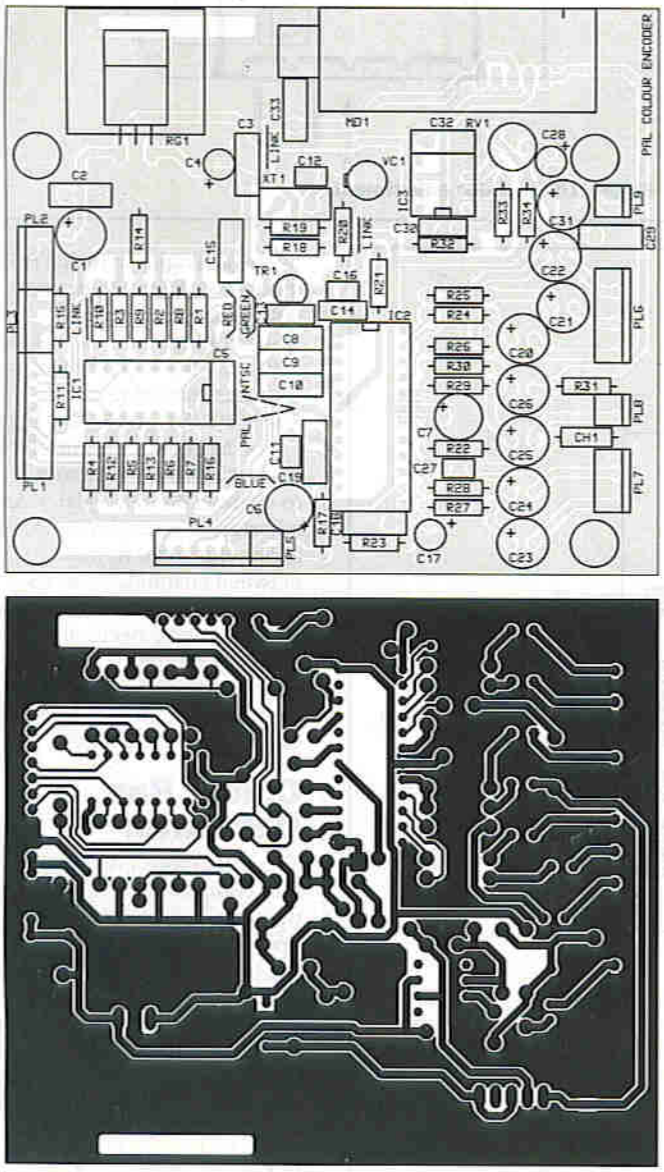


Figure 6. PCB legend and track.

Colour	R0	R1	G0	G1	B0	B1
Dark Red	1	0	0	0	0	0
Medium Red	0	1	0	0	0	0
Light Red	1	1	0	0	0	0
Dark Green	0	0	1	0	0	0
Medium Green	0	0	0	1	0	0
Light Green	0	0	1	1	0	0
Dark Blue	0	0	0	0	1	0
Medium Blue	0	0	0	0	0	1
Light Blue	0	0	0	0	1	1
Black	0	0	0	0	0	0
Dark Grey	1	0	1	0	1	0
Light Grey	0	1	0	1	0	1
White	1	1	1	1	1	1
Orange	0	1	1	0	0	0
Yellow	1	1	0	1	1	0
Purple	0	1	0	0	1	0
Pink	0	1	1	0	1	0
Cyan	0	0	1	0	0	1

Table 3. 18 of the 64 possible colours using the digital input.

The composite video generated by the CXA1645 appears on pin 20 of the chip and is taken off to the TV modulator MD1 via R30, R31, and C26. The signal is also capacitively coupled to PL8 pin 1. When using a video monitor with a high input impedance it is important that the composite video output is correctly loaded with a 75Ω resistor.

S-Video in the form of separate Y and C signals are output by IC2 on pins 15 and 16, respectively. These signals are capacitvly coupled to PL7 as follows:

Y_{OUT}
Signal = PL7 pin 1
Return = PL7 pin 2

C_{OUT}
Signal = PL7 pin 3
Return = PL7 pin 4

The CXA1645 also provides fully buffered analogue RGB outputs capable of driving a 75Ω load. These are brought out to PL6 as follows:

R_{OUT}
Signal = PL6 pin 1
Return = PL6 pin 2

G_{OUT}
Signal = PL6 pin 3
Return = PL6 pin 4

B_{OUT}
Signal = PL6 pin 5
Return = PL6 pin 6

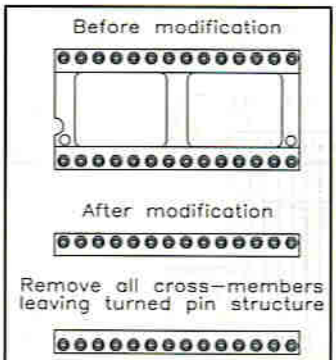


Figure 7. Modifying the DIL socket for the Sony CXA1645P chip.

Printed Circuit Board

A high quality fibreglass PCB (stock code GJ12N), with a printed legend to assist you in correctly positioning each component is shown in Figure 6. The following assembly hints should also prove useful in making construction as straightforward as possible.

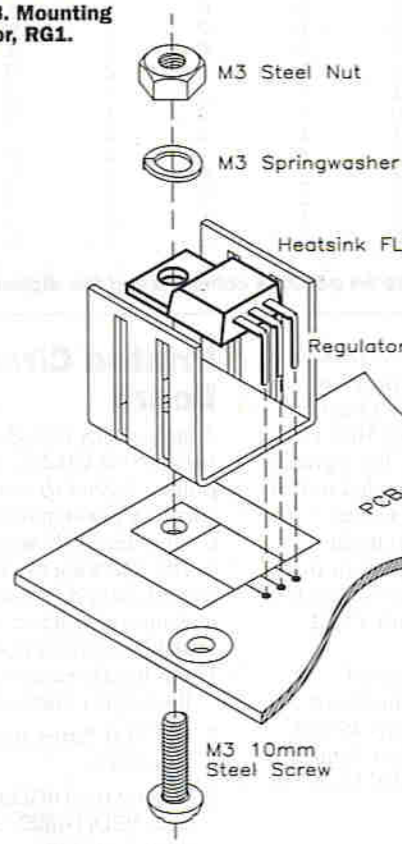
1. It is usually easier to start with the smaller components first,
2. DO NOT forget the three wire links,
3. If using the DIGITAL input, links RED, GREEN and BLUE must be made,
4. Remember to select PAL or NTSC mode by fitting the appropriate wire link,
5. If intending to use the S-Video and/or RGB buffered outputs, optional components must be purchased and fitted, see the Optional Parts List,
6. When fitting the 'Minicon' connectors ensure that the locking tabs are facing outwards to the edge of the PCB,
7. The socket for IC2 will require cutting down to size, see Figure 7,
8. When fitting the semiconductors you must carefully match the case to the outline shown on the legend,
9. DO NOT overheat the crystal XT1,
10. Regulator RG1 should be fitted as shown in Figure 8.

Testing And Alignment

Connect a 12V power supply to PL2, positive to pin 1, negative to pin 4. Using a test meter in the positive line, measure the DC current which should be approximately 170mA. Remove your meter from the supply input and set it to read DC volts. Connect the meters negative lead to a convenient ground point (PL3 pin 3 and 4) and measure the positive 5 volts which should be present on pin 1 and 2 of PL3.

Next connect the video output to a colour monitor, or the RF from the modulator to a colour television. Until the composite sync and blanking (If using the digital input) is applied to PL1 (digital RGB and blanking), PL4 (analogue RGB) and PL5 (composite sync) the monitor/TV screen should be blank, with the state of the colour inputs having no effect. With the correct sync (and blanking) the entire screen should change to the colour set

Figure 8. Mounting regulator, RG1.



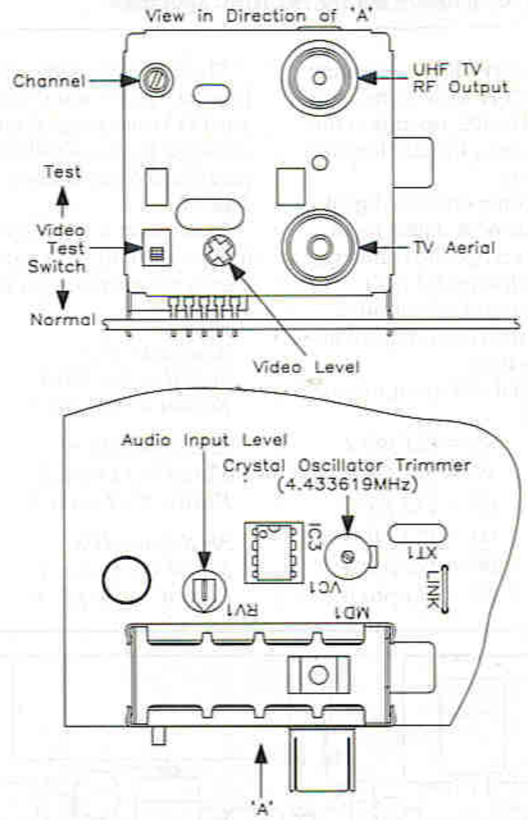
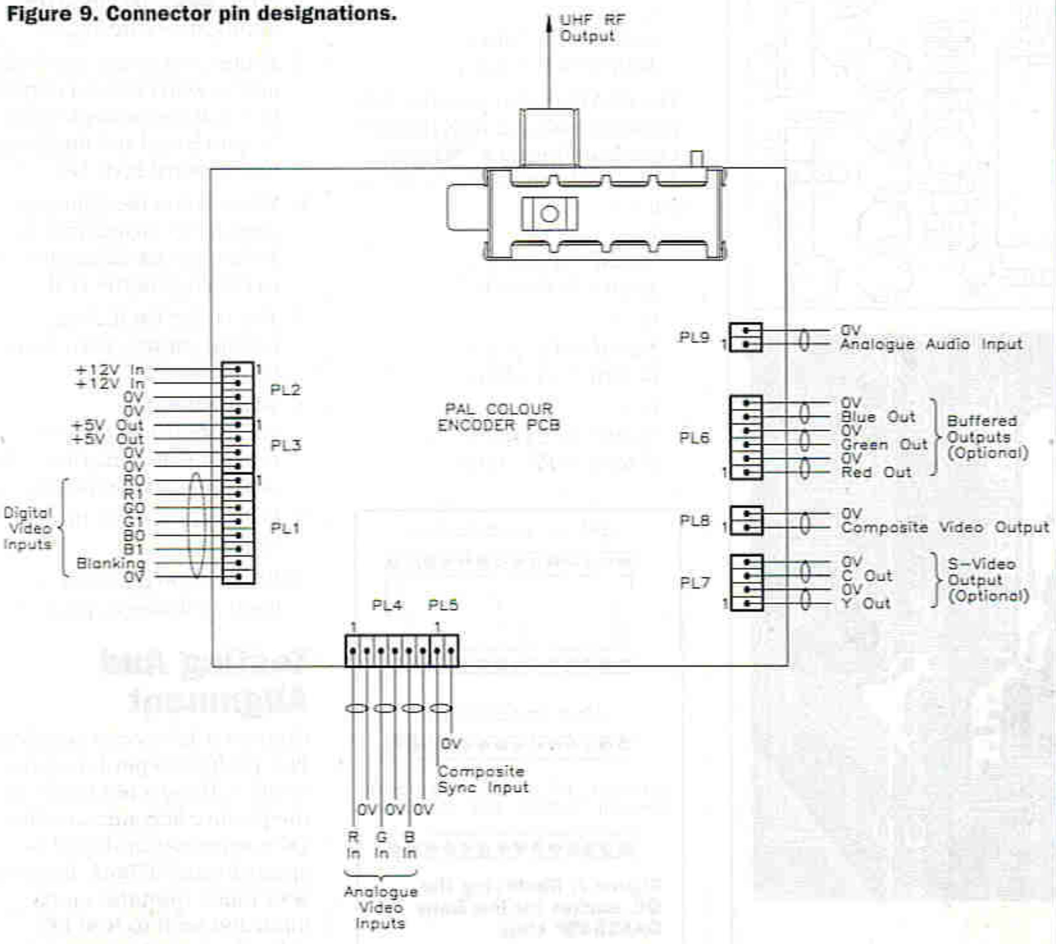


Figure 10. Encoder adjustment.

Figure 9. Connector pin designations.



by the analogue or digital RGB inputs, see Figure 9. If no colours are seen then try adjusting VC1 until the colour locks in – this will be when the crystal is oscillating at 4·433619MHz, see Figure 10.

The frequency output of the video modulator is factory set to channel 36 (591·5MHz). An adjustment screw on the back allows this to be moved between channels 30 and 39, see Figure 10. This adjustment should only be necessary if you are using the unit in conjunction with a video recorder or if interference from Channel 5 is experienced.

Colour Bar Generator

The PAL Colour Encoder is a fully compatible replacement for the now discontinued Colour Encoder LM66W and, as such, can be used with the Colour Bar Generator (LT50E), see Photo 1. The PCBs are interconnected by means of ribbon cable and Minicon connectors, as indicted in the wiring diagram shown in Figure 11. In addition, it is possible to 'piggyback' the two kits using M3 hardware as shown in Figure 12. ELECTRONICS

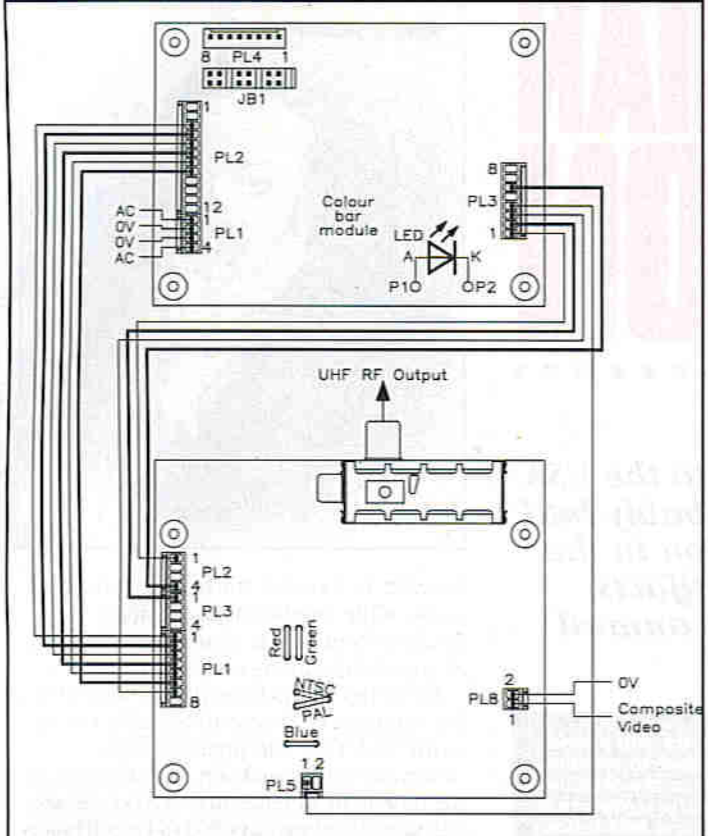


Figure 11. Wiring diagram for the Colour Bar Generator (LT50E) and the PAL Colour Encoder.

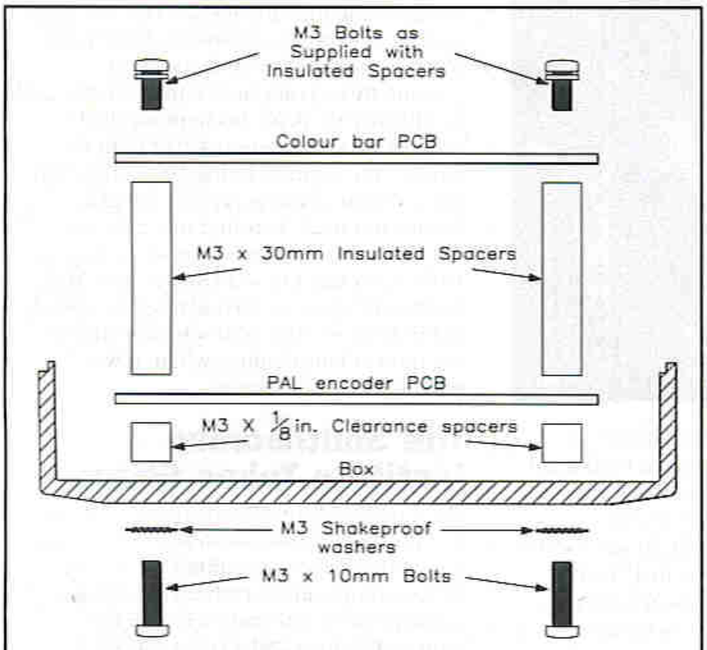


Figure 12. Piggyback mounting of modules.

PAL Colour Encoder and Colour Bar Generator PCBs mounted piggyback.

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1-7	Min Res 10k	7	(M10K)
R8, 10, 12	Min Res 15k	3	(M15K)
R9, 11, 13	Min Res 5k6	3	(M5K6)
R14-16	Min Res 1k2	3	(M1K2)
R17, 21	Min Res 2k2	2	(M2K2)
R18, 19	Min Res 100k	2	(M100K)
R20	Min Res 3k3	1	(M3K3)
R22	Min Res 16k	1	(M16K)
R23	Min Res 47k	1	(M47K)
R29	Min Res 75Ω	1	(M75R)
R30	Min Res 150Ω	1	(M150R)
R31, 34	Min Res 220Ω	2	(M220R)
R32	Min Res 27k	1	(M27K)
R33	Min Res 4k7	1	(M4K7)
RV1	50k Cermet Preset	1	(WR43W)
CAPACITORS			
C1, 25, 26, 31	GenElect 220μF 16V	4	(AT41U)
C2, 3, 5, 8, 9, 10, 15, 18, 19, 29, 32, 33	Minidisc 100nF 16V	12	(YR75S)
C4, 17, 28	GenElect 10μF 63V	3	(AT77J)
C6, 7	47μF 10V Tant	2	(WW75S)
C11	Ceramic 4p7F.	1	(WX40T)
C12	Ceramic 6p8F	1	(WX42V)
C13, 14, 30	Ceramic 100pF	3	(WX56L)
C16	Ceramic 1nF	1	(WX68Y)
C27	Ceramic 27pF	1	(WX49D)
VC1	Trimmer 22pF	1	(WL70M)
SEMICONDUCTORS			
RG1	L7805CV	1	(QL31J)
IC1	HCF4503BEY	1	(QQ41U)
IC2	CXA1645P	1	(VQ61R)
IC3	TL071CN	1	(RA67X)
TR1	BC548	1	(QB73Q)
MISCELLANEOUS			
XT1	4·433619MHz Crystal	1	(FY85G)
CH1	47μH Choke	1	(WH39N)
MD1	UHF Modulator 6MHz	1	(WC20W)
PL1	PCB Latch Pl 8w	1	(YW13P)
PL2, 3	PCB Latch Pl 4W	2	(YW11M)
PL4	PCB Latch Pl 6W	1	(YW12N)
PL5, 8, 9	PCB Latch Pl 2W	3	(RK65V)
	PCB Latch Hsng 8W	1	(YW23A)
	PCB Latch Hsng 4W	2	(HB58N)
	PCB Latch Hsng 6W	1	(BH65V)
	PCB Latch Hsng 2W	3	(HB59P)
	PCB Terminal	3	(YW25C)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 16-pin	1	(BL19V)
	Turned Pin DIL Skt 24-pin	1	(FJ67X)
	Slotted Heatsink	1	(FL58N)
	M3 10mm Steel Screw	1	(JY22Y) ★
	M3 Springwash	1	(JD96E) ★
	M3 Steel Nut	1	(JD61R) ★
	Colour Encoder PCB	1	(GJ12N)
	Colour Encoder Leaflet	1	(XZ41U)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
R24-28	Min Res 75Ω	As Req.	(M75R)
C20-24	GenElect 220μF 16V	As Req.	(AT41U)
PL6	PCB Latch Pl 6W	1	(YW12N)
PL7	PCB Latch Pl 2W	1	(RK65V)
	PCB Latch Hsng 6W	1	(BH65V)
	PCB Latch Hsng 2W	1	(HB59P)
	PCB Terminal	As Req.	(YW25C)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LU74R (PAL Colour Encoder) Price £25.49

Please Note: Items in the Parts List marked with a ★ are supplied in 'package' quantities (e.g., packet, strip, reel, etc.), see current Maplin Catalogue for full ordering information.

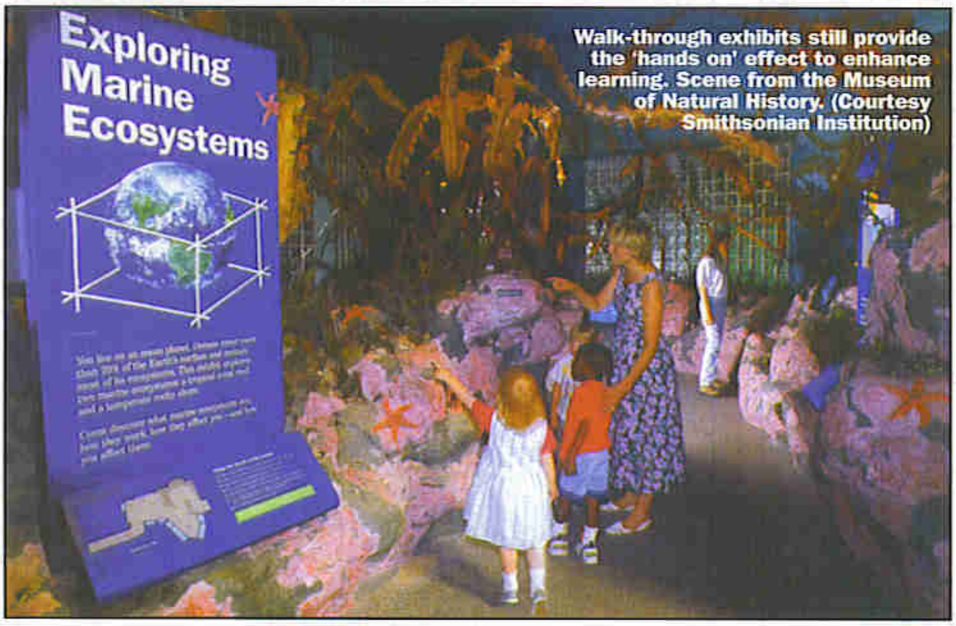
The following new item (which is included in the kit) is also available separately.

Pal Colour Encoder PCB **Order As GJ12N Price £4.49**

THE SMITHSONIAN INSTITUTION

by Douglas Clarkson

Which Englishman bequeathed $500,000 to the USA – a country he had never visited and probably had never corresponded with? What institution in the USA now presides over 140 million artifacts, employs 5,000 staff directly and has an annual budget of around $600 million?



Walk-through exhibits still provide the 'hands on' effect to enhance learning. Scene from the Museum of Natural History. (Courtesy Smithsonian Institution)

The answers are James Smithson and the Smithsonian Institute based in Washington DC.

The scale of the Smithsonian is vast. It has played a dominant role in the documentation and preservation of many diverse strands of art, history and science and technology – albeit with a strong North American flavour. This example of giving without any thought of personal reward is a key feature of the steady growth of the Smithsonian through continued bequests and donations.

The Smithson Link

James Smithson was born in France in 1765 as the illegitimate son of Elizabeth Keate Moore, widow and member of the wealthy Hungerford family and Hugh Smithson, who was to become Lord and Duke of Northumberland. He returned with his mother to England when he was ten years old. He entered Oxford University at age 17 as John Louis Macie and graduated from Pembroke College in 1786 after having shown great promise in his work as a chemist and mineralogist.

The choice of science was apparently forced on Smithson, since more traditional careers in civil or military service were barred to him. It was, in fact, Henry Cavendish who sponsored Smithson for the Royal Institute around 1789. In 1791, he read his first paper to the Royal Society on the chemical characteristics of tabasheer – a compound found in bamboo.

After the death of his mother in 1800, he took on the name of Smithson. In his lifetime, he published around 27 papers on topics in chemistry and had a mineral of zinc carbonate – smithsonite – named after him. He apparently, however, could not establish himself in England and spent extensive periods of time travelling around Europe – as was the fashion of the time.

By this time, he had presumably inherited some or all of the wealth of his mother. In his will of October 23rd, 1826, at the age of 61, Smithson indicated that in the first case, his estate should pass to a nephew, Henry James Hungerford. In the event of there being no heirs, the entire estate would be bequeathed 'to the United States of

James Smithson.

America, to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase and diffusion of knowledge among men'.

There has always been debate as to what led Smithson to choose to leave his fortune to the USA. One interpretation is the observation that Smithson, with his roots in the monarchy of England and who was also well acquainted with a period of French history which climaxed in the French revolution and its continuing reign of terror, was very much anticipating the potential of the USA to outshine the monarchies and dictator states of tired old Europe. Leastways, there is still plenty of conjecture on this subject.

Some three years later, Smithson died and in a further six years, his nephew died without issue and events fell in train to transfer the bequest to the USA. There was some debate about accepting the gift. Britain and the US around this time were not always on the best of terms. In August 1838, however, a boat arrived at New York bearing 105 bags of gold sovereigns valued at $508,308.46. The gold was delivered to the mint at Philadelphia, where it was recoined in US currency.

The Smithsonian Institute Takes Shape

Once the funds had been accepted, there was then much discussion as to what form the embryonic organisation should take. Various propositions included a library, a natural history museum, a school for training teachers and an observatory. It was, however, in 1846 that Congress finally created the Smithsonian Institution and indicated that a building be constructed 'of plain and durable material and structure without unnecessary ornament'. The initial building comprised a museum, a study, a collection of scientific materials, a chemical laboratory, a gallery of art and lecture rooms. The cornerstone of the building was laid in 1847. The Chief Justice of the USA and the Vice President were established as two of the 15 governing 'Regents' of the Smithsonian. Smithson had died in Genoa in 1829 aged 64 and had been buried in a small English cemetery there. When, in 1904, the burial ground was due to be displaced by the enlargement of a nearby quarry, the Smithsonian Board of Regents voted to

Museum	Number of Objects
Anacosta Museum	7,044
Copper-Hewitt Museum of National Design	250,000
Freer Gallery of Art	27,397
Hirshhorn Museum and Sculpture Garden	12,500
National Air and Space Museum	32,300
National Museum of African Art	7,000
National Museum of American Art and Renwick Gallery	37,000
National Museum of American History	3,200,000
National Museum of Natural History	121,647,123
National Museum of the American Indian	1,000,000
National Portrait Gallery	17,705
Arthur M. Sackler Gallery	2,641
National Zoological Park	5,956 (animals)
Archives of American Art	12,000,000
Smithsonian Institute Libraries	1,000,000 (books)

Table 1. Summary of items and artifacts in the main Smithsonian Organisations.

bring Smithson's tomb to America. This was overseen by Alexander Graham Bell in his role as a Regent of the Institute. Smithson's tomb is today one of the key places to visit on the main campus in Washington.

Perspectives

Describing even a small fraction of the vast collections of the Smithsonian is an onerous task. Aspects of cataloguing such a vast collection is a mammoth information exercise. Not considering its collection of 1-2 million books, the total number of artifacts, works of art and specimens in the Smithsonian's collections is estimated at over 141 million. The majority of this material, to the tune of 120 million specimens, forms part of the National Museum of Natural History. Table 1 summarises the number of objects in the various major museums.

Routes to Collection

Objects enter the various collections of the Smithsonian through a variety of routes. These include donations from individuals, private collections and Federal agencies such as NASA. In the field of Natural History, significant numbers of items are obtained via field expeditions though there is also a significant level of interchange between other museums.

One of the key aspects of accepting an exhibit is its 'readability' – i.e., whether a visitor can understand an object by looking at it. This perhaps reveals also a hidden psychological aspect to designing meaningful web pages – their 'readability'. In the case of museums, the tradition has perhaps been that 'big is beautiful' – since the more dominant the display, the simpler it is to catch and hold the attention. With more and more of the planet being turned over to theme parks, this has been accompanied with a rapid development of ways of presenting objects and concepts to the general public and using all the tricks and ploys of space, image, light and sound.

There will, however, always be a discrete difference between museum archive databases and the pages of the Internet. Extensive use is made of image data bases run on mini computers that allow Smithsonian staff and academic researchers with appropriate permission to access such databases in the line of academic research and the general ebb and flow of curiosity. The levels of security at the Smithsonian do not allow unauthorised access to the 'formal' data bases which modern technology with mass storage of tens of Gigabytes now makes available.

Also, just as objects pass into collections, there is also the reverse process – the selling of objects which are considered surplus to requirements. Some artifacts are, therefore, traded or sold at public auction. There are, however, very definite limits to growth of what any organisation can acquire, catalogue, provide access to and possibly put on view to the public. The Smithsonian, therefore, adds to its collection only a very small percentage of the items it is offered.

Certain areas of collection, however, never stop. The Political History Department of the Museum of American History must continue to collect material from modern presidential campaigns so that future generations will have access to such material. Also, the collection of specimens from regions of vanishing habitat is naturally regarded as being particularly important. Specimen collections are, therefore, particularly active, obtaining specimens from the tropical rain forests of Central and South America, Asia and Africa. Increasingly, there is a focus to preserve species using liquid nitrogen in order to provide a record of genetic diversity at the molecular level. Thus, while there are degrees of rarity of species – endangered, rare, extinct, there could be added yet another – 'genetically preserved'.

The Role of the Museum: It's Good to Look

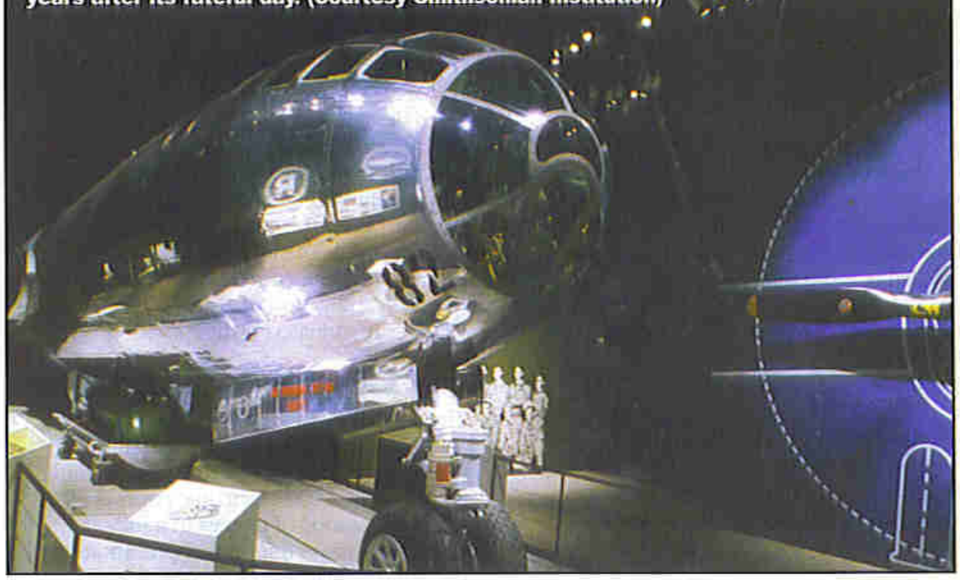
There can be little to doubt the ability of things visible to stimulate the senses. Technology, tactfully displayed, broadens scientific understanding. Works of art make us search inwardly for the many strands and fibres of the makeup of human awareness and creativeness. The modern technological age as it has been ushered in has been optimised for financial efficiency, commercial competitiveness, speed of transport and length of traffic queues. Art in many of its various aspects will hopefully re-enter our technological age – so that our surroundings are more stimulating, more pleasant, more exciting. As it is today, we derive more art from the images on the advertisements on the London underground than in our cities at large.

Things of history make us a more reflective society with a perspective that can perhaps provide some guidance as regards the many major decisions that wait to be taken in the future. There will certainly be many decisions that will be required to be made. It's good to look. The images of the past, however, can also haunt us.

While the Smithsonian is essentially a window on things cultural and historical, this includes also acknowledging weapons of mass destruction. Very much at the centre of a recent storm, the presentation of the B-29 Superfortress – Enola Gay that dropped the Atomic Bomb on Hiroshima, precipitated a great amount of controversy, both within the USA and outside it.

The Enola Gay was displayed – in a rescheduled exhibition setting – with shining restored forward fuselage, glistening brightly in the clear focused lights of the museum display. While the gallery shows the plane and all the individuals that flew the mission, what they do not obviously show is the horrific destruction that accompanied the release of the bomb over Hiroshima – essentially a civilian target. It is displayed something like a turbo car in a motor show – the star attraction. Is this an epitaph for our age – plenty of power to alter the world but not the ability to do it in a responsible way?

The legacy of the past – the Enola Gay – with the ability to inflame passions some 50 years after its fateful day. (Courtesy Smithsonian Institution)



A mineral of zinc carbonate – smithsonite – named after Smithson.

What the episode demonstrated, however, was the power of a physical object to draw out controversy – not a new documentary, not a network chat show, not even a revealing article in the Washington Post; simply an exhibit that would be seen by some hundreds of thousands of individuals. No matter how electronic our age becomes, there will always be scope for physical objects that we can see and touch to influence us.

The Smithsonian keeps alive also, the memory of great aviation feats. There is an annual Charles A. Lindbergh lecture given typically by distinguished flyers to remind up and coming generations of the heroism of the past and the challenge which flight still presents.

Smithsonian Astronomical Observatory

One of the earliest suggestions for the use of the Smithsonian bequest was for an astronomical observatory. The Smithsonian Astrophysical Observatory (SAO) functions jointly with the Harvard College Observatory in the Harvard Smithsonian Centre for Astrophysics in Cambridge, Massachusetts. A combined professional staff of 250 scientists is engaged in a wide range of studies including astronomy, astrophysics and Earth and space sciences. A range of Earth-based observing stations include the Frank Whipple Observatory in Arizona and the Oak Ridge Observatory in Massachusetts.

Ongoing developments in observing systems include the construction in Hawaii of a sub-millimetre telescope array (SMA) of six dishes each 6m in diameter. When complete, the facility will be equivalent to a huge radio telescope 500m in diameter.

Existing radio telescope facilities at the SAO have already found some of the best evidence for the existence of massive black holes in the universe – but thankfully, not in our backyard. Signals from galaxy NGC 4258 have revealed a disk of material a few hundred times the size of our solar system rotating at velocities of 1,000km/s round a central mass concentration of some 40 million Suns – implying that at the heart of this feature exists a massive black hole.

This remit of the Smithsonian to undertake research as well as act as a storehouse of knowledge can be traced back to the influence of the Smithsonian's first director, Professor Joseph Henry – a Princeton science professor.

Smithsonian Environmental Research Center

This facility based in Edgewater, Marlyand, in the Chesapeake Bay Area, undertakes a range of research, principally in the marine environment and on the various pressures put upon it by our modern age. One apparently important but not often reported element of investigation relates to the contamination of coastal waters by the ballast water of ships in ports and harbours. Live pathogen microorganisms, shellfish parasites and exotic species are among the organisms being transported between harbours all over the world. The centre routinely monitors the ballast waters of ships in Baltimore harbour.

With global warming also, will this be a fast-track way to import new species into UK coastal waters? Does anyone monitor the ballast waters of ships in our ports?

Continuing anxieties over the levels of oestrogen and testosterone released through intensive livestock farming have resulted in careful monitoring of the levels of these compounds in waters draining through agricultural land in the Chesapeake Bay area. Biological effects have already been detected in the rivers and streams in this area. In the UK, this work is of particular relevance, where water is increasingly being taken from rivers or pumped from the ground where recent infestations of the intestinal parasite, cryptospyridium (not a bacteria or a virus), is a likely indication of abstraction of ground water contaminated by livestock.

The Electronic Smithsonian

The Smithsonian Home Page on the Internet (http:/www.si.edu) was launched on 8th May 1995. At this time, the facility consisted of 2,000 electronic pages and many thousands of images in a fully integrated, cross-referenced presentation of the Smithsonian's sites, people and resources. By 30th September 1995, more than 8·5 million 'hits' had been recorded.

Since then, the 'Electronic Smithsonian' has expanded considerably and with significant resources of the organisation used to actively develop such sites. Thus, in many respects, the phrase 'increase and diffusion of knowledge' is very apt and with expansion of web sites one of the key goals of the Institution.

Smithsonian Photographs On-Line

(http://photo2.si.edu)

This is a major point of access for online photographic material. The site provides essentially a sampling of material across a wide range of sources within the Smithsonian itself and also within modern society at large. Over 40 sub sites are accessible, ranging from tips for photographing fireworks successfully to experiencing the exotic abundance of the jungle canopy of Panama. To those with more than a passing interest in dinosaurs, the page 'Photographs from the Dinosaur Hall of the Smithsonian National Museum of Natural History' will be very tempting.

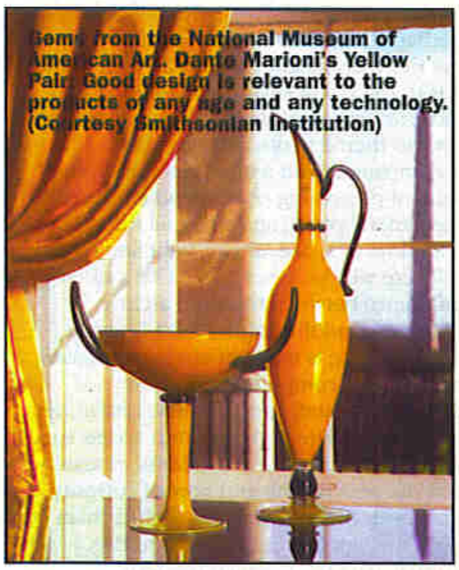
A major sub-section within this site, however, is a 'Search and Retrieve' database of around 1,000 GIF file images over a range of topics including Air and Space, Science, Nature, Technology and History and People and Places.

In addition, it is possible to log via FTP with the Smithsonian photo server – an anonymous ftp server with image files in GIF and JPG formats.

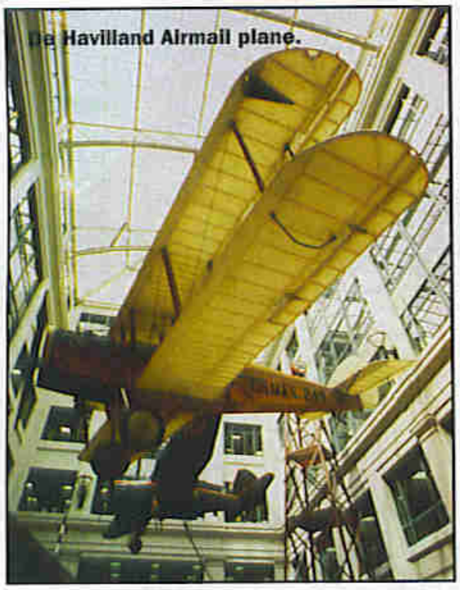
Science in Cyberspace

(http://www.si.edu/resource/topics/science.htm)

The Science in Cyberspace initiative is a series of web pages developed jointly by the Smithsonian and the National Science Foundation. The aim of this partnership is to bring the talents of the 'curator' to bear on problems of dissemination and generally making available research and development work to a wider community. While there will always be a focus on research developments, there will also be a focus on aspects of basic principles. It is anticipated that these planned web sites will in time become some



Gems from the National Museum of American Art. Dante Marioni's Yellow Pair. Good design is relevant to the products of any age and any technology. (Courtesy Smithsonian Institution)



De Havilland Airmail plane.

Multiple mirror telescope.

of the best available on a wide range of scientific topics.

Complementing the Smithsonian's strengths in Natural History, it is intended to develop online resources in Volcanology, Palaeontology, Atmospheric Science, Mineralogy and Oceanography. These areas are also part of the remit of the NSF Directorate for Geosciences.

Another major area of endeavour will relate to communicating technology – history and present development. This itself will be introduced through the Computer and Information Science and Engineering (CISE) Directorate at the NSF.

Thus, it would appear that not only is the technology in place to disseminate information, there appears to be a structure in the USA to draw together resources from diverse organisations and pool them to develop an information resource.

Lemelson Center

(http://www.si.edu/lemelson/)

The Jerome and Dorothy Lemelson Center for the study of invention and innovation was founded in 1995 as a gift from the Lemelson Foundation. Jerome H. Lemelson hold more than 500 patents on inventions relating to the VCR, camcorder, fax machine, mobile phones and machine vision. The centre has established a number of initiatives relating to the understanding of science and the encouragement of inventiveness and creativity. The Lemelson National Program has established on a number of university campuses, 'Excellence – Teams'.

These teams consist essentially of undergraduates who take initial concepts through all the necessary stages to a completed business product. Funds have been allocated, for example, to Hampshire College for establishing the educational component of such an initiative. Projects within this scheme have included computer games for AIDS education and publication of a literary journal using desktop publishing. Central to the thinking of such schemes is that future economic strength and employment must come from new products.

Enter the Hologlobe

(http://www.si.edu/hologlobe/how.htm)

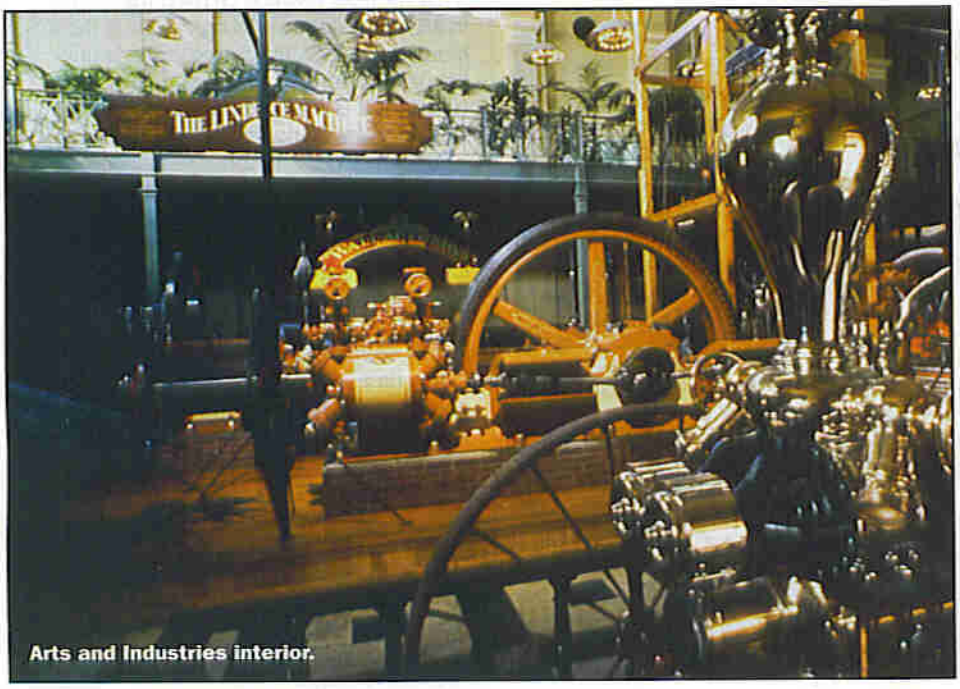
One of the newer high-tech exhibits at the National Museum of Natural History is the Hologlobe – a 3-D visualisation of the Earth as seen from space. Using state-of-the-art 3-D laser image projection technology, the Earth can be made to appear just as it would appear from space.

The Trail of New Things

(http://www.si.edu/whatsnew/startold.htm)

This page, which prints to around 10 A4 pages, provides in a way, a history of developments of the major Smithsonian web pages – dating all the way back to May of 1995. There is the indication here of the steady expansion of established web pages maintained by the Smithsonian. While already a major resource, over the years, significantly more material will be added.

One extremely powerful facility is a search engine which allows research of topics and retrieval of relevant web pages within the Smithsonian.



Arts and Industries interior.

The National Museum of American History

Within this major museum, the collection on the History of Science and Technology holds unique artifacts and displays relating to the topics of agriculture and natural resources, armed forces, history, engineering and industry, medical sciences, physical sciences and transportation.

The page 'Information Age: People, Information and Technology' **(http://photo2.si.edu/infoage.html)** uses a series of unique Smithsonian images to trace the progression of development from Samuel Morse's original transmitter and receiver of 1837 to the analogue video and CD-ROM of the 1980s. The original Morse code equipment of 1837 was designed to print patterns of characters – it was, therefore, an essentially 'silent' device.

The more familiar Morse/Vail telegraph key and Morse/Vail telegraph register (receiver) were first used for the first time in 1844 to send and receive the famous message 'What God Hath Wrought' on the experimental line between Washington DC and Baltimore, Maryland.

The landmark even of the first Atlantic cable of 1858, which worked for only a short time, was an epic achievement of its time. The style of cable used essentially survived unchanged for the next 100 years. Items also displayed on this page include early development items and also the first commercial telephones invented by Alexander Graham Bell.

While the work on breaking the code of the German Enigma cipher system at Bletchley Park is well known, it also transpires that in the USA, the ENIGMA machine was used to crack this 'enigmatic' code. It was this embryonic work in machine code systems that fostered the later development of electronic computers.

Also on exhibit are details of the ENIAC system (Electrical Numerical Integrator And Computer). This physically large digital electronic computer (which occupied a large room 30×50ft.) was used to calculate tedious electronic calculations involving ballistic tables.

One of the more revealing additions to the collection is an Apple I computer kit developed by Steve Jobs and Steve Wozniak in 1976. This development was, as everyone knows, very much a garage industry, and one that wrong-footed the major players of the IT industry who never guessed the tremendous impact such technology would have on all our lives.

It is a curious thought, that if the museum added a 'top of the range' Pentium PC as an exhibit today, what technology will render it an amusing anachronism – say, in barely 25 years. The exhibit, therefore, provides a useful perspective to show that the modern information age has been with us in some shape or form for the last 160 years.

Giant Squids:

An Expedition into the Depths of the Last Frontier

(http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/)

At the Smithsonian, there is always the aspect of searching in faraway places for the unusual. A search for the Giant Squid in the undersea chasm of the Kaikoura

National Air and Space Museum (95-7091).

Canyon, located off the coast of New Zealand's South Island, is documented in this web site and certainly sounds interesting. Modern technology provides, therefore, a unique way of communicating images of the deep to a worldwide audience.

Smithsonian Institution Libraries

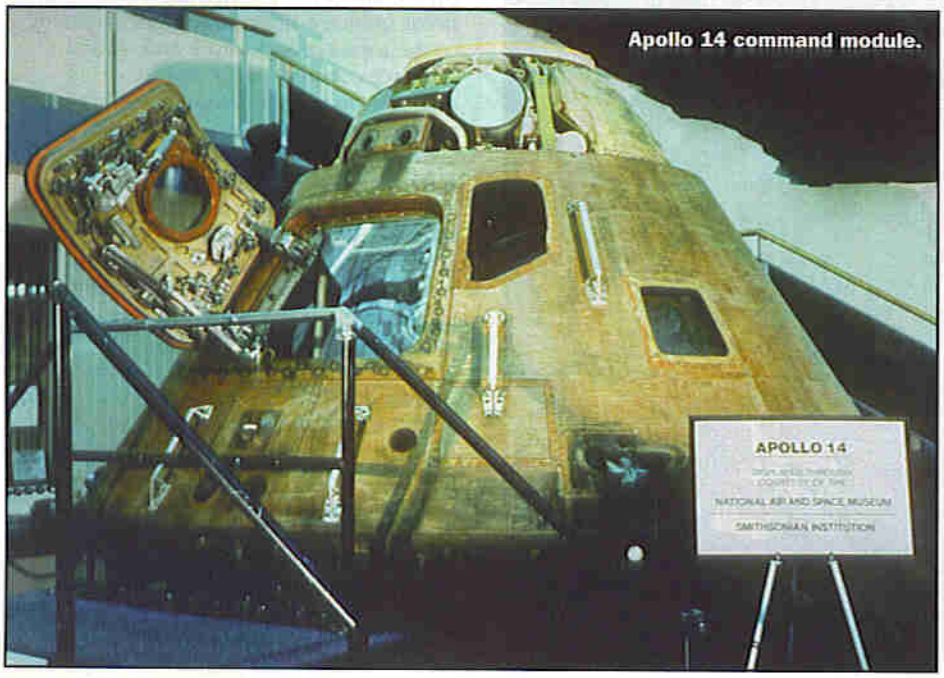
The service provides an integrated service to 18 branches of the Smithsonian Library System. In all, a total of 1·2 million books, 15,000 journals, 40,000 rare books and 18,000 groups of manuscripts are available and are online on the Internet via the Libraries World Wide Web site, **http://www.sil.si.edu.**

Travelling Exhibitions

Museums always have many more items in archive store than can be put on display to the public. This provides ample opportunity for the Smithsonian to undertake travelling exhibitions within the USA and also overseas. This also makes possible the reception and display of items from other major collections around the world so that diversity and variety are provided.

National Science Resource Centre

One of the interesting features of the Smithsonian is that it appears to try to complete the cycle in the dissemination of knowledge. Not only does the Smithsonian collect and preserve knowledge, art and culture, it also plays an active part in developing curriculum material for teaching – particularly in the sciences where the Smithsonian-based National Science Resource Centre, in association with the National Academy of Sciences, is continuing to develop a broad range of teaching packages for the Science and Technology for Children (STC) curriculum project. Thus, as well as presenting the science of the past and the present, the Smithsonian is actively engaged in developing its future.



Apollo 14 command module.

Summary

James Smithson could have had little idea what his legacy, which crossed the Atlantic in 1838, would grow to represent in the fabric of the USA in science, arts, natural history and history. In a short article, however, it is only possible to cover but a small fraction of the entire organisation.

It is always easy to indicate that in the UK we should be doing more in way of preserving and disseminating knowledge. It would be helpful, certainly, to determine just what we are doing, for example, in establishing educational Internet sites. There is no doubt that we have material just as relevant in our major collections.

In a time of faltering public finances (in a period of sustained economic growth but with tax reductions), it is not the best of times to ask the public purse for additional resources. Even at the Smithsonian, there is increasing funding restraint. Who will be the Carnegie of the 21st century and provide knowledge for all on the Information Superhighway. Perhaps it will be the supermarkets who will endeavour to redress the yawning cultural gap in our National Heritage.

PROJECT UPDATE

Discriminating CONTINUITY & LEAKAGE TESTER EMC

The Discriminating Continuity & Leakage Tester (LT78K) is an extremely popular project and was originally published in the March 1995 issue of Electronics the Maplin Magazine. It has recently been updated and details of the changes are included in this article so as to allow existing projects to be modified and brought up to date.

EMC Compliance

The update to this project forms part of the overall programme of EMC compliance for project kits that Maplin has been working on since 1995. Maplin is proud of its range of project kits and takes its responsibility for ensuring EMC compliance seriously.

The change that has been made to the Discriminating Continuity & Leakage Tester, described in this update, does not alter how it works or its performance in use, but simply ensures that the requirements of the EMC directive are met. With the change implemented, radio frequency emissions from the unit are within the limits defined in EN 50081-1.

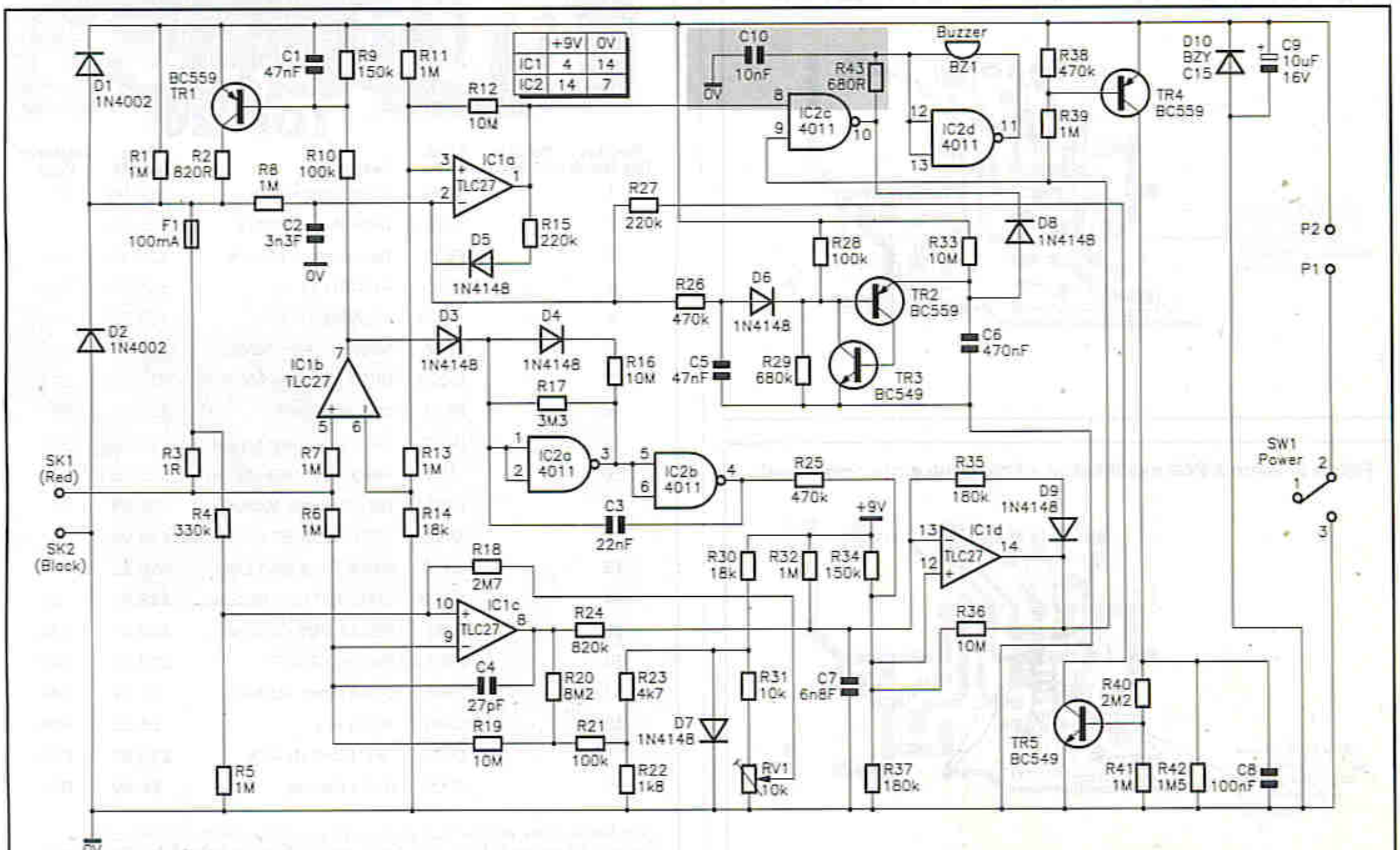


Figure 1. Revised circuit diagram of the Discriminating Continuity Tester – the extra components are highlighted by the tinted panel.

Investigations into the original design (i.e. without the change detailed in this update implemented) revealed that the piezo sounder driver circuit was generating radio frequency emissions. Whilst these emissions were not, in general terms, of particularly high level, they were in excess of the limits defined in the standard. For this reason, Maplin temporarily withdrew the kit from sale until a suitable cure was found.

The Cure

The cure proved to be quite straightforward. A simple RC network, comprising a 680Ω resistor and a 10nF capacitor, when inserted into the piezo sounder driver circuit (see Figure 1) increases the rise-time of signal fed to the sounder and 'rounds-off the sharp edges' which are otherwise present. The net effect of this 'rounding-off' is that emissions are brought within limits.

Issue 1 PCBs (GJ07H) will require these extra components to be fitted on the underside of the PCB. These extra components are now supplied in the latest kits produced, together with Issue 2 Instruction Leaflet (XV25C) and a supplementary sheet detailing the modification.

Kits supplied with an Issue 2 (or later) PCB, together with an Issue 3 (or later) Instruction Leaflet are supplied with these extra components and make provision for them to be fitted during normal PCB assembly – they do not require further modification (i.e. please ignore this update!).

It is recommended that this modification be implemented on existing units – many constructors will already have the necessary items in their 'spares' box.

On the underside (solder side) of the PCB, cut the track indicated in Figure 2 (this track links pins 10 and 12 of IC2). On the underside of the PCB fit the following components as shown in Figure 3: a 680Ω $^1/_4$W metal film resistor (M680R) between pins 10 and 13 of IC2 and a 10nF ceramic disc capacitor (BX00A) between pins 12 and 7 of IC2.

If you have any queries relating to this modification, please contact Maplin Technical Sales (see page 79 for contact details).

Figure 2. Issue 1 PCB modification – cutting the PCB track.

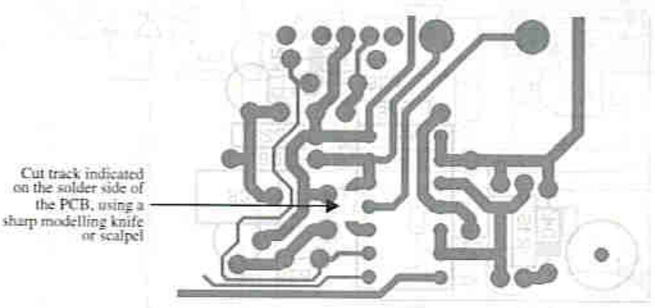
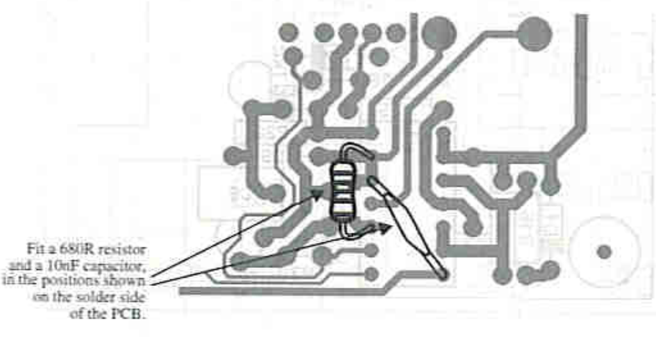


Figure 3. Issue 1 PCB modification – fitting the extra components.



Maplin MPS Catalogue KEY CALL CODES CONVERTER

by Stephen Perrott

This program has been written to convert Maplin MPS Catalogue Order Codes into the correct numbers required for the Key Call telephone ordering system. The program is written in Microsoft™ GWBASIC, and will operate on most IBM-compatible PCs that have a BASIC compiler. Note that when using the program, Caps Lock must be on when the Catalogue Order Codes are entered. The program allows for numerical codes which do not need converting, e.g., from special offers. Resistor colour codes must also be entered using this.

For further details on the Key Call system, refer to the back of the order form in the current MPS Catalogue, or see the December 1994 issue (No.84) of *Electronics*.

```
10 CLS : PRINT "KEY CODE NUMBER TRANSLATOR BY
STEPHEN PERROTT. PLEASE ENSURE CAPS LOCK IS ON"
20 DIM A$(200)
30 I=1
40 CLS : PRINT "KEY CODE NUMBER TRANSLATOR BY
STEPHEN PERROTT. PLEASE ENSURE CAPS LOCK IS ON" :
PRINT "ITEM ";I
50 PRINT:PRINT:PRINT
60 IF I>1 THEN LOCATE 3,3 : PRINT "SUBTOTAL £";T;"
LAST ITEM WAS..." : LOCATE 4,3 : PRINT A$(I-1)
70 PRINT " ENTER PAGE NUMBER. ENTER 1 TO END DATA
ENTRY"
80 INPUT A : IF A>1000 THEN 70
90 IF A=1 THEN 270
100 PRINT "ENTER DESCRIPTION"
110 INPUT B$ : IF LEN (B$)>20 THEN 100
120 L=LEN(B$): FOR Z=1 TO 23-L : B$=B$+"." : NEXT
130 PRINT "ENTER ORDER CODE IF ALPHA-NUMERIC, OR 1
IF ENTIRELY NUMERICAL." : PRINT "THEN PRESS ENTER
IF CORRECT, OR * TO RESTART CODE ENTRY"
140 GOSUB 460
150 PRINT : PRINT "ENTER COST EACH"
160 INPUT D
170 PRINT "ENTER QUANTITY"
180 INPUT E
190 F=D*E : T=T+F
200 A$=STR$(A) :L=LEN(A$):FOR Z=1 TO 4-L :
A$="."+A$ : NEXT
210 D$=STR$(D) :L=LEN(D$):FOR Z=1 TO 7-L : D$="
"+D$ : NEXT
220 E$=STR$(E) :L=LEN(E$):FOR Z=1 TO 3-L :
E$="."+E$ : NEXT
230 F$=STR$(F) :L=LEN(F$):FOR Z=1 TO 7-L : F$="
"+F$ : NEXT
240
A$(I)="|."+A$+"|."+B$+"..|."+C$+"|."+E$+"|."+H$+"|.
£"+D$+"|.£"+F$+"|"
250 I=I+1
260 GOTO 40
270 CLS
280 PRINT "PRESS ENTER TO PRINT"
290 INPUT Z$
300 LPRINT " MAPLIN ORDER"
310 LPRINT DATE$
320 LPRINT "CUSTOMER NUMBER ...1029974..."
330 LPRINT "KEYCODE PIN NUMBER ... 5600..."
340 LPRINT "TELEPHONE: 01702 556 751"
350 LPRINT ""
360 LPRINT "|PAGE.|.DESCRIPTION..............|CAT
NO|.Q..|...ADOC....|..£ EACH.|£ TOTAL..|"
370 FOR M=1 TO I
380 LPRINT A$(M)
390 NEXT
400 LPRINT
410 LPRINT
"|..TOTAL...............................................
..............| £";T;"p |
420 LPRINT : LPRINT : LPRINT : LPRINT
"CONFIRMATION NUMBER ....................." : LPRINT
: LPRINT : LPRINT
430 LPRINT
"****************************************END*********
******************************"
440 PRINT " PRINT AGAIN? Y/N"
450 INPUT Z$ : IF Z$="Y" THEN 270 ELSE STOP
460 X$=INKEY$ : IF X$="" THEN 460 ELSE IF
ASC(X$)=49 THEN 710 ELSE IF ASC(X$) <65 OR ASC(X$)
> 90 THEN 460
470 C$=X$
480 PRINT X$;
490 Y$=INKEY$ : IF Y$="" THEN 490 ELSE IF
ASC(Y$)<65 OR ASC(Y$)>90 THEN 490
500 C$=C$+Y$
510 PRINT Y$;
520 N$=INKEY$ : IF N$="" THEN 520 ELSE IF
ASC(N$)<48 OR ASC(N$)>57 THEN 520
530 C$=C$+N$
540 PRINT N$;
550 O$=INKEY$ : IF O$="" THEN 550 ELSE IF
ASC(O$)<48 OR ASC(O$)>57 THEN 550
560 C$=C$+O$
570 PRINT O$;
580 P$=INKEY$ : IF P$="" THEN 580 ELSE IF
ASC(P$)<65 OR ASC(P$)>90 THEN 580
590 C$=C$+P$
600 PRINT P$;
610 U$=INKEY$ : IF U$=CHR$(13) THEN 630 ELSE IF
U$=CHR$(42) THEN 620 ELSE 610
620 PRINT " RE-ENTER ORDER CODE" : GOTO 460.
630 G$=STR$(ASC(X$)-54)
640 H$=G$
650 G$=STR$(ASC(Y$)-54)
660 H$=H$+G$
670 H$=H$+N$
680 H$=H$+O$
690 L=LEN(H$) : FOR Z=1 TO 10-L: H$=H$+"." : NEXT
700 RETURN
710 PRINT "READY TO ACCEPT ALL DIGIT ORDER CODE.
PLEASE ENTER NUMBER IN FULL." : INPUT H$ :
C$="ADOC " : GOTO 690
```

F GREAT BRITAIN

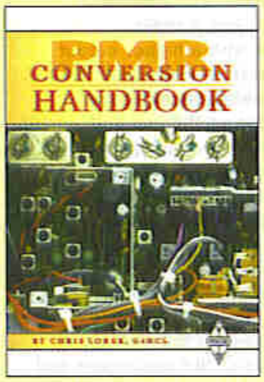
AMATEUR RADIO

RadCom on CD-ROM £18.80

Contains nearly a thousand pages of *RadCom* and *D-i-Y Radio* - the RSGB premier colour magazines.

The PMR Conversion Handbook £15.28

by Chris Lorek, G4HCL



This handbook clearly shows you how to identify, choose and buy PMR sets which are suitable for conversion. It gives step by step conversion instructions, and is packed with practical tips, photos and diagrams to help you all the way.

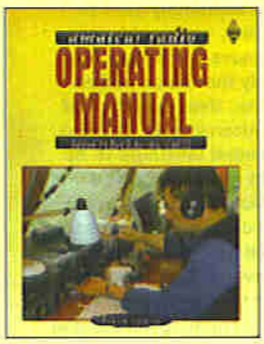
Radio Data Reference Book £10.35

by Robin Hewes, G3TDR, and George Jessop, G6JP

Presents a wide range of essential reference data in convenient graphical and tabular form without needless repetition of basic theory, and arranged in sections to simplify retrieval.

Amateur Radio Operating Manual £12.23

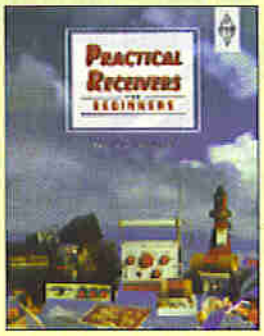
Edited by Ray Eckersley, G4FTJ



This book covers the essential operating techniques required for most aspects of amateur radio, taking the reader from the principles of basic contacts right through to the secrets of working DX and winning contests.

Practical Receivers for Beginners £12.50

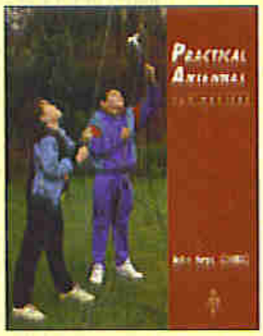
by John Case, GW4HWR



This book contains a selection of easy-to-build receiver designs suitable for amateur bands (including microwaves), together with simple 'fun' projects and test equipment.

Practical Antennas for Novices £6.29

by John Heys, G3BDQ



The antenna is one of the most important parts of an amateur radio station, and is one of the most difficult to get right in order to avoid disappointing results. This book will be invaluable not only to Novices, but also to any radio amateur looking for easy-to-build antenna systems that really work.

Practical Transmitters for Novices £12.29

by John Case, GW4HWR

This book contains a selection of easy-to-build transmitter designs suitable for the UK Novice bands (including microwaves), together with simple test equipment. It will be of interest to any amateur who is building transmitters for the first time or who is considering moving up to microwaves.

(Please add post & packing: £1.25 (one book) or £2.50 (two books or more)

For a complete list of RSGB publications, or more information about the Radio Society of Great Britain and amateur radio, telephone 01707 659015 and we will send you an information pack. Please mention this advert when you call.

Just contact the RSGB Sales Order Hotline on 01707 660888 to place your credit card order, or send a cheque to cover the cost of the book plus post and packing to:

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Under Surveillance

As a reader of *Electronics and Beyond*, I wonder whether you can advise me on how I may construct a radio frequency transmitter jamming device. That is, a device which could either interfere with or disable any close proximity radio frequency transmission. I am thinking, in particular, of surveillance bugging devices. Can such a device be easily constructed? How can I obtain plans for such a device? Would I need to establish the exact frequency on which such a bugging transmitter were operating before it could be either interfered with or jammed, or is it possible to construct a device which would interfere with, disable or jam all radio frequency transmissions within close range of the jammer? Is it possible to purchase such devices ready-made, in kit form or plans, and if so, where? What basic components and principles are involved in the jamming of a radio frequency transmission? I do hope that you shall be able to advise and assist me with this enquiry or alternatively, inform me of someone who may be able to do so. I apologise for troubling you with this enquiry, and thank you for any assistance you may be able to provide.

Mr. J. Easton, Chingford, London.

The initial problem with trying to deal with preventing suspected bugging devices from working is to establish exactly which type of bug(s) have been planted; in addition to the usual radio transmitting ones, there are phone line taps which may be fitted practically anywhere along the communication path (e.g., to telephone wiring on the building's exterior or the termination box down the street), bugs which can transmit the signal along a mains supply and even sonic magnifiers which merely need to be directed at a window of a room from outside in the street to be able to listen in on the conversation in the room (these operate by shining a laser at the window and processing the reflected, vibration modulated beam). There may even be a combination of all of these in use. If you have confirmed the bugging devices to be radio transmitting types, you would then need to establish the frequency they are operating on; amateur ones sold cheaply in kit or ready-built form usually operate within the commercial AM/FM radio bandwidth, and can thus be picked up by tuning around on a normal radio placed nearby (most of the cheap bugs have a maximum range of between 1-3km). However, the professional bugs operate at a far higher frequency similar to that of mobile phones, and their transmitting range is often further. A scanner capable of covering the higher frequency range would be needed to listen in on the signal they generate. However, to complicate detection, some bugs transmit a scrambled signal, which can only be deciphered with the matching receiver. Security firms use a scanner in conjunction with specialised bug finding equipment to 'sweep' a room suspected of harbouring bugging devices. The bug finder sweeps through a range of frequencies and when its frequency matches that of the bug, a whistling tone is generated in the receiver, to indicate the presence of the bug. More sophisticated checks can then be made using a spectrum analyser to pinpoint the exact location of the bug and show graphically the signal it is emitting. Bug jamming devices operate on the principle of emitting a strong signal at the same frequency to that of the bug, thus drowning out any signal it might be picking up and transmitting in a sea of noise. Hence, it is just a radio transmitter with a higher output power than that of the bug. This, however, makes them just as illegal to use as the bugging devices themselves, especially if they are operating on the commercial radio bandwidth or interfering with the operation of other equipment in the vicinity. Prolonged use of such gadgets is likely to be rewarded sooner or later by an inspection from the Radio Authorities followed up by confiscation of the equipment and prosecution! However, there are a growing number of suppliers of surveillance/detection equipment that openly advertise their goods, since it is perfectly legal to sell and buy such items so long as one doesn't actually use them! Such a company, Suma Designs of Warwickshire (Tel/Fax: (01827) 714476), advertises in another well-known electronics magazine and offers a range of kits to suit amateur and professional requirements. The same magazine also advertises a number of other firms offering similar products. The simpler kits are straightforward to build, and consist of typical RF components – coils, transistors, capacitors, etc. One could make a room bug proof, turning it into a Faraday cage by lining the floor, walls, windows and ceiling with metal panels or foil then earthing the lot, to ensure that no radio signal could escape from or enter the area. To be absolutely sure of confidentiality, you would also need to remove the phone line and possibly the mains outlets and air vents, then sound-proof the room! Alternatively, develop your own coded language to be shared with others only on a 'need to know' basis and use it whenever you need to discuss sensitive information with them. That way, even if someone does listen in on you, they won't be able to gain anything meaningful from it!

Growing at the Speed of Light

Dear Sirs,

It is generally accepted that the 'big bang' occurred about 15,000 million years ago, give or take a Tuesday. If this is so and we take the speed of light to be

$$e = 3 \times 10^8 m/s,$$

then after this period of time has elapsed, we could presumably assume the size of the universe to be a sphere with a diameter of $141,912 \times 10^{18}$km – and growing!

Donald Hopkins, Tarves, Aberdeenshire.

Ah, but what's outside of the sphere? Presumably, whatever it is is getting smaller as the universe expands to fill it?

Down Boy!

Dear Editor,

I began to subscribe to *Electronics* some years ago, attracted by the many radio projects and 'fun' applications, all powered by nothing more serious than a 9V battery. Many could be readily bought as kits in Maplin shops or a pleasant evening could be spent with the satisfyingly chunky catalogue ordering a wonderful array of parts which arrived promptly in a strong padded bag. Now, *Electronics and Beyond* is flying way above my head. Satellite and electronic music freaks may be happy but those of us who would like to build a small DC project to occupy the kids get short shrift. I wouldn't ever trust myself to build something I plugged into the mains, so what about an article or project for us battery freaks? I've looked in vain for a shortwave project that didn't involve decorating the neighbourhood with festoons of aerials. Or perhaps a Christmas tree Father Christmas with seasonal messages in a plummy voice and tasteful lights? Or a table-top golf course game? Or, for Eurosceptics, a small flag which rose or fell on its pole to the National Anthem? Perhaps there is scope for a back to basics column which explained in idiot-proof language, how components or simple circuits work? If your article writers can create the recipes for building your own digital TVs, then I'm sure they can devise something to encourage my neighbours' dogs to bypass my garden? I wait in electronic anticipation (but only low voltage).

Paul Lishman, Brigham, nr. Cockermouth, Cumbria.

Sorry to hear that we've been flying a little too high for you lately. We do try to strike a balance to offer projects of interest to all abilities of constructor, so please bear with us; we do have plenty of nice, simple, low-powered projects in the pipeline. Looking back through recent issues, there have been a fair number of straightforward projects, such as various single-chip sound generators, electronic dice, continuity tester, alarms, metal detector, mini circuits, etc., most of them available in kit form through our increasingly chunky catalogue. Going further back, to June 1992, a simple 9V battery-operated 'Pet Communicator' project appeared in Issue 54, based around a two-transistor flip-flop (astable multivibrator), which could be used to persuade dogs away from your patch, or at least enable you to make an attempt to communicate to them how much you disapprove of their visits. Thank you for your imaginative project suggestions which may well lead to their development. However, considering that *Electronics and Beyond* has a wide audience outside of Britain, we might have to steer clear of the Eurosceptics' project idea.

In this issue, R. J. Homer, of Halesowen, W. Midlands, wins the Star Letter Award of a Maplin £5 Gift Token for sending in this galvanising (or should that be electrolysing?) letter.

£5 MAPLIN GIFT VOUCHER

Star Letter

Dear Editor,

Regarding descalers, natural water is not inert; it exhibits a variety of often aggressive electrical properties. It's all down to the number of ions derived from dissolved salts and gases in water forming an electrolyte in equilibrium; create an imbalance by introducing a metal and/or heat, or even allowing to stand, and deposition occurs. Metal ions (corrosion) are drawn into solution by a weak battery action; a sacrificial anode manufactured from copper or aluminium may enhance the formation of protective oxide coatings and maintain electrolyte equilibrium and to an extent, reduce deposition. Sacrificial anode life is governed by the strength and temperature of the electrolyte; now you know why metal water tanks and kettles leak when least expected. (Reference: IMI Range Ltd., 1981 report of factors affecting corrosion). In the April 1997 issue, J. G. Wilkinson applies 400V pulses (14kHz) to a series connected capacitor; this means that the copper pipe is floating and exhibits a voltage potential relative to the electrodes of one half, i.e., 200V. Although grounded, this voltage must be present through and throughout the pipe length between and including ground points and is relative to the electrolyte potential of the water. Presumably, an excess of electrons at the inner surface/electrolyte interface at a molecular level neutralises metal ion formation where a battery action is already taking place and maintains the electrolyte equilibrium. This would account for M. Perry being unable to discern a penetrating field – it already exists; dissipation is minute because the battery action is extremely weak. Applying Wilkinson's device to plastic pipes with opposing electrodes, the full 400V potential is applied across what is after all a lossy dielectric; despite the apparent insulating factor of the pipe, presumably, electrons must be discharged at the pipe interface as before into and across the electrolyte. As a matter of interest, the electrodes need not be opposing, they could be and on with a suitable gap whereby the electrolyte becomes the 'floating electrode', thus increasing the effect. As for permanent magnets, could it be that the attraction and displacement of ions to the relative poles reduces ionisation potentials and thus sustains equilibrium when entering a metallic system, or perhaps there may even be a Faraday effect inducing minute voltages; after all, water is an electrical conductor. Finally, congratulations on producing an excellent magazine which has improved year by year; I find the historical aspects specifically appealing. Perhaps someone could provide me with an answer to an outstanding question; James Watt the Engineer met Humphrey Davy on many occasions and was particularly interested in his galvanic researches. How long did his association with Davy continue?

Perhaps our knowledgable readers may be able to help out with R. Homer's enquiry? Letters will be forwarded.

Trip the Light Fantastic

Dear Sir,

I read with interest your construction article, Mains Socket Wiring Tester, Issue 111 Electronics and beyond. In fact, it is possible to modify this unit to check whether neutral and earth are reversed, ONLY if your house is equipped with an RCD. I built a similar unit several years ago. In addition to the neons, my unit has a pushbutton switch in series with a 5kΩ resistor connected between the Live and Earth pins. When the button is depressed, a current of 48mA will flow which will cause a 30mA RCD to trip. If Neutral is incorrectly connected to the socket's Earth pin, then there is no earth leakage and the RCD will not trip. CAUTION – power dissipation in the resistor, should the RCD fail to trip is 12W, therefore, use a resistor with an adequate power rating, and do not hold the pushbutton depressed for more than a couple of seconds. Congratulations on the continuing high standard of *Electronics and Beyond* – as an electronics professional, I find the articles interesting and useful.

Mike Rose, mrr@paladin3

Thanks for the tip and your opinion on the magazine.

Better Out than In?

Dear Sir,

Your April star letter seems to have found what I've been looking for many years – a virtual perpetual motion situation – power out greater than power in. Unless there is a cockup with the figures quoted, your descaler designer uses "8V at up to 90mA" (720mW) to drive his design and says it uses "400/425V at several milliamps" to operate the descaler – several is more than two but taken as 2mA, your intrepid designer is getting better than 800mW out – if more than 2mA, it is even more efficient! I would like to patent his freebie power device but suspect that the very critical inductor from Electrovalue, coupled with the early issue of your April edition, might be the answer. Or is it a follow up from another letter on the next page – "Wind-up Merchant"?

R. A. Webb, Catterick Garrison.

The figures given were printed correctly. However, it is stated that the circuit will work at 9V maximum and consumes up to 90mA; this would equal a power consumption of 810mW, giving an efficiency of 98·8% if an output power of 800mW is produced. Not quite the perpetual motion situation, alas!

History of the RADIO RECEIVER

by Ian Poole

In 1895, Marconi demonstrated the first viable radio system, and the year 1995 saw the centenary of radio celebrated. The radio equipment we use today is a far cry from that which Marconi and other experimenters of the day used.

Early sets were very crude and very insensitive. Nowadays, a huge variety of transmissions can be transferred over vast distances. To be able to achieve this, receiver technology has changed beyond all recognition. These changes represent the work of many people from the earliest days of wireless sets. Some of these people have their names entered in the technology history books, but the majority were just ordinary engineers or radio enthusiasts who remain unknown.

The story of the development of the radio receiver as we know it today began over a hundred years ago. It is fascinating and shows how new developments in one area of electronics and radio technology have opened the doors to further developments in other areas. It is also fascinating because it shows how many outside influences pushed the development in one direction to overcome the problems of the day.

Wireless Beginnings

The first person to prove that radio waves existed was a brilliant Scottish scientist named Maxwell. He proved mathematically that a form of electromagnetic wave existed. However, he was unable to show them in a practical form. This honour fell to a German named Heinrich Hertz. He used some spark gap equipment to transmit and receive radio or Hertzian waves, as they were first called.

Hertz used a number of variations of the basic equipment. Essentially, the transmitter consisted of a circuit in which a spark was made to jump across a gap. A second circuit with similar dimensions but with a smaller gap was placed within a metre or so of the first circuit. When a spark was made to jump across the gap in the transmitter circuit, a smaller but simultaneous spark would be seen to jump across the gap in the second.

Naturally, the range of this arrangement was very limited, mainly because the receiving circuit had to pick up a large amount of energy for the spark to jump across the gap.

Coherer Developments

It was soon realised that more sophisticated and sensitive methods of detecting radio waves were needed. A device called a coherer (see Figure 1) became the basis for reception, and remained in widespread use for about ten years. The coherer is based around the effect that the small particles of dust or even metal filings stick together or cohere when an electric field is present.

The first person to use the phenomenon to detect radio waves was a Frenchman named Edouard Branly. He discovered that the resistance of a glass tube filled with metal filings fell from a few megohms to a few hundred ohms when placed close to a discharge. A short mechanical shock then restored the coherer to its high resistance state.

Once Branly had developed the basic idea, Oliver Lodge popularised it and improved it. Usually, the coherer was made to operate a bell so that when a spark or discharge took place, the bell rang. A self-restoring feature was also introduced. The current flowing through the coherer was made to operate a small tapper that restored the coherer as well as ringing the bell. This meant that it was ready for the next discharge almost immediately.

Guglielmo Marconi

It was possibly Marconi who did more for the new technology of radio than any other person, especially in its early days. In terms of receiver design, he took the coherer, and by having his assistant spend many hours experimenting with different materials and configurations, he managed to make some considerable improvements.

Marconi's chief aim was to use radio for communications. He was continually trying to improve the distance over which his equipment could communicate. In one of his early experiments, he managed to span the Bristol Channel, and later he managed to send a message across the English Channel. During this experiment, the signals were picked up at his factory in Chelmsford. This was considerably further than anyone had expected the signals could travel, and it made Marconi think that it would be possible to span the Atlantic.

Marconi set about building stations in Britain and America and after many difficulties, he managed to make contact. However, the sensitivity of the receiver again proved to be the limiting factor. This set Fleming thinking, because he designed much of the equipment for the transatlantic tests.

Fleming's Valve

As professor of electrical engineering at University College London, Fleming had a wide experience in electrical technology. It was out of an idea he had seen some years previously that the diode valve was borne, and in 1904, he patented an idea for a thermionic rectifying valve.

The idea found its origins with Edison in America. He had been investigating the reasons for filament failures in light bulbs and methods of increasing their life. In one experiment, he placed a second wire or electrode into the bulb and noticed that current would flow between the electrodes if the negative end of a battery was connected to the heater filament and the positive end to the additional electrode. He also noticed that if the battery was reversed, then no current flowed.

Surprisingly, Edison could not find a use for this interesting phenomenon. Fleming, who had seen the effect demonstrated by Edison, wondered if it could be used to detect radio waves. He got his assistant to set up an experiment to discover if it could be used, and to their delight, it did. The new 'oscillation valve' was patented and gave a new and improved method for detecting signals.

Other Detectors

Fleming's oscillation valve did not become an instant success. It was expensive to manufacture, and run. It could only be powered by batteries when used as a radio detector and batteries did not last for long because of the power required by the filament.

Work on other detectors produced results in the form of the famous cat's whisker, shown in Figure 2. It consisted of a crystal of a material such as galena with a small springy piece of wire brought up against it. The detector was constructed so that the

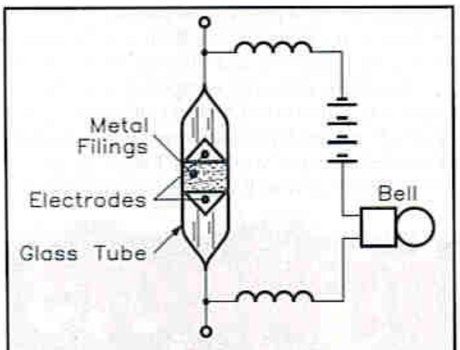


Figure 1. The coherer.

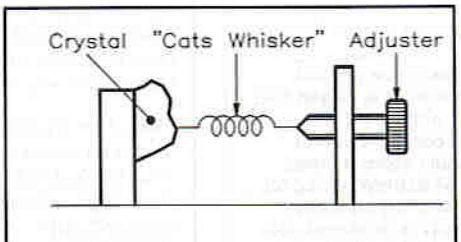


Figure 2. A cat's whisker.

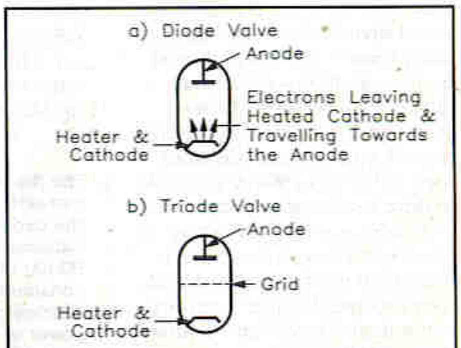


Figure 3. Diode and triode valves.

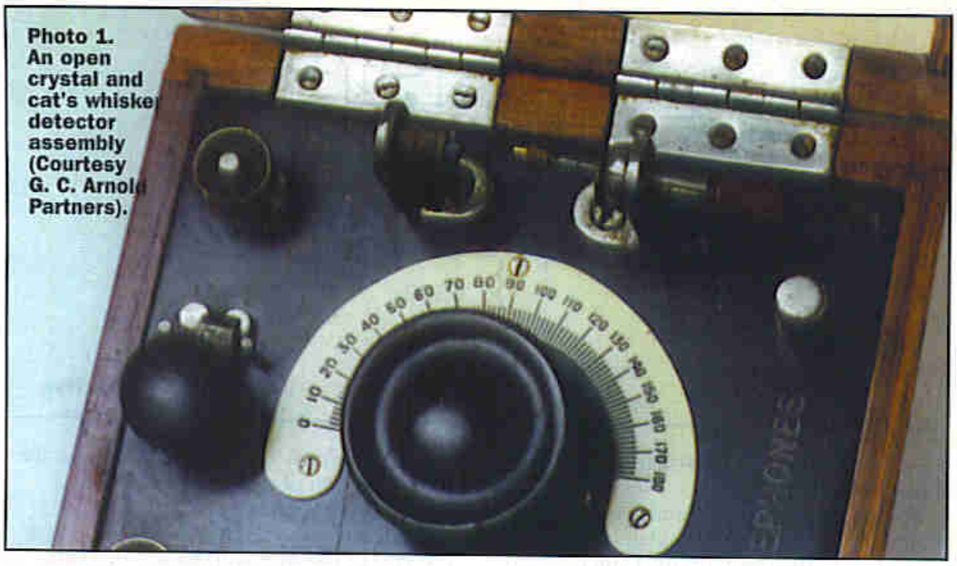


Photo 1. An open crystal and cat's whisker detector assembly (Courtesy G. C. Arnold Partners).

wire contact could be moved to different points on the crystal, and thereby obtain the best point for rectifying the signal and the best detection.

These detectors soon gained the name cat's whiskers as a result of their construction. They were never very reliable and the whisker needed to be moved periodically to enable it to detect the signal properly. However, they were very much cheaper than valves and gained widespread acceptance. Photo 1 shows a typical cat's whisker.

It is interesting to note that the cat's whisker was the first semiconductor device. The materials which were used were semiconductors, and cat's whisker formed a very crude point contact.

Triodes

Despite the success of the cat's whisker, work did not stop on the development of thermionic technology. An American named Lee de Forest was developing radio equipment. He needed to develop new detectors if he was to gain a foothold in the market and compete with Marconi. Accordingly, he devoted a large amount of time in developing a thermionic detector which did not infringe Fleming's patents. The result of his work was in the form of the triode valve, in which he introduced a third element called a grid into the envelope – see Figure 3 and Photo 2.

Fleming felt that the triode valve infringed his patents and took de Forest to court. Unfortunately, de Forest won, and Fleming remained bitter about it for many years.

At this time, surprisingly little was known about the way in which valves worked. De Forest did not realise the implications of his discovery. For the first few years of its life, the triode was only used as a leaky grid detector.

It was not until 1911 that valves were used to amplify signals. Once this fact had been discovered, many people were quick to exploit this fact in a variety of applications. One of the first areas in which valves were used was in the manufacture of telephone repeaters, and although the performance was poor, they gave significant improvement in long distance telephone circuits.

With the discovery that triode valves could amplify signals, it was soon noticed that they would also oscillate. This was a mixed blessing. It was a great disadvantage because these early valves were very difficult to stabilise when used for signals above a few kilohertz. However, the fact that valves could be used as oscillators was exploited in generating signals. Previously high frequency signals had been difficult to generate. If steady signals were required, electromechanical techniques had to be used, and these had obvious frequency limitations. With the use of valves, it was possible to make relatively compact electronic oscillators.

TRF Receivers

The triode valve made a tremendous impact on receivers by allowing signals to be amplified. Previously, most sets were crystal sets, and the only way to improve the signal was to improve the aerial system. This resulted in large aerials being required for even modest receiving stations. The valve gave the possibility of making very large improvements without the need for improving the aerial or increasing the transmitter power. In virtually all cases, the valve was used as an audio amplifier because of stability problems.

The cost of valves was high and this meant that people investigated ways of making the most efficient use of them. Soon, the positive feedback was used to increase the gain of a receiver when the regenerative detector was discovered.

This came about in 1913, when a number of people came up with the idea almost simultaneously. One was Lee de Forest, and another was a brilliant young engineer named Edwin Armstrong, whilst in Europe, Langmiur and Meissner also came upon the idea. It is still unclear who was the first, but Armstrong is generally credited with its invention.

These regenerative receivers proved to be very successful. The amount of feedback could be adjusted to the point of oscillation, and this greatly increased the gain and selectivity, enabling this type of receiver to out-perform all other forms.

A New Impetus

Shortly after the development of the regenerative receiver, the First World War broke out in Europe. Like all modern conflicts, the need for new and improved technology became apparent. Military leaders realised the importance of radio technology, for their own communications as well as detecting the enemy presence.

One of the main areas where development took place was in the improvement of valves. In these early days of thermionic technology, their performance was poor. They lacked gain, especially at high frequencies and they were prone to oscillate when they were used at frequencies anything above a few kilohertz.

Originally, it was thought that a small amount of gas in the envelope was key to their operation. However, an American named Langmuir disproved this and as a result, a new generation of totally evacuated 'hard' valves were introduced. Not only was the operation of valves improved by the complete evacuation, but it also allowed the heaters to have coatings applied to them to improve their emission. In the old 'soft' valves, the gasses in the envelope contaminated the coatings, making them unusable.

The other problem with valves was their susceptibility to oscillation. One of the main reasons for this was the level of capacitance between the grid and anode. A number of attempts were made to reduce this. A British engineer named H. J. Round undertook some work on this and in 1916, he produced a number of valves with the grid connection taken out of the top of the envelope, away from the anode connection. This proved to give a major improvement, but the final solution did not come until the 1920s.

Although the TRF receiver represented a major improvement in performance over

Photo 2. An Audion valve of about 1914 (left), accompanied by a Naval NT9X triode (right) of about 1920 (Courtesy G. C. Arnold Partners).

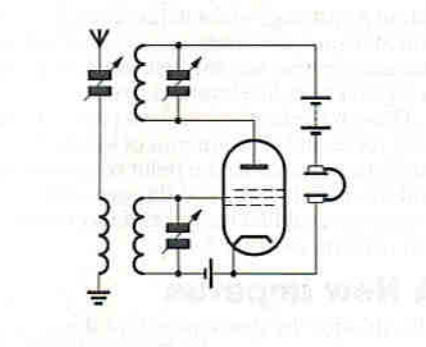


Figure 4. The autodyne receiver.

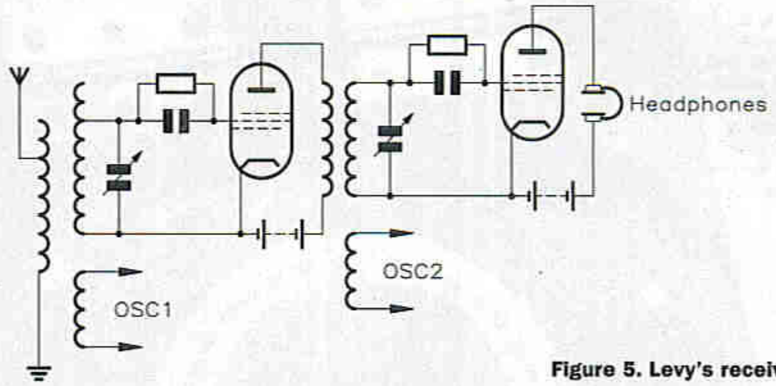


Figure 5. Levy's receiver.

what had been available before, it still fell short of the needs for some of the new applications. To enable receiver technology to meet the needs placed upon it, a number of new ideas started to surface.

One of these was a new form of direct conversion receiver. Here, an internal or local oscillator was used to beat with the incoming signal to produce an audible signal which could be amplified by an audio amplifier. Although the basic principle of the direct conversion had been known about for many years, many considered the system was wasteful of valves because the oscillator and mixer did not contribute to the gain of the set. Even in military circles, this was a consideration because of the size and cost of the valves and their associated batteries.

The problem was overcome by H. J. Round. He developed a receiver called the autodyne – see Figure 4. This set used the same valve to function as a mixer and oscillator, overcoming many of the objections of valves which did not provide any gain. Whilst the set used less valves, it was not ideal because it was difficult to optimise its operation in two different functions. Despite this, it was a useful stepping stone to further developments.

The Superheterodyne

The next major development in receiver technology was in the form of the superheterodyne (superhet) radio. It took some while for the idea to emerge in its final form. The first stage was developed by a French engineer named Lucien Levy. He was investigating methods of improving the selectivity of receivers. He devised a system where the signals were converted to a lower frequency where the filter bandwidths would be narrower. As an added bonus, the gain of valves was much higher at these frequencies, and they were less prone to bursting into unwanted oscillation. Figure 5 shows Levy's receiver.

The idea had many advantages and Levy thought it could totally eliminate all interference. However, his idea still retained the idea of variable frequency filters at the intermediate frequency and as such, it was not the superhet used today.

The idea for developing a receiver with a fixed intermediate frequency amplifier and filter is credited to Edwin Armstrong, although Schottky working in Germany actually patented an idea six months before Armstrong.

Working for the American Expeditionary Force in Europe, Armstrong thought that if the incoming signals were mixed with a variable frequency oscillator, a low frequency fix tuned amplifier could be used. Like Levy's idea, this would enable the valves to operate at a lower frequency where they would be more efficient. It also meant that a fix tuned amplifier could be used and this would be capable of providing much greater degrees of selectivity than a variable one. This is because several stages could be cascaded relatively easily and the tuning preset before use.

Armstrong's original receiver consisted of a total of eight valves. In the set, the signal was converted from its incoming frequency down to a fixed intermediate frequency stage. By altering the frequency of the local oscillator, the frequency of the received signal was changed. The low intermediate frequency stage allowed greater levels of gain, as in the case of Levy's set, because the low frequencies allowed greater levels of gain and stability. Also, having a fixed frequency intermediate stage allowed the filters to be more selective. Several tuned circuits could be cascaded to improve selectivity, and being on a fixed frequency, they did not all need to be changed in line with one another. The filters could be preset and left correctly tuned. Figure 6 shows the block diagram of a superhet receiver.

The new superhet gave an impressive performance, but its development came at the end of the war. With its use of a large number of valves, it was only viable for use in specialist applications, many of which were no longer required after the cessation of hostilities. Accordingly, Armstrong's discovery was rarely used for a number of years.

One use for which it is documented occurred when radio amateurs tried to send transmissions across the Atlantic on the short wave bands. After the first attempts failed when British amateurs used simple TRF sets, the Americans sent Armstrong over with one of his sets. On the second attempt, signals were received on the Armstrong set, although many British stations using TRFs also managed to receive signals from the States.

Superhet Gains Acceptance

Initially, there was no need for the superhet radio to be used. Broadcast stations were relatively few, and the selectivity provided by TRF sets was quite adequate for most purposes. The performance of valves was beginning to improve.

However, as the 1920s passed, more stations came on the air, especially in America, and the need for the selectivity provided by the superhet became more apparent. As a result, the superhet started to be used increasingly. A number of developments in valve technology also helped. Originally, all valves were directly heated, and this meant that each valve required a separate filament supply. The introduction of the indirectly heated valve meant that an alternating supply could be used. This was because of the heater's

Photo 3. A National HRO communications receiver (Courtesy G. C. Arnold Partners).

Photo 4. An early transistor portable radio – a Pam 720 made by Pye in 1956/7; the second transistorised set they produced, covering medium wave plus pre-set on long wave for receiving the Light Programme (Courtesy G. C. Arnold Partners).

different connection to the cathode. This allowed the bias conditions to be fulfilled even if the filaments were connected in series or parallel with one another.

The use of superhets by domestic users forced further developments to be made. Originally, these sets were very cumbersome and sometimes difficult to use. Ganged tuning capacitors were also introduced to enable the local oscillator and the radio frequency stages to be tuned by one control. Many other refinements were added, enabling them to be made more cheaply and easier to use.

The need for the increased performance of the superhet was first felt in America and by the late 1920s, most sets were superhets. However, in Europe, the number of broadcast stations did not start to rise as rapidly until later. Even so, by the mid-1930s, virtually all sets in Europe as well were using the superhet principle.

Valve technology improved again with the introduction of further electrodes into the envelope. In 1926, the tetrode valve was introduced. This valve had a second grid placed between the normal control grid and the anode. This had the effect of reducing the capacitance causing the feedback, and enabled valves to operate far more reliably than they had done before. Three years later, the tetrode was improved by the introduction of the pentode. In this type of valve, yet another grid called the suppressor grid was introduced. This overcame a discontinuity in the curve of the tetrode, and enabled further improvements in their performance.

Further Refinements

In 1939, another war broke out, and like the First World War, it gave a new impetus to radio development. Although the superhet was well established by this time, the performance of radios in terms of selectivity, sensitivity and frequency coverage was improved as a result of the need to meet ever more exacting requirements for the war effort. During this time, a number of classic communications receivers were designed. Some, like the AR88 or HRO, as shown in Photo 3, are still sought by short wave listeners today, and even though they are relatively large by today's standards and they do not have all the latest refinements, they can still give a good account of themselves under current crowded band conditions.

Problem of Stability

In the following years, radio technology continued to develop. Especially in professional circles, new modes of transmission and higher frequencies were used. As a result, new requirements were placed in receivers and in particular, frequency drift was a problem which needed to be overcome.

To address this problem, a number of new ideas started to surface. In one approach, a two-conversion process was used. The first one used a very stable crystal oscillator to convert an incoming band of signals down to a wide band intermediate frequency stage. A variable-frequency oscillator accomplished the tuning and final conversion down to the stages where the selectivity was contained. This approach was successful in many respects, but needed a large number of switched bands to cover the majority of requirements.

Another approach used a system called the Wadley Loop. This was very successfully used by Racal in producing their world-beating RA17 communications receiver. This type of system used an additional number of valves to achieve the improved performance, but there was virtually no drift, a luxury which had not been easy to achieve in a wide band communications receiver before.

This was not the final solution to the reduction of drift. A further invention was needed before the solution used today could be implemented.

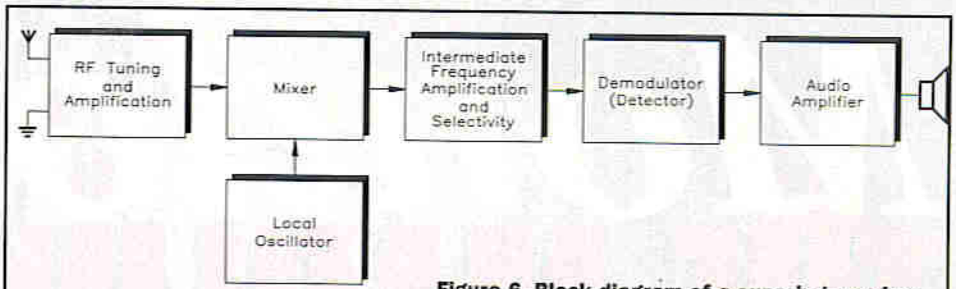


Figure 6. Block diagram of a superhet receiver.

Transistorised Radios

In the late 1940s, the transistor was discovered. Initially, the devices were not widely used because of their expense, and the fact that valves were being made smaller, and performed better. However, by the early 1960s, portable transistor broadcast radios were hitting the market place. These radios were ideal for broadcast reception on the long and medium wave bands. They were much smaller than their valve equivalents, they were portable and could be powered from batteries – see Photo 4. Although some valve portable receivers were available, batteries for these were expensive and did not last for long. The power requirements for transistor radios were very much less, resulting in batteries lasting for much longer and being considerably cheaper.

Although transistors gained a wide level of acceptance for broadcast sets, their introduction was a little slower in the professional market. The performance of the early transistors was lower than that of valves, and this meant that high performance sets were not so easy to design. Nevertheless, as transistor performance improved and field effect transistors were introduced, semiconductor technology soon started to overtake valves.

Further developments in semiconductor technology led to the introduction of the integrated circuit. This enabled radio receiver technology to move forwards. The fact that integrated circuits enabled high performance circuits to be built for less cost, and significant amounts of space could be saved, both gave advantages.

New techniques were also to be introduced. One of these was the frequency synthesizer which was used to generate the local oscillator signal for the receiver. By using a synthesizer, it is possible to generate a very accurate and stable local oscillator signal. As synthesizers can interface with microprocessor technology very easily, it also gave increased flexibility in terms of receiver operation, allowing facilities like scanning, memory channels and keypad frequency entry. In fact, virtually every radio with a digital frequency display uses a synthesizer. This means that not only do communications receivers and scanners use them (see Photo 5), but so do a large number of car radios, Hi-Fi tuners and many portable sets.

Naturally, integrated circuits have been used in a wide variety of other areas within radios. As the radio frequency performance of ICs has been improved, they are finding uses in most sections of the radio, from audio right up to the front end. This is particularly true in mobile phones, where size, performance and very low power consumption are all of the utmost importance. It is certain that without the integrated circuit, the very small sets which are widely available today would not be possible.

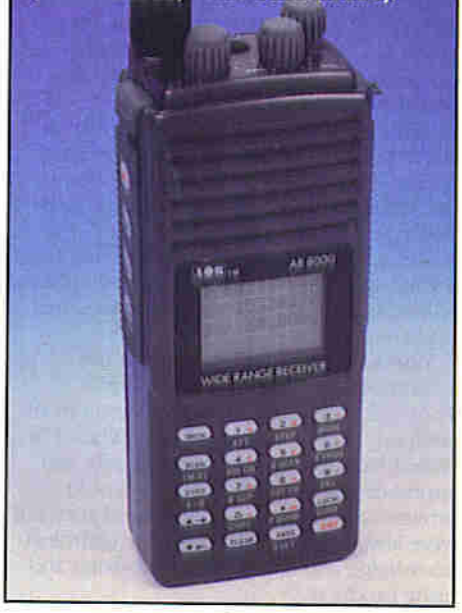
The Future

In the years to come, radio technology will undoubtedly surge forwards. New techniques like digital signal processing are being introduced, mainly in the area of professional communications, but with the introduction of Digital Audio Broadcasting, consumer radios will have to use these new techniques as well. The cellular phone business is also forcing many new developments, especially in terms of size and power consumption.

Nowadays, radio is an integral part of today's technology. Not only are the traditional broadcast roles of radio moving with the times with developments like digital audio broadcasting, but mobile telecommunications is also a major force, ensuring that radios are at the forefront of technology.

Whilst today's radios are miracles of modern technology filled with low power, high performance integrated circuits crammed into the smallest spaces, the basic principle of the radio is usually the superhet, the same idea which was developed by Edwin Armstrong back in 1918.

Photo 5. A typical scanner which includes microprocessor and frequency synthesizer technology (AOR AR-8000, Order Code RU98G).



Mondo

THE MAPLIN SUPERSTORE A NEW ERA FOR ELECTRONICS

Last month saw the launch of the latest Mondo, the Maplin superstore at Lakeside Retail Park, Thurrock. The new store is the third in the UK and follows the success of stores in Leeds and Nottingham.

The Concept

Mondo was officially launched in September 1995 when the old Maplin site at Regent Street, Leeds was transformed to become the first Mondo superstore.

The concept behind Mondo is to bring together a vast range of products from the Maplin catalogue allowing customers to test and try out products before buying them. The result is an interactive store with a host of innovative and hi-tech products not found anywhere else under one roof.

Jackie Featherstone, manager of Mondo Leeds defines the superstore as a place which "brings to life an array of products beyond the traditional hobbyist and into the home and leisure market.

She adds: "We often say to customers that if you want to make your equipment better, bolder, bigger or faster then Mondo is the place to be!"

Mondo has been designed with the customers' needs in mind, as Mondo Thurrock manager and recent recruit to the company Sharon Gorman says: "When I first visited Mondo I noticed how friendly and approachable the staff were. You could browse without feeling intimidated and staff were always willing to share their technical knowledge and expertise on choosing and using products."

Products

Mondo has five specialist sections in-store, each designed to make shopping easier for customers:

Computers, Accessories and Networking

In an age where technology is moving faster than ever it is important to keep your equipment up to date. The company boasts an impressive range of computer accessories and peripherals, specialising in the latest networking equipment, cables and connectors and computer security products. Customers are also in for a treat as they can experience the wonders of virtual reality and multi media. And each store has an Internet cafe where customers can buy refreshments and surf the net.

Specialist Electronics

Trade and business customers, as well as shoppers, are well served by Mondo Maplin superstores. Maplin has built its reputation on providing electronics equipment for professionals and amateurs alike and each Mondo store has an MPS trade counter dedicated to providing a personal service. This includes a full range of specialist tools, cables and components, trade accounts, a Call and Collect fax order service. Exclusive mailing lists keep customers up to date on in-store trade events and promotions.

Sound and Vision

Music fans are well catered for at Mondo, state-of-the-art sound displays demonstrate high quality systems, surround sound

Inside the Mondo Superstore at Leeds.

equipment, speakers and accessories for both the home and car. A fully equipped sound production stage features professional DJ mixing equipment and disco lighting. There is also a video editing section where camcorder enthusiasts can learn how to edit their own home videos.

House and Home

There is an impressive range of security products on offer. CCTV systems are on show and a comprehensive selection of home, office and car alarms, smoke detectors and security lighting is available.

Additionally, there is an excellent choice of communications products including telephones and fax machines. Practical and fun gadgets are also popular with Mondo customers and the latest electronic device to feature in-store is the amazing plant light. Launched at the 1997 Ideal Home Exhibition, the Plant Light is a sensor rod with a light socket that is inserted into a household plant pot. When the leaves of the plant are touched the light can be dimmed and switched on and off. This amazing gadget will even tell you when the plant needs watering!

Hobbies and Education

Beginners and electronics enthusiasts will be amazed at the variety of projects and modules on display. Mondo is an ideal place for hobbyists to develop their interest and as Chris Jeffries, manager at Mondo Nottingham says: "Customers will have a field day at Mondo! It's definitely the place to go if you need inspiration for a new hobby or pastime."

Schools and educational institutions can take advantage of exclusive account packages and Jackie Featherstone has developed a GCSE Components Pack in association with a school CDT advisor. Aimed at students and beginners, it contains everything you need to get started with over 300 components.

Mondo is also responsible for pioneering a new education award. The Mondo Merit Award will be launched over the next couple of months and students will be invited to submit designs to enter one of two categories: 'energy and environment conservation' and 'help for the infirm or disabled'.

The Future

Both new customers and those already familiar with Maplin stores and the MPS catalogue will find something to spark the imagination at a Mondo store. As Chris Jeffries says, "Mondo will carry the torch for electronics into the next century. It is great to see the reaction from customers when they walk into the store for the first time and the staff really enjoy demonstrating the new products."

Line-to-RIAA INPUT CONVERTER

FEATURES

Compact size

Low component count

APPLICATIONS

Converting line level signals into RIAA level and frequency corrected signals

Connecting CD Players, Cassette Decks, Tuners, etc. to the Phono input of pre- or integrated-amplifiers, MIDI systems, etc.

Introduction

Throughout the history of hi-fi the 'Phono' input on amplification equipment has always been reserved for the exclusive use of turntables. However, with so many people swapping their records for CDs, many Phono inputs across the country now remain unused.

The problem is, the output from turntables is of very low level and, in addition, has been pre-equalised in the recording process in accordance with the internationally agreed RIAA curve; large low-frequency stylus excursions being avoided by cutting the bass while treble is boosted to improve signal-to-noise ratio. These contours occur on each side of a small 'flat' region centred on 1kHz, see Figure 1.

Simply 'plugging in' a CD player, etc. into a Phono input stage will result in highly distorted and tonally unbalanced reproduction due to its high signal level (1V to 2V as opposed to the more modest output from a turntable of 5mV) and lack of RIAA correction.

The Line-to-RIAA Input Converter described in this article has been primarily designed to free-up the Phono input on pre- and integrated-amplifiers as well as Mini/Micro systems, thereby allowing you to connect that one last piece of equipment. See Figure 2 for typical system use.

Two good reasons for using a Line-to-RIAA Input Converter

1. Our Separate Ways

Pre-Amplifiers and integrated amplifiers have rows of phono sockets on their rear panel to which all your individual hi-fi separates connect. Wire in a CD Player, tuner, two cassette decks (for tape-to-tape recording) and possibly a graphic equaliser, and you will soon run out of inputs! Well, not quite true – unless you play records, there will always be one input you cannot use – the Phono input.

2. Mini & Micro Machines

It's not uncommon to find integrated hi-fi systems with twin cassette decks, CD player, tuner, graphic equaliser, and amplifier all in one unit. However, all this miniaturisation has no doubt helped the demise of a once highly desirable piece of hi-fi – the good old Turntable!

To keep die-hards happy a turntable input can sometimes be found lurking around the back panel of these systems. All well and good if the only

PROJECT RATING 1

Kit Available
Order as LP40T
Price £4.99

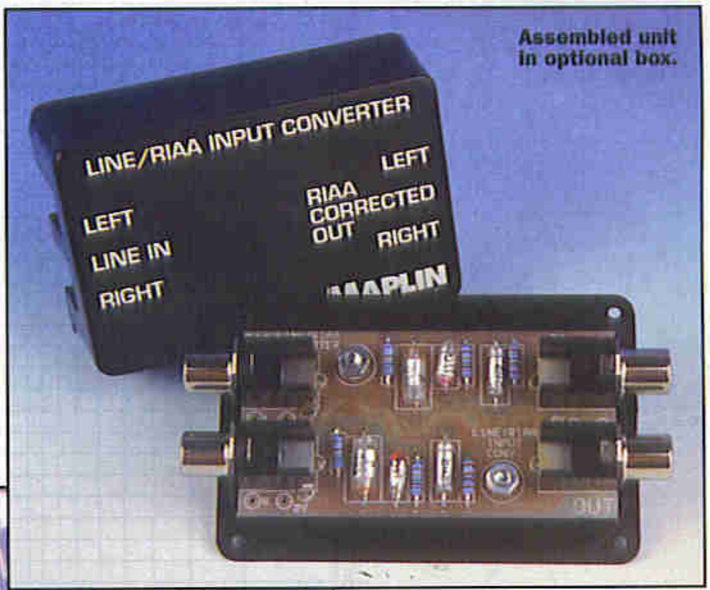
external unit you wish to plumb into your hi-fi is a turntable, but what about that new Nicam VCR, satellite system or surround-sound unit?

Line-to-RIAA Converter

The circuit diagram of the Line-to-RIAA Converter is shown in Figure 3, and could not get much simpler! Consisting of two identical circuits for the left- and right-hand channels (only one channel shown), three resistors and capacitors are cleverly configured to provide both the correct level of attenuation and equalisation.

Figure 4 shows the PCB legend and ghost track of the (stereo) circuit board supplied in the kit. Provision has been made for either PCB pins or Phono sockets to be fitted on the input and outputs, thereby offering maximum versatility.

As supplied, the kit comes without housing or Phono sockets – this is to aid fitment in existing equipment. If, however,



Assembled unit in optional box.

you wish to use the converter unit outside of any existing equipment, you will require the items listed in the Optional parts list, see end of article.

Begin by fitting either the PCB pins (supplied with kit) or Phono sockets (optional), followed by the remaining components. When fitting the PCB pins, insert and press them into position using a hot soldering iron; when the pins are heated in this way very little pressure is required to push them into place. Once the pins are in position they can then be soldered. All component leads should be kept as short as possible and the height of the components above the component side of the PCB should be kept to a minimum.

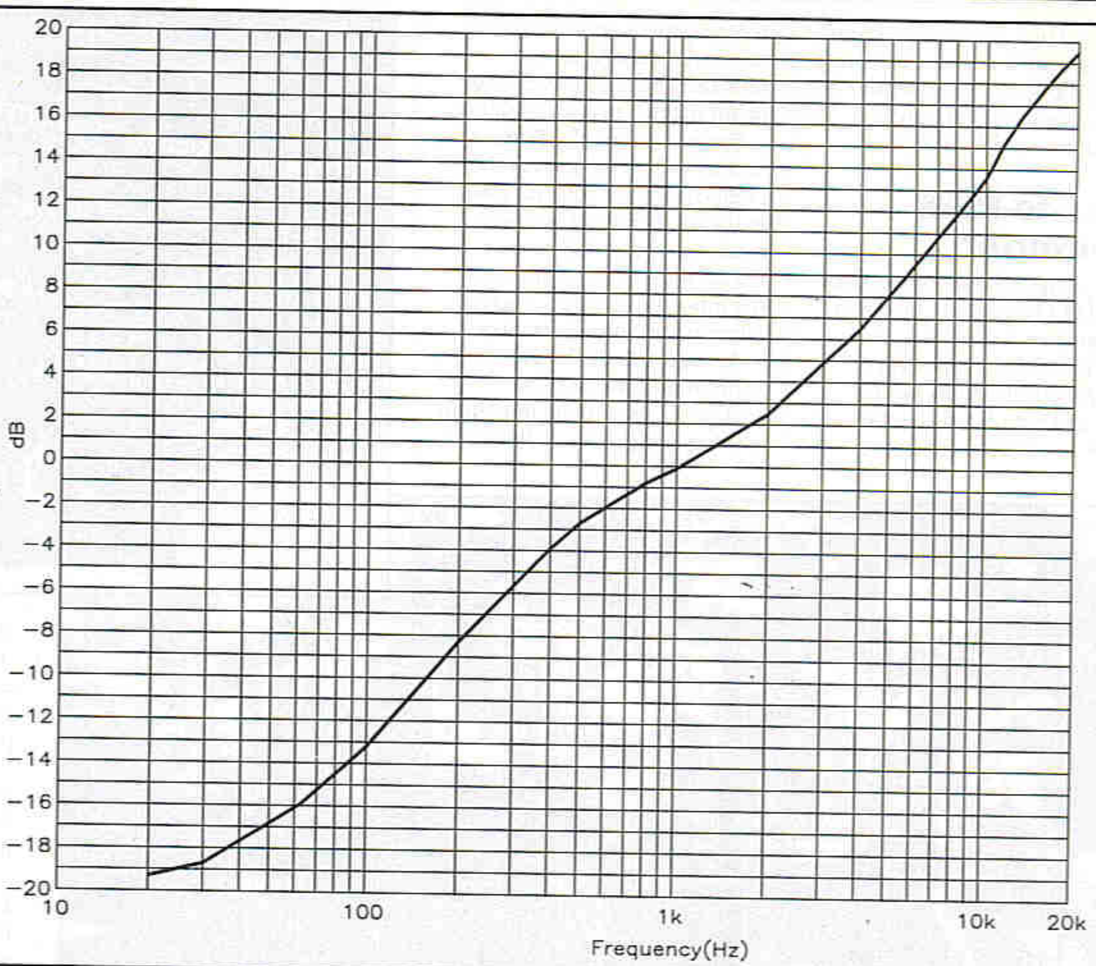
If fitting the Line-to-RIAA Converter into an existing piece of hi-fi equipment, ensure the unit is disconnected from the mains supply before removing any covers. In addition, check there is nothing behind any panels before drilling fixing holes, etc.!

Alternatively, the PCB can be fitted into a plastic enclosure, a suitable box being our 'T3 Box', stock code KC92C. See Figure 5 for box drilling and Figure 6 for box assembly, while a suitable label is shown in Figure 7. When mounting the unit in the recommended box, take care that the signal 'IN' and 'OUT' connections line up correctly with the box label!

In Use

As shown in Figure 2, line-level signals are applied to the unit to the side marked 'IN', whilst RIAA corrected signals are available from the 'OUT' connectors. It's simplicity itself!

Figure 1. RIAA recording characteristic.



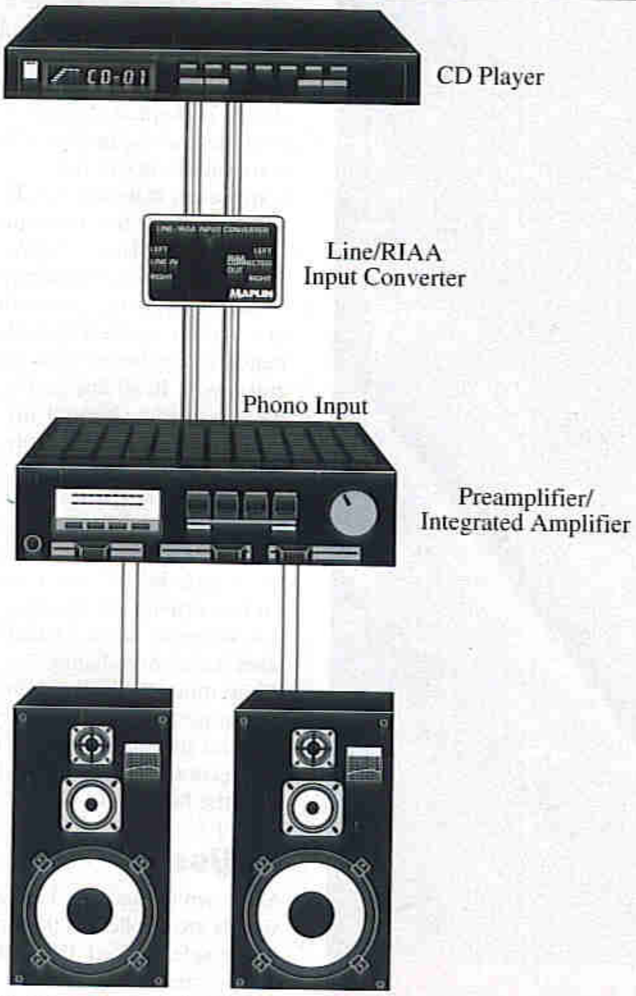


Figure 2. Typical system use.

Figure 3. Circuit diagram.

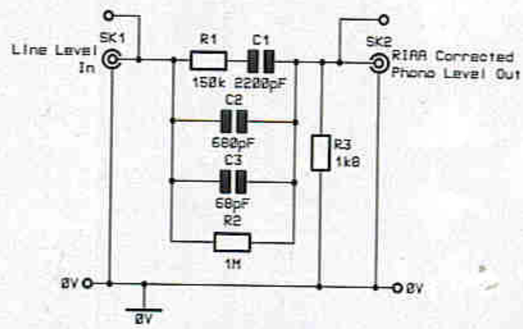


Figure 4. PCB legend and track.

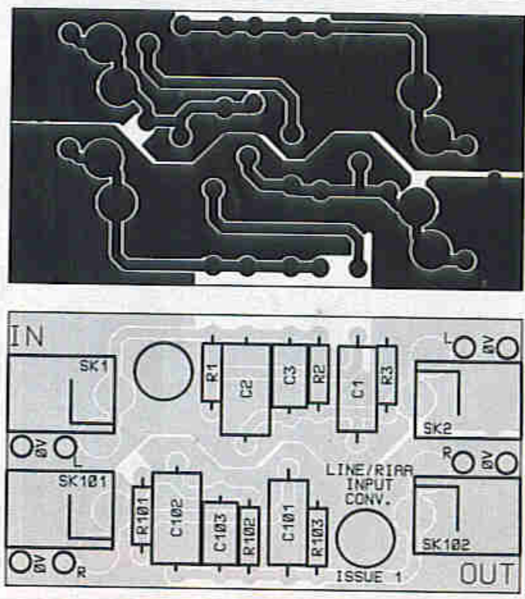
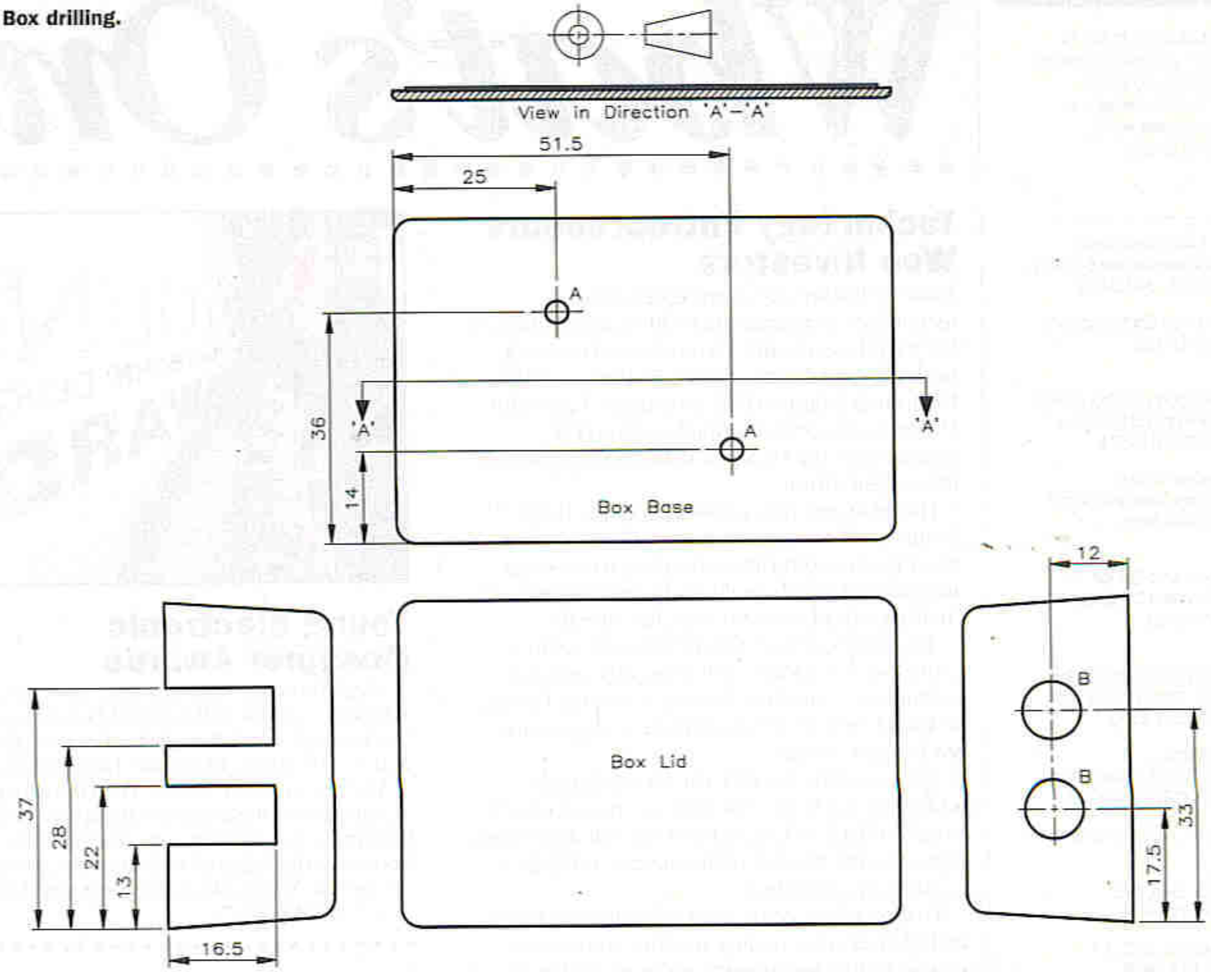


Figure 5. Box drilling.



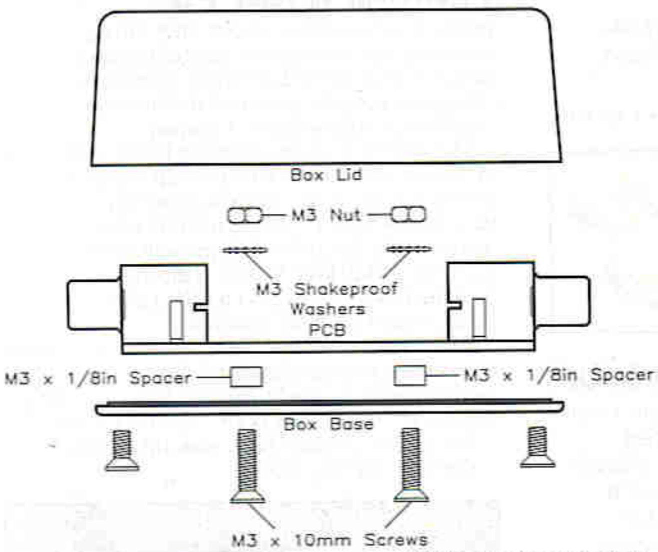


Figure 6. Box assembly.

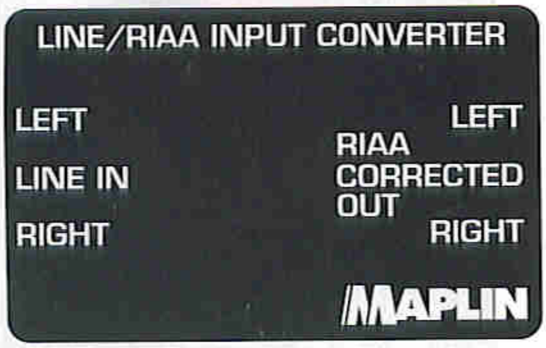


Figure 7. Label

PROJECT PARTS LIST

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

R1,101	Min Res 150k	2	(M150K)
R2,102	Min Res 1M	2	(M1M)
R3,103	Min Res 18k	2	(M1K8)
CAPACITORS			
C1,101	1% Polystyrene 2200pF	2	(BX60Q)
C2,102	Polystyrene 680pF	2	(BX34M)
C3,103	Polystyrene 68pF	2	(BX27E)
MISCELLANEOUS			
	Pin 2145	8 pins	(FL24B)
	Line/RIAA I/P Convrtr PCB	1	(GP00A)
	Line/RIAA I/P Convrtr Lflt	1	(XZ44X)
	Constructors Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
SK1,2,101,102	PCB Phono Socket	4	(HF99H)
	T3 Box	1	(KC92C)
	M3 12mm Poz Screw	1Pkt	(BF37S)
	Steel Nut M3	1Pkt	(JD61R)
	M3 Shakeproof	1Pkt	(BF44X)
	M3 Spacer 1/8in	1Pkt	(FG32K)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LP40T (Line/RIAA Input Converter) Price £4.99

Please Note: Items in the Parts List marked with a are supplied in 'package' quantities (e.g., packet, strip, reel, etc.), see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.

Line/RIAA Input Converter PCB **Order As GPOOA Price £2.99**

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.

June 1997

2 to 5 June. CIRED – 14th International Electricity Distribution Conference and Exhibition, ICC, Birmingham. Tel: (0171) 344 5478.

3 to 6 June. UKCMG Annual Conference and Exhibition, Riviera Centre, Torquay. Tel: (01635) 32338.

4 June. Vacuum & Semiconductor Processing, Trident Exhibitions, Royal Highland Exhibition Hall, Edinburgh. Tel: (01822) 614671.

9 June. Two Metre Direction Finding Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

15 June. Electronic Commerce Europe '97, EEMA Maastricht Exhibition and Congress Centre, Maastricht, Netherlands. Tel: (01628) 28080.

18 to 19 June. Government Computing and Information Management, Royal Horticultural Halls, London. Tel: (0171) 587 1551.

23 June. Technology Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

24 to 26 June. IT Expo 97, NEC, Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Database Expo, NEC Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Networks '97, NEC Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Software Development '97, NEC Birmingham. Tel: (0181) 742 2828.

24 to 26 June. Systems '97, NEC Birmingham. Tel: (0181) 742 2828.

29 June. Radio Rally, Longleat, Wiltshire. Tel: (01707) 659015.

July 1997

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

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

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

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

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

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

August 1997

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

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

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?

Technology Entrepreneurs Woo Investors

Some of Britain's most entrepreneurial technology companies met with over 60 investors last month, as the first step toward cementing deals for capital finance at the Federation of the Electronics Industry (FEI) Investment Forum for IT, electronics and communications (ITEC) companies – the UK's first national sector-specific investment forum.

Hailed as the 'best investment networking forum for IT companies in over 20 years', over two thirds of companies attending have set up negotiations which could lead to the financing of their growth plans in the next few months.

The forum, held in Gwent, brought venture capitalists face-to-face with managing directors of technology companies looking for equity finance to launch new products and take an aggressive lead in new markets.

Sponsored by the DTI, the forum directly addressed the issues raised in two recent reports from the Bank of England and the CBI, expressing concern over the lack of investment in Britain's technology companies.

Products from companies attending the forum included Internet trading systems, automotive engine testing instruments, software for health authorities and a hand-held scanner that captures 3-D pictures of buildings.

For further details, check: www.fei.org.uk.
Contact: Federation of Electronics Industry, Tel: (0171) 331 2000.

Marconi Collection Stays in UK

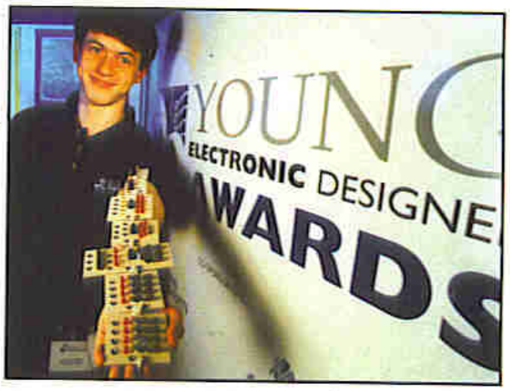
The Science Museum, Essex County Council and Chelmsford Borough Council have reached agreement to keep the Marconi Collection of historic documents and artefacts intact and in the UK.

GEC will donate the Collection, valued at £3 million, to the nation with ownership being transferred to the Science Museum. It has also been agreed that all or some of the objects will be loaned to Chelmsford Borough Council and will be made available to the public. Chelmsford Borough Council plans to put many of the objects on display.

Guglielmo Marconi established the first radio factory in Chelmsford in 1898 and there are several GEC-Marconi units based in the area today. It is only fitting that this collection should reside at the birthplace of Marconi's enterprise.

Construction is about to begin on a new state-of-the-art Essex Record Office and it is proposed that the document archive will be housed there, together with the latest technology to make it accessible internationally.

For further details, check: www.gec.com.
Contact: GEC, Tel: (0181) 9542311.



Young Electronic Designer Awards

Michael Brown of Leytonstone, who attends Bancroft's school in Woodford Green, has won the Duke of York's Awards for Creative Technology at the 1997 Young Electronic Designer Awards.

Michael's project, called 'The Gremlinator', is designed to test electronic circuits for faults. He received a trophy, laptop PC and fax from Prince Andrew at the Science Museum at the end of March.

Contact: Young Electronic Designer Awards, Tel: (01798) 874767.

Intel Demonstrates Pentium II Net PC

Intel's chief executive officer, Andy Grove, demonstrated an engineering prototype of the Net PC with a 233MHz Pentium II processor during his keynote speech at the Innovate conference, sponsored by Compaq.

The Net PC is a new emerging family of business PCs designed to reduce ownership. Systems based on the Net PC design guidelines are expected to be available from PC manufacturers by mid-year. As part of its Wired for Management initiative, Intel plans to deliver Net PC platforms and building blocks to support a wide range of performance in OEMs' systems.

"Businesses need high-performance clients to be competitive, and manageability innovations to reduce computing costs. Intel's managed PCs, including the Net PC, will deliver both", said Dr. Grove.

For further details, check: www.intel.com.
Contact: (01793) 403000.

The museum.

Lights! Camera! ACTION!

by Alan Simpson

This month, Out & About has gone up North to visit the National Museum of Photography Film & Television in Bradford. This is certainly an eye-opener of a museum – one not to be missed by any visual media buff.

The most visited museum outside of London, features six floors and galleries bursting with displays, interactive equipment with mega and not-so-mega screens plus constantly changing exhibitions.

If it is fun entertainment, art, education and science you seek, then the NMFPT is the venue. The developing history of photographs, 1930 news theatre, the UK's largest IMAX cinema screen and the pictureville cinema showing the best old and new in world cinema are there for the asking.

In 1988, the National Museum of Photography was voted Museum of the Year: in 1990, it was runner-up as European Museum of the Year, with accolades bestowed by such authorities as The Sunday Times, and The International Herald Tribune.

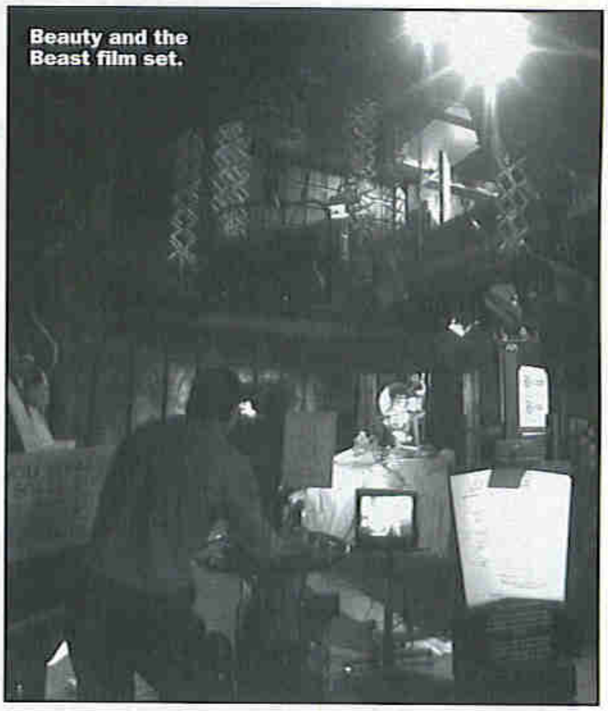
Opened in 1983, the National Museum of Photography, Film & Television has quickly become the most visited British museum outside London, welcoming around 750,000 visitors each year. Its popularity justified the original decision to site a major national museum in the north: over nine million people have visited since the NMPFT opened 14 years ago. It is part of the National Museum of Science and Industry in London.

The Museum's renowned collection contains many historic milestones; notably, the world's first example of moving pictures – Louis le Prince's 1896 film of Leeds Bridge. As home to one of the leading photographic archives, the Museum holds 6,000 images from the work of William Henry Fox Talbot; 1·3 million images contained in the Daily Herald Archive spanning 1911-1960s; Julia Margaret Cameron's Herschel Album and the photographic works of 'Lewis Carroll'. Its collection of rare early film and television technology is one of the finest of the world.

Non Static

As one commentator put it, Britain's NMPFT has been exemplary, perhaps even uniquely successful in capitalising on the natural assets of a media museum. For such a museum, it is especially well positioned to put itself on display; the technologies of selection, reproduction and distribution that it employs to do its work are the same ones the visitors expect to see, 'experience' and presumably, learn more about. The exhibition policies include a deep reluctance to put anything behind glass; a firm commitment to audience-interactive installations; a preference for non-linear 'enter anywhere' exhibition organisation; and an outright refusal of lengthy and complex printed information (labels must be less than 50 words). As much as photographic history, television production or the triumphs and vicissitudes of British cinema, technically mediated 'user-friendliness' itself is on exhibit here.

Inside the museum; Television Gallery 4.



Beauty and the Beast film set.

Some 70 years ago, John Logie Baird transmitted the first television picture, while back in 1889, William Friese-Greene invented the cine-photographic camera. Both events are celebrated.

Visitors can start their tour with a look at the Kodak museum on the first floor, then work their way up, literally, through the history of photography and film to the TV production gallery. Whether you want to fly on a special effects magic carpet, read the news or operate the cameras to a director's instructions, it's all here.

Then there's Nickelodeon, the world's most popular children's satellite TV channel, which broadcasts from within the museum itself. Children will be able to get in tune with a real TV studio that's in tune with them. First hand experience of editing, live-links and a chance to talk back on the unique Nickelodeon video box.

With IMAX and Pictureville just around the corner, and special events and exhibitions going on all the time, you'll hardly have a spare minute. But if it's a quick sit-down you need, then TV Heaven is the place for you. A wonderful opportunity to select and watch some of your favourite shows from 60 years of British TV.

The Medium is the Message

First stop then, is on level one – photography – an introduction. This stunning exhibition traces the milestones in the history of photography. Permanent displays include: The Story of Popular Photography (the Kodak Museum). Previously sited in Harrow, this collection of over 50,000 objects and images was given to the NMPFT by Kodak Limited. In Bradford, it has been theatrically re-interpreted to tell the history of 150 years of photography from the point of view of the man and woman in the street.

Kodak Gallery 3; a beach scene.

Six sections, surrounding the largest lens in the world, trace the history of the development of popular photography. Photography is News: an exploration of the techniques and history of photo-journalism. Exhibits include a news editor's desk; recordings of great photo-journalists talking about their most memorable assignments; a 1930s news cinema; and displays from the Museum Daily Herald Archive.

One floor up, you can 'fly' on a special-effects magic carpet. In fact, one of the most popular museum exhibits in Britain today is a carpet. It's small, looks much like any other carpet and it sits on a bare patch of floor in Bradford. Not that thrilling you might think, except that when you sit on this carpet, it takes off into the sky and transports you on a journey oversoaring mountain ranges and storm-churned seas. For this is no ordinary piece of Axminster, but the amazing Magic Carpet, one of the star attractions at the NMPFT. It is designed to demonstrate the marvels of chromakey, a process whereby an image in the studio (i.e., you on a carpet) can be superimposed on a different piece of film entirely. Thus, although you don't actually leave Yorkshire soil, when you look on the overhead video screen, you see yourself and the carpet amid rapidly moving Alps or heaving Atlantic swell.

Two floors are devoted to the history and practice of the craft of television. Visitors have experience of news-reading (and see themselves on screen keyed into a news programme of their choice); operating a camera; vision mixing; and some of television's tricks of the trade. TV Heaven, the NMPFT's unique public-access television archive, is home to some of the most important, entertaining and influential programmes made since 1950. Visitors can catch up on classic programmes – whether it's early Coronation Street or the best of The Young Ones.

TV Heaven

One of the remarkable features of the television galleries is that they allow you to actually watch many of the milestone programmes produced over the last 40 years. TV Heaven is a unique part of the Museum's archives. Holding almost 500 programmes, it reflects the rich diversity of British television, including classic drama award-winning documentaries, children's shows, soap opera and forgotten curios from Hancock's Half-Hour to The Jewel in the Crown. The majority of the programmes in TV Heaven can no longer be seen on terrestrial or satellite television and many have not been released on sell-through video.

Watch With Mother, a gallery devoted to children's TV, which gathers together for the first time many of young viewers' favourite icons, including the Play School Toys and currently, characters from the classic children's television programme, Bagpuss. Then, there is Nickelodeon, which is one of the fastest growing satellite television channels. This is a prime opportunity for students to see a working studio in action and to quiz staff on the various aspects of production and broadcasting.

November 2nd 1996 marked the 60th anniversary of the first publicly available television broadcast from Alexandra Palace, London. To mark the occasion, the museum has rewritten television history, revealing the world's earliest video recordings – nearly 30 years older than previously thought. They date from the earliest days of television, when John Logie Baird was first developing his invention. But Baird never saw the recordings. Only after extensive work by the Museum, in co-operation with IBM and Symposium Records, can these amazing pieces of our history be seen for the first time since they were made, almost 70 years ago.

They can be viewed in Gallery Four, alongside a stunning introduction to the future of television. Developed in partnership with Pace Micro Technology, the new hands-on satellite display enables visitors to explore the potential that this technology offers, not only in terms of entertainment, but to change our entire lives. Never before has it been possible to view the remarkable history of this media in such detail in a single gallery or to see what the future might hold.

The Chromakey process enables a Magic Carpet ride.

A Bright Picture for Visitors

If you love film, you'll love Pictureville. With seating, comfort and a sound system that's second to none, it won't take you long to agree that this really is the number one spot for anyone who appreciates the finer points of the cinema experience. A full programme of new releases and classic films runs throughout the year, and watch out for Screen Talk evenings – a must for all film buffs. Directors, actors and cameramen introduce their own films and answer the questions you've always wanted to ask.

Pictureville is also home to one of the legends of film history. During the 1950s and 1960s, Cinerama was the star attraction for millions of film goers. The enormous three projector 'wrap-around' screen engulfed the viewer: sadly, or rather luckily, one of only two places in the world where you can re-live the rare treat is right here at the NMPFT.

Certainly, pictures do not come any brighter (or bigger) than the IMAX cinema the Museum's most popular exhibit. This is the UK's largest cinema screen at 52 × 64ft. (the height of a five-story building), showing the world's largest film format. The film (ten times the size of a standard 35mm frame) runs horizontally through a huge projector, the size of a small family car: IMAX is the largest film format in the world, and the NMPFT is currently the only place in the UK that you can see it. At least, as at now. Plans are already afoot to install no less than 4 IMAX 3D giant screen cinemas in the UK.

Films currently showing include Special Effects, a behind-the-scenes exploration of the wizardry used to create such blockbusters as Independence Day, Star Wars and Jumanji; and Sir David Attenborough's first foray onto the IMAX screen Survival Island, which takes you on a spectacular exploration of the animal cities of south Georgia, breeding ground to millions of penguins, seals and albatross.

If the opening sequence of Star Wars amazed you 20 years ago, then prepare to be stunned with the awesome sight of a giant Imperial Star Destroyer filling the world's biggest cinema screen. Re-shot for the vast five-storey high IMAX screen, the sequence is just one of the amazing examples of film special effects.

However, the featured films are not just a catalogue for the latest in cinema trickery. Rather, they are a guide to the history of visual effects and an explanation of how cinema, with its repetition of images, 'tricks' the eye into seeing movement. From the work of the Melies Brothers, via the spaceships-on-string film-making of the 1950s, it explores how familiar visual cues – colour, form, light, motion and depth – are manipulated to create the illusion of reality on screen.

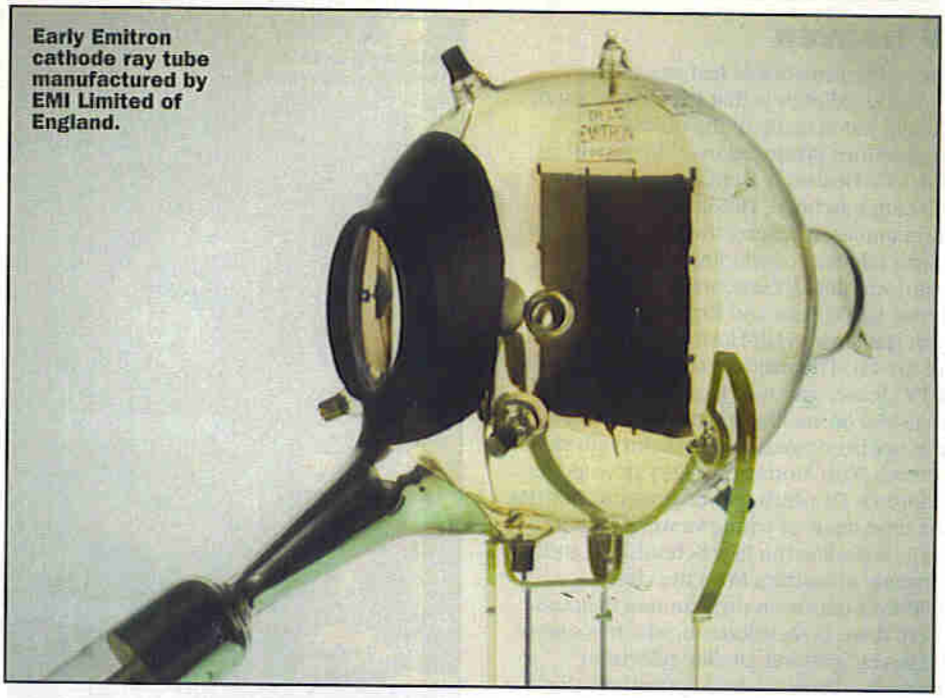
From the earliest days of cinema, film-makers have used a variety of techniques to trick the eye. The films explore how these ideas have developed over a century of film-making, evolving from using what were obviously models to an industry where computer animations have created the fantasy worlds of Jurassic Park and Jumanji.

This is one movie experience that has the power to move the audience, where such


Exhibits in the Photography section of the museum.

I'm just a Television Man!


Getting to grips with a TV camera.


Early Emitron cathode ray tube manufactured by EMI Limited of England.

slogans as 'Be there – be part of the action' score reality points. All in all, a memorable blend of illusion, art, imagination and technology. In other words, don't believe what you see.

For once, Bradford got there first and remains, at least for the time being, as the only place where you can see the greatest special effects technicians in the world creating movie magic – beyond your wildest dreams. Forget Madonna's Evita. Star Wars in IMAX is many times more memorable.

Crossing the Imaging Frontier

Every day, millions of people throughout the world are exposed to photography, film and TV. Yet, only at the NMPFT can the three media that have shaped the 20th Century be explored and enjoyed in one visit. Stunning audio visual journey awaits, taking you from the very first photography, over 150 years ago, right up to the digital wizardry of the 1990s.

And *Electronics and Beyond* can make it all happen for you. We have no less than 10 sets of family (2 adults and 2 children – tickets, value £15), for the winners of our easy-to-enter contest. See you in Bradford.

Contact
National Museum of Photography, Film & Television
Booking and Tickets, Tel: (01274) 727488
Museum open 10.00 am – 6.00 pm
Tuesday to Sunday

The Contest

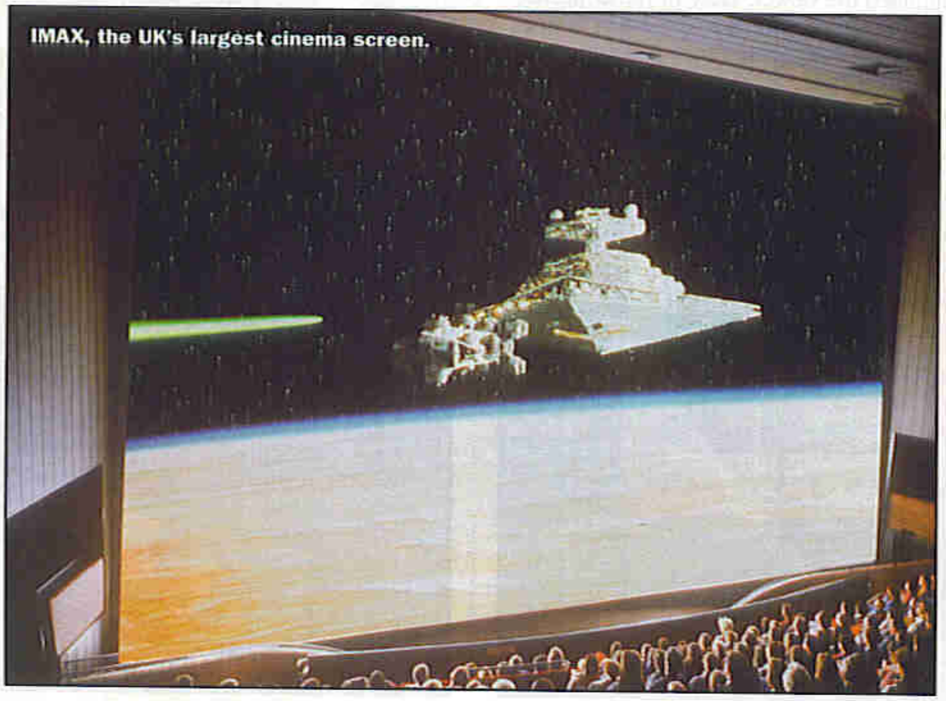
This is one contest for all you film and TV buffs. Enter and you could win one of our ten sets of family tickets to the National Museum of Photography, Film & Television in Bradford.

How to Enter

All you have to do to enter, is complete the contest coupon, correctly answering the four questions or write your answers on a postcard or back of a sealed-down envelope – please don't forget to add your phone contact number. Entries to be received by 4th July 1997.

Send your entry to:
Lights! Camera! Action! The Editor, *Electronics and Beyond* – The Maplin Magazine
PO Box 3, Rayleigh, Essex SS6 8LR
Good Luck!

Please note that employees of Maplin Electronics, associated companies and family members are not eligible to enter. In addition, multiple entries will be disqualified. The prizes will be awarded to the first all-correct entries drawn. The Editor's decision will be final. Prizes are not exchangeable for cash. Any related costs will not be met by the publication or the contest promoters.


IMAX, the UK's largest cinema screen.

LIGHTS! CAMERA! ACTION!

Answer all the questions below, ticking one box for each question.

1. Identify the Oscar winner:
a) Katherine Hepburn ☐
b) Anthea Turner ☐
c) Ruby Wax ☐

2. Who invented and first demonstrated TV?
a) David Mellor ☐
b) Richard Dimbleby ☐
c) John Logie Baird ☐

3. Who took the earliest known photograph?
a) Lord Snowdon ☐
b) Joseph Nicephore Niepce ☐
c) Charlie Chaplin ☐

4. Which is the odd one out?
a) Hoover ☐
b) Kodak ☐
c) Canon ☐

PROJECT

Slow Scan TV DECODING

PART 2

Design by Roger Thomas GW8JQW

How the Windows Software Works

Windows 95 reads the serial information coming in from the interface and continually stores this in a communications buffer. This data is moved from the communications buffer into a program buffer within the SSTV program, as often as possible. This is to prevent the Windows 95 communication buffer from overflowing and picture data being lost.

The data is read from the program buffer and processed to see if it is picture data, synchronizing pulse or any other frequency (which is disregarded). If it is picture data, it is transferred into yet another buffer (line) which holds only picture information.

When a line sync is correctly received, the line buffer is divided up into three (assuming a colour picture) and moved into one of the three individual colour arrays (see Figure 7).

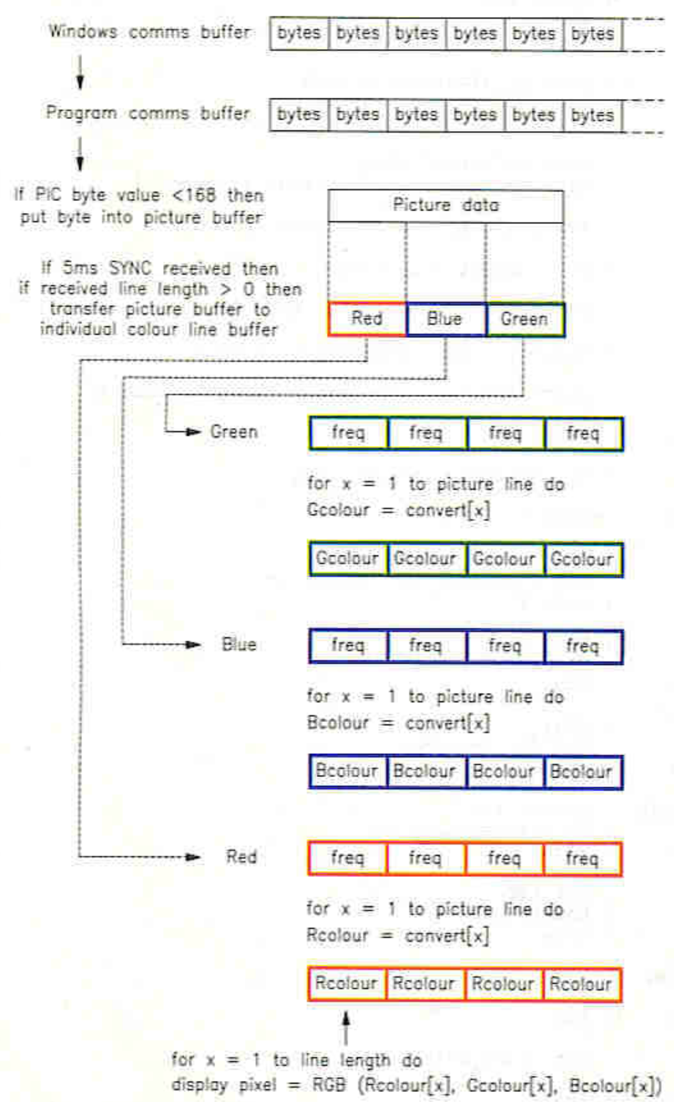


Figure 7. Line buffer assignation.

Each byte in the picture line buffer array represents a particular value from the PIC, which (via a look-up table) is translated into a corresponding colour intensity. Intensity for each colour is in the range 0 through to 255 (byte). If all three intensities are zero, the result is a black display. If all three intensities are 255, the result is white display.

These three colours then represent the colour of an individual pixel within a slow scan picture. The three bytes are passed to the Windows RGB function, which returns the closest colour based on the RGB levels and the colour capabilities of the installed graphics card.

The colour information passed to the graphics card is always correct for the mode or number of colours selected. If the display mode is changed, then the SSTV software will automatically work with the capability of the new mode.

This is one advantage of Windows 95, where the operating system takes care of the graphics display. However, this does comes with a penalty of slower processing speed as the applications software communicates with this additional software interface. It can also be less flexible as Windows imposes a particular approach to programming.

RSF Windows File

With the Windows 95 program, data can be saved to disk in a file with an RSF extension. RSF files are not bitmap picture information but the actual byte information received directly from the PIC interface. Neither the display or SSTV mode influences this data, and this enables previously saved SSTV data to be viewed.

This means that if the graphics capability is changed, previously saved data will be displayed depending on the capabilities of the graphics card, not on any of the settings when the data was originally written to disk. These RSF files can be copied but the data contained in these file will not make any sense to any other program.

What does RSF stand for?, Roger's Slowscan Format <grin>.

Saving slow scan as data is much better than attempting to record the SSTV audio. It is possible to record slow scan on a good quality tape recorder but on playback, any variation (even of a few Hertz) can degrade the picture quality. Loading SSTV directly from the hard disk is very much quicker than reloading SSTV from the cassette tape, and more convenient.

These files can get quite large because the program is saving data all the time while the RSF save function is selected. The Windows program automatically appends a different number to the RSF filename each time SSTV data is saved, along with the date and time.

Transmission times of slow scan picture is typically over 100 seconds, consequently, RSF files can be between 200-700k-byte long. The size of the file is determined by the length of time the function is selected, not the actual picture content.

This ability to simultaneously save the data and display the picture is not possible with a DOS-based program. A DOS program does not have enough time to process, display and store the picture all at the same time.

The program can save the screen to disk as a bitmap file (BMP file) and can also print this to the default Windows printer.

ASM Code Description

The PIC assembler code is given, but please respect the copyright notice. There are two routines needed to 'digitise' slow scan television. The first is to convert the SSTV audio into frequency data and secondly, to send the data to the PC, in this case, via the serial port.

This interlinking of the two functions is necessary to maintain the correct timing needed for the conversion and the serial communications. The PIC programs transmit information continuously at 38,400 baud.

All timings assume that the PIC is running at 4MHz. With this clock frequency, each instruction requires four clock cycles to execute, which sets the minimum time 'resolution'.

With a speed of serial transmission of 38,400 baud,

$$\frac{\frac{4{,}000{,}000}{4}}{38{,}400} = 26{\cdot}04\mu s$$

To achieve this rate, the program is kept in a loop of 52μs, in which it transmits 2 bits.

The highest frequency used by slow scan is 2,300Hz (white), so the system needs to sample faster than that. The most convenient sample rate is 8 × 52μs = 416μs. This will cope with frequencies of up to 2,404Hz, hence, some of the possible byte values are not used.

Consequently, the PIC software is sampling the slow scan audio at 250kHz; the sample rate is limited by the speed at which the PIC can reliably transmit the data. Every 416μs, the program transmits the last conversion. The PIC timer is left in free running mode with clocking every 4μs. When the input to the PIC goes high, the value of the timer is read and stored as the last reading.

The PIC reads the port via the indirection register. This allows the PIC to change the indirection register to point to a dummy register after the input goes high. When the port goes low, the PIC changes the indirection register to point back to the port. NOPs are used to equalise the timings between the different program fragments.

Every 4μs, the program checks to see if the port has gone high. It does this by interleaving the check input port with the RS232 transmit program. The program then runs a fragment, which is the same code as if it had remained within the loop except where it would have tested the port, it reads the timer and sets the indirection register.

The fragment then rejoins the main loop at the correct place. Due to a jump taking twice as long, the fragment is 1μs shorter than the main loop. This, however, can cause a 1μs jitter in the RS232 output, but this is within tolerance and does not cause a problem.

Interrupts are not used in this application as the PIC requires too much time to handle the interrupt and to save the STATUS and W registers. Then, more time is needed to restore the registers prior to continuing the program.

Each byte of information sent to the PC is different from the preceding one, so that the PC software will know if this is a valid data or a repeat byte. The PIC software 'idles', repeating the last value while waiting for an input; it cannot stop sending as this will upset all the timings.

To determine if the byte received is new data or the PIC software idling, the following algorithm needs to be implemented in the display program.

The actual value that will be displayed is the difference between the last value and the current one, and the code required to do this is:

```
// PICcurr = PIC current value
// PIClast = PIC last value
// PICval = PIC value used to
display

if PICcurr <> PIClast then
begin
 if PICcurr > PIClast then
PICval = PICcurr - PIClast
 else PICval = (256 - PIClast)
+ PICcurr;
 PIClast = PICcurr;
end;
```

If the byte value received is below 168, then this is picture information. For Martin M1 mode, a picture line takes 147ms per colour, and multiplying this by three gives 441ms per line. Dividing this by the number of samples possible per line gives the 'dot rate' for picture display.

PIC ASM Source Code

The PIC code was assembled using MPASM 01.30.01. Part of the cross-reference file is given so that you can check your code for any typing errors.

```
; Slow Scan Television - PIC16C84
;
; (©) 1997, Roger Thomas GW8JQW
;
;
; You can use this code for your own non commercial use.
; Any distribution or commercial use without written
; permission is strictly prohibited.
;
        list p=16C84,r=HEX
        __config H'3ffl'

PTR      equ H'0'            ; Dummy indirection register
OPT      equ H'1'            ;
RTCC     equ H'1'            ; Timer
PC       equ H'2'            ; Program counter
STATUS   equ H'3'            ; F3 is STATUS Register
FSR      equ H'4'            ; Value of offset
PORTSG   equ H'5'            ; Port with signal
PORTRS   equ H'6'            ; Port with RS232 signals

PCLATH   equ H'0A'           ; Upper program counter bits
C        equ H'0'            ; Carry flag
DC       equ H'1'            ; Digit carry flag
Z        equ H'2'            ; Zero flag
PD       equ H'3'            ; Power down flag
TO       equ H'4'
RP0      equ H'5'
TxChr    equ H'20'           ; Next character to transmit
TxWrk    equ H'21'           ; Working register during transmit
TxRes    equ H'22'           ; Reset value of count
TxCnt    equ H'23'           ; Count
PortSt   equ H'24'           ; Value used to set Port shifted right 1 bit
Dummy    equ H'25'           ; Dummy register when waiting for Sync
RSOut    equ 0  ; RS232 Out
SigIn    equ 0  ; Signal In
         goto main
main     call reset          ; Reset PIC
         call cnv            ; Do conversion
         goto main

reset    bsf STATUS,RP0      ; Swap to alternative bank
         clrf PORTRS         ; Enable Port B as output
         movlw H'C1'         ; Set / 8 to timer
         movwf OPT
         bcf STATUS,RP0      ; Swap to normal bank
         movlw H'0'          ; set next transmit character to zero
         movwf TxChr
         movlw H'7e'         ; Set count to transmit next
         movwf TxCnt
         movlw H'0'          ; Set current output to 0
         movwf TxWrk
         movlw H'78'         ; Set reset counter value to 8 Hex 80-78 = 8
         movwf TxRes
         movlw PORTSG        ; Point indirect register to Port A
         movwf FSR
         clrf Dummy          ; Dummy register when not looking at port A
         return
cnv      btfsc PTR,SigIn     ; Edge ?
         goto frag1
cnv1     bcf STATUS,C        ; Set Msb Move LSB to carry
         rrf TxWrk,f
         btfsc PTR,SigIn     ; Edge ?
         goto frag2
cnv2     incf TxCnt,f        ; Increment transmit count
         comf TxChr,W        ; Get inverted next character
         btfsc PTR,SigIn     ; Edge ?
         goto frag3
cnv3     btfsc TxCnt,7       ; Next
         movwf TxWrk         ; Store character
         btfsc PTR,SigIn     ; Edge
         goto frag4
cnv4     btfsc TxCnt,7       ; Next
         bsf STATUS,C        ; Set for stop bit
         btfsc PTR,SigIn     ; Edge
         goto frag5
cnv5     btfss PORTSG,SigIn  ; Signal low
         bcf FSR,5           ; Re enable checking
         btfsc PTR,SigIn     ; Edge
         goto frag6
cnv6     rlf PortSt,W        ; Set LSB
         movwf PORTRS        ; Update port
         btfsc PTR,SigIn     ; Edge
         goto frag7
cnv7     nop   ; Keep loop timing
         nop
         btfsc PTR,SigIn     ; Edge
         goto frag8
cnv8     movf TxRes,W        ; Get count reset value
         nop
         btfsc PTR,SigIn     ; Edge
         goto frag9
cnv9     btfsc TxCnt,7       ; Next
```

```
        movwf TxCnt           ; Reset count
        btfsc PTR,SigIn       ; Edge
        goto frag10
cnv10   nop    ; Keep loop timing
        nop
        btfsc PTR,SigIn       ; Edge
        goto frag11
cnv11   bcf STATUS,C          ; Set MSB move LSB to carry
        rrf TxWrk,f
        btfsc PTR,SigIn       ; Edge
        goto frag12
cnv12   rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        btfsc PTR,SigIn       ; Edge
        goto frag13
cnv13   goto cnv
frag1   bcf STATUS,C          ; Set Msb Move LSB to carry
        rrf TxWrk,f
        bsf FSR,5             ; Point indirection to
dummy
        incf TxCnt,f          ; Increment transmit count
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        comf TxChr,W          ; Get inverted next
character
        btfsc TxCnt,7         ; Next
        movwf TxWrk           ; Store character
        goto cnv4             ; Restart in loop

frag2   incf TxCnt,f          ; Increment transmit count
        comf TxChr,W          ; Get inverted next
character
        bsf FSR,5             ; Point indirection to
dummy
        btfsc TxCnt,7         ; Next
        movwf TxWrk           ; Store character
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        btfsc TxCnt,7         ; Next
        bsf STATUS,C          ; Set for stop bit
        goto cnv5

frag3   btfsc TxCnt,7         ; Next
        movwf TxWrk           ; Store character
        bsf FSR,5             ; Point indirection to
dummy
        btfsc TxCnt,7         ; Next
        bsf STATUS,C          ; Set for stop bit
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        btfss PORTSG,SigIn    ; Signal low
        bcf FSR,5             ; Re enable checking
        goto cnv6

frag4   btfsc TxCnt,7         ; Next
        bsf STATUS,C          ; Set for stopbit
        bsf FSR,5             ; Point indirection to
dummy
        btfss PORTSG,SigIn    ; Signal low
        bcf FSR,5             ; Re enable checking
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        goto cnv7

frag5   btfss PORTSG,SigIn    ; Signal low
        bcf FSR,5             ; Re enable checking
        bsf FSR,5             ; Point indirection to
dummy
        rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        nop
        nop    ; Time
        goto cnv8

frag6   rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        bsf FSR,5             ; Point indirection to
dummy
        nop
        nop    ; Time
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        movf TxRes,W          ; Get reset value
        nop
```

```
        goto cnv9
frag7   nop
        nop    ; Time
        bsf FSR,5             ; Point indirection to
dummy
        nop
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        movf TxRes,W          ; Get reset value
        btfsc TxCnt,7         ; Next
        movwf TxCnt           ; Reset count
        goto cnv10

frag8   movf TxRes,W          ; Get reset value
        nop
        bsf FSR,5             ; Point indirection to
dummy
        btfsc TxCnt,7         ; Next
        movwf TxCnt           ; Reset count
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        nop
        nop
        goto cnv11

frag9   btfsc TxCnt,7         ; Next
        movwf TxCnt           ; Reset count
        bsf FSR,5             ; Point indirection to
dummy
        nop
        nop
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        bcf STATUS,C          ; Set MSB move LSB to carry
        rrf TxWrk,f
        goto cnv12

frag10  nop
        nop
        bsf FSR,5             ; Point indirection to
dummy
        bcf STATUS,C          ; Set MSB move LSB to carry
        rrf TxWrk,f
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        goto cnv13

frag11  bcf STATUS,C          ; Set MSB move LSB to carry
        rrf TxWrk,f
        bsf FSR,5             ; Point indirection to
dummy
        rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        nop
        nop
        goto cnv1

frag12  rlf PortSt,W          ; Set LSB
        movwf PORTRS          ; Update port
        bsf FSR,5             ; Point indirection to
dummy
        movf RTCC,W           ; Get timer
        movwf TxChr           ; Save timer as next
character to transmit
        bcf STATUS,C          ; Set Msb Move LSB to carry
        rrf TxWrk,f
        nop
        nop
        goto cnv2

frag13  nop
        nop
        bsf FSR,5             ; Point indirection to
dummy
        bcf STATUS,C          ; Set Msb Move LSB to carry
        rrf TxWrk,f           ; Get timer
        movf RTCC,W           ; Save timer as next
character to transmit
        movwf TxChr
        incf TxCnt,f
        comf TxChr,W          ; Get inverted next
character
        goto cnv3
        end
```

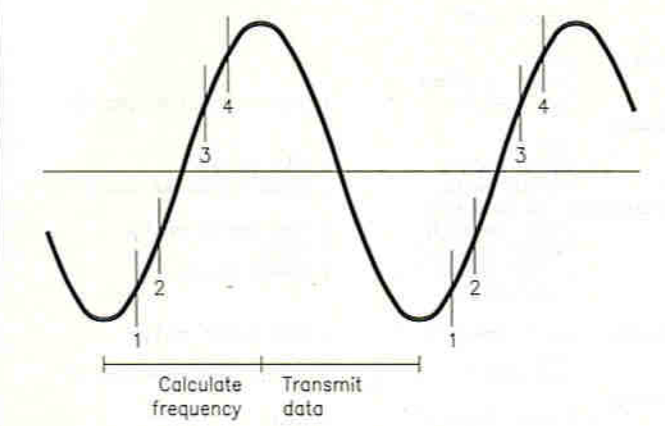


Figure 8. Sinewave Calculations.

Slow Scan MkII

An alternative method is to use a PIC 16C71 microcontroller (sorry, there is no source code for this version). This PIC incorporates an onboard analogue-to-digital converter (ADC) and the audio is fed into this pin.

Referring to Figure 8 showing the sinewave calculations, the PIC software samples the signal every 32μs at points 1, 2, 3 & 4 on the graph. These sample values are then added according to the calculation:

$$\frac{(1 + 4) + (2 + 3)}{2}$$

This gives the point at which the signal crossed the zero line and calculating the slope (or rate of change) gives the frequency (actually, this gives the wavelength). This method is most resistant to noise, as a burst of noise will be averaged out over successive calculation and gives a more accurate conversion.

However, if the signal is heavily contaminated with noise, then no amount of processing will be able to distinguish between noise and the wanted audio.

As can be seen if the ADC is overloaded and the input turns into a square wave, the PIC software is unable to function correctly (unlike the other version).

Once the audio wavelength is calculated, the PIC transmits this number to the computer via the RS232 serial link. The PIC software then takes several readings, waiting for the readings to start to go positive, which indicates it has reached the bottom of the sinewave and is ready to start the process again.

This method does not generate data all the time (unlike the other example), but does require much more processing. A graphics scaling correction is also required when the picture is displayed because it take less time to convert a white pixel (higher frequency) than a black pixel.

Where to Find SSTV

The recommended slow scan frequencies for the following amateur bands are shown in Table 2:

Note that these are only IARU (International Amateur Radio Union) recommendations, but the majority of radio amateurs observe these band plans, although there is a long-established American DX net that insists on ignoring the 14MHz SSTV band plan.

80m	3·730-3·740MHz
40m	7·035-7·045MHz
20m	14·225-14·235MHz
15m	21·335-21·345MHz
10m	28·675-28·685MHz
2m	144·500MHz calling frequency
6m	50·510MHz calling frequency

Table 2. Recommended slow scan frequencies for amateur bands.

During contests, you may find high powered stations encroaching into this sub band with the inevitable interference. Occasionally, radio amateurs use these frequencies for voice communications, unaware of the existence of slow scan television.

The best band for slow scan (when conditions are good) is the 14MHz band (20m). Listen out for the repetitive 1,200Hz synchronising pulse and tune slowly as a few hertz will make a visible difference. With practice, it is possible to recognise the different audio characteristics of the distinct slow scan modes.

Most slow scan pictures have a grey scale along the top and this will be displayed correctly even if viewed with the wrong mode selected. A grey 'colour' has the same value with each different colour, so the colour sequence does not matter but the wrong sequence will result in the wrong colour.

A slow scan television net is on 14·235MHz every Saturday afternoon with SM5EEP (Nils) as the net controller. The number of other stations that join in vary from week to week but it is usually well worth a listen.

Acknowledgements

A programmed PIC, PC Windows software and printed circuit board are available directly from the author, please send an SAE for details to: Roger Thomas, 121 Tyn-y-Twr, Port Talbot, West Glamorgan SA12 8YE.

Special thanks to Andrew Thomas for help with the PIC software and the SSTV decode algorithm.

The Microchip name and PIC are registered trademarks of Microchip Technology Incorporated, USA.

DOS and Windows 95 are registered trademarks of the Microsoft Corporation.

Robot is a trademark of Robot Research Inc., San Diego, USA.

Martin SSTV mode developed by Martin Emmerson G3OQD.

Scottie SSTV mode developed by E. T. Murphy GM3SBC.

Wraase SSTV mode developed by Volker Wraase DL2RZ.

Label	Type	Filename	Source File References
__16C84	V	SSTV.ASM	11*
cnv	A	SSTV.ASM	48. 70* 120.
cnv1	A	SSTV.ASM	72* 252.
cnv10	A	SSTV.ASM	108* 204.
cnv11	A	SSTV.ASM	112* 216.
cnv12	A	SSTV.ASM	116* 228.
cnv13	A	SSTV.ASM	120* 240.
cnv2	A	SSTV.ASM	76* 264.
cnv3	A	SSTV.ASM	80* 276.
cnv4	A	SSTV.ASM	84* 132.
cnv5	A	SSTV.ASM	88* 144.
cnv6	A	SSTV.ASM	92* 156.
cnv7	A	SSTV.ASM	96* 168.
cnv8	A	SSTV.ASM	100* 180.
cnv9	A	SSTV.ASM	104* 192.
frag1	A	SSTV.ASM	71. 123*
frag10	A	SSTV.ASM	107. 231*
frag11	A	SSTV.ASM	111. 243*
frag12	A	SSTV.ASM	115. 255*
frag13	A	SSTV.ASM	119. 267*
frag2	A	SSTV.ASM	75. 135*
frag3	A	SSTV.ASM	79. 147*
frag4	A	SSTV.ASM	83. 159*
frag5	A	SSTV.ASM	87. 171*
frag6	A	SSTV.ASM	91. 183*
frag7	A	SSTV.ASM	95. 195*
frag8	A	SSTV.ASM	99. 207*
frag9	A	SSTV.ASM	103. 219*
main	A	SSTV.ASM	45. 47* 49.
reset	A	SSTV.ASM	47. 52*

Label Types
A Address
V Variable

* label defined on this line
Program Memory Words Used: 202
Program Memory Words Free: 822
Errors: 0

Table 1. MPASM Cross Reference File.

SLOW SCAN TV DECODER PARTS LIST

RESISTORS		
220Ω	1	(F220R)
330Ω	1	(F330R)
3K3	1	(M3K3)
5k6	3	(M5K6)
68k	1	(F68K)
100k Potentiometer	1	(VH06G)
CAPACITORS		
33pF Ceramic	2	(WX50E)
1nF Ceramic	3	(RA39N)
33nF Ceramic	2	(RA46A)
10µF Electrolytic	2	(YY34M)
SEMICONDUCTORS		
1N4148 Diode	1	(QL80B)
PIC16C84 Microcontroller	1	(AY31J)
4MHz Crystal	1	(FY82D)
78L05 Voltage Regulator	1	(QL26D)
27L2 Low Power Dual Op-amp (for filter)	1	(AX54J)
MISCELLANEOUS		
9-pole D-type Socket Connector	1	(FG25C)
OPTIONAL		
LED and appropriate current limiting resistor	1	

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

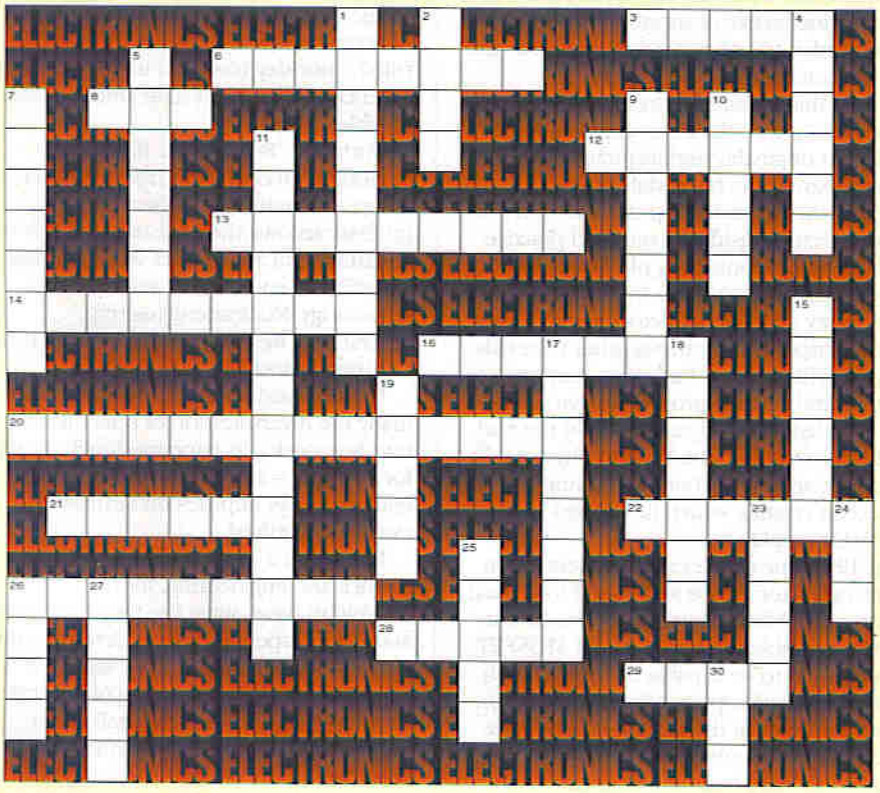
Note: It is worthwhile using close tolerance 1% components for the filter (5k6, 3k3, 33nF) to ensure the frequency response of the filter. The other components can be normal tolerance.

ELECTRONICS and Beyond

£25 CROSSWORD COMPETITION

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

CROSSWORD No. 4 — July 1997



Name

Address

Postcode

Daytime telephone number

No purchase necessary. Entries on a postcard, back of a sealed-down envelope or photocopies will be accepted.

We are giving away a cash prize of £25 to the first correct entry received by 20th June 1997. Send it to us at the following address:

Magazine Crossword 2, Maplin House, PO Box 777, Rayleigh, Essex SS6 8LU.
All employees of Maplin Electronics are excluded from entering.

CROSSWORD No. 2 *Solution* — May 1997

Unfortunately nobody got all the answers - so no winners this time.

ACROSS

3. 01702-554000 What's this Maplin phone number for ?

6. This type of memory goes with the power, switch off all is lost !

8. 01702-554001 What's this Maplin phone number for ?

12, 13 & 26. Plug in and strum , turn up the volume. With the LT80B no one else will hear a thing, but what is it ?

14. Signal that stops a process to carry out another, then reverts back to original process. Don't while I'm talking.

16. Digital code that represents a memory location of data or instruction. Part of Postal code.

20. The name of the orbit satellites use above the earth.

21. The name given to the style and arrangement of data.

22. Term to describe the simultaneous communications on two frequencies using a common aerial system. Is Di perplexed ?

28. Order code for the 220mfd / 16v Axial capacitor.

29. Orders received before 5 pm are dispatched the —— day.

DOWN

1 & 11 Arthur C Clarke proposed this form of communication in 1945, a real high flyer.

2. Name given to a device that excepts current from another. Found in the kitchen perhaps.

4. Name given to a device that supplies current to another. Cheeky person has plenty of this.

5. Operation code that a microprocessor recognises. Used for sewing.

7. Type of microphone or to describe force of personality.

9. The centre of the atom.

10. If it makes a sound, flash ! Now you've got a photograph, what's the order code for this kit ?

15. Term to describe the switching on of a chip or device. To provide the means to do something.

17. A very common passive component.

18 & 26. The initial signals required between a modem and the data terminal equipment. Friends do it too.

19. This is used to connect digital equipment to analogue telephone lines to transfer data.

23. If you have no animals it doesn't matter. Buy this kit and you can hear them.

24. Abbreviation used for the Exclusive Or logic operation. X marks the spot !

25. Use this order code for mains power from your car battery.

27. Abbreviation of the most common digital code used for alpha numeric characters .

30. We used to write Mc/s, now its like renting a car.

WHAT'S IN A NAME

PART 5

Wiggling it Right

by Greg Grant

In 1922, much of the world listened to the ever-increasing number of radio stations via a Crystal Set. This equipment consisted of a tuned circuit attached to an antenna along with a metal-to-mineral connection which made one-way current flow possible, thus reproducing the audio content of the broadcast.

In other words, a spring-loaded metal contact termed a 'Cat's Whisker' was pressed against a sliver of crystalline mineral, usually either galena, silicon or silicon carbide. Silicon, it was noted, was the most stable of the three. Getting the best results meant applying the right pressure to the right spot or – putting it another way – wiggling it right.

Almost exactly twenty-five years later, a Bell Laboratories research physicist called Walter Brattain and his colleague, John Bardeen, discovered that, in Brattain's words, 'wiggling it just right' produced a semiconductor audio amplifier with a gain approaching 100. The Point-Contact Transistor was born.

So, what had happened in the quarter of a century that separated the two wigglings? To answer that question, is to trace the rise of solid-state physics from their beginning as an esoteric research area to their present position at the centre of the electronics industry.

The 'Cat's Whisker', of course, was by far the weakest part of the early broadcast receivers. Consequently, when the valve rectifier and other improvements came along, interest in crystals waned. Yet, some interesting work on understanding the phenomenon of semiconductors had already been carried out.

The British physicist, A. H. Wilson, had, by the early years of the present century, fully investigated semiconductors using the band theory to understand how conduction within them took place. It was Wilson, for example, who introduced the Donor and Acceptor states of semiconductor material, after it had been 'doped' with a carefully measured amount of impurity. In fact, his names for such classes of material were Defect and Excess types. They were designated N-type and P-type as recently as 1941, by another Bell Laboratories physicist, J. H. Scaff.

By 1917, J. Czochralski had developed a Pulling Process for producing single-crystal silicon material. Twelve years later, the Hungarian-British physicist, Sir Rudolf Peierls, found that current could be carried by positive charge carriers. Today, of course, these current carriers are termed Holes. At this time, germanium point-contact rectifiers were still used, and since valve and copper oxide-selenium rectifiers were proving ineffective at shorter wavelengths, it was decided to use purer germanium in the point-contact devices.

To do this required more than simply a lone physicist or electronics engineer with sufficient originality and inspiration. Consequently, the multi-skilled team became the normal research pattern in this field, a trend considered standard practice today. Groups containing physicists, metallurgists and chemists began looking into the theory of semiconductors anew, as well as the properties of various other materials.

Meanwhile, others had taken matters further and actually proposed devices based on knowledge already available. In the mid-1920s for example, the Russian physicist, O. V. Lossev, apparently built amplifying devices based on crystals, which he termed 'detector amplifiers.'

In 1930, one of the earliest patents for a semiconductor device was issued to Leipzig University's Julius Lilienfeld, whose device, which resembled the present-day MOSFET, was claimed to be capable of amplification in a thin film of copper sulphide. However, since the holes in the material would have had a very low mobility, it's doubtful if the gain would have been much greater than that of an emitter follower. However, this, coupled with the probability that a working device was never produced, didn't stop Lilienfeld applying for American patents also!

Five years later, Patent Number 439,457 became the earliest British recognition of a semiconductor device. It was granted to the German research engineer, Oskar Heil, for what he described as 'improvements in or relating to Electrical Amplifiers and Other Control Arrangements and Devices.' Figure 1 – which is taken from the original patent application – shows a device whose nearest modern equivalent is the Insulated Gate Field Effect Transistor, or IGFET.

Region three is a thin layer of semiconductor material such as vanadium pentoxide, iodine or cuprous oxide, and

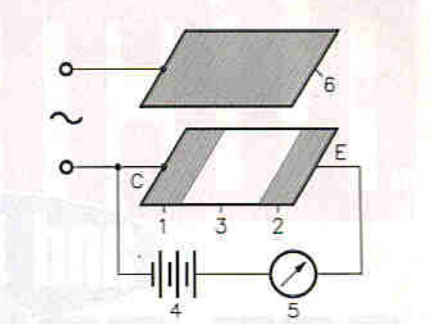


Figure 1. Oskar Heil's early Field Effect transistor device.

regions one and two are ohmic contacts. Region six is a thin metallic layer adjacent to, yet insulated from, the semiconductor layer. It is, in fact, the control electrode. If a signal is applied to this control electrode, it will modulate the resistance of the semiconductor layer and an amplified version of the input can be monitored by the meter, designated five.

In 1940, two Bell Laboratory research physicists, Walter Brattain and William Shockley, attempted to make what we, today, would term a Schottky Gate Field Effect transistor amplifier. Although they failed, Shockley observed in his laboratory notebook that a solid-state amplifier was feasible.

World War Two was the first truly technological conflict in history. In fact, a surprising number of industries and professions owe their existence to this most devastating of all conflicts. Among these are Materials Science, Space and Satellite technology, Nuclear engineering, Operational Research and, above all, Radar, Computers and Semiconductors.

The downside of this, of course, was firstly the diversification of scientific effort into war work – as happened to Shockley, for example – and secondly, the secrecy conflict always imposes on virtually everyone involved.

This last is a concept totally alien to science and engineering, for both disciplines have, since the times of Newton and Watt, respectively, been determinedly international in almost every way, and especially so in the exchange of information.

The conflict, however, curtailed the interchange of scientific information considerably and so, very probably, a fair amount of research duplication took place. It's known, for example, that both the Americans and the Germans improved silicon purity considerably, such that by 1944 or thereabouts, p- or n-type silicon could virtually be made to order. In fact, H. C. Theuerer and J. H. Scaff at Bell Laboratories produced one slab of silicon which was n-type at one end and p-type at the other.

Bell, of course, were not the only research organisation working in this area. In 1942, Purdue University's Karl Lark-Horovich led a multi-disciplined team investigating the possibility of using germanium as a radar detector. The group looked into the material's electrical properties and the possibility of creating it in a purer form, as well as manufacturing detectors from it. In the end, however, it was the Bell Laboratory team that triumphed. Why?

Largely because of a number of small factors which, taken together, added up to a significant whole. For starters, the Purdue team returned to their pre-war research projects at the end of hostilities and secondly, there was still only a limited understanding of the importance of impurities in crystals. Finally – and crucially – Bell Laboratories set out, in July 1945, to deliberately investigate the whole area of semiconductor materials. The result of this, they hoped, would be improved communications engineering components.

The rest is history, epitomised by Figure 2, which is taken from the famous photograph, the whole culminating in 1956 with the award of the Nobel Prize in Physics to Shockley, Bardeen and Brattain. But how was the name 'Transistor' arrived at?

After all, the device could equally well have been termed the BSB Amplifier after its discoverers, for example, or the Labbel Amplifier, as a sort of tribute to the organisation that underwrote the development programme. Instead, the somewhat mundane 'Transistor.' Why?

Actually, the name is based on how the original device worked. Two contacts, surprisingly like those of the Cat's Whisker, were connected to a small piece of germanium. With a small positive voltage applied to one contact, the current flow in the other contact increased substantially. In fact, the second contact's resistance depended on the current flowing in the first one. In short, the resistance was transferable, this phenomenon resulting in an amplification of around 40 or so.

It was at this time that another distinguished Bell engineer, John Pierce, asked the solid-state team how things were coming along. They replied that a development announcement was expected shortly, despite the fact that they had no name for their discovery.

Pierce replied that if his understanding of what they'd been up to was correct, they'd been attempting to transfer current across a resistance. Couldn't they, therefore, concoct something from the words Transfer and Resistance? It was as simple as that.

Today, the acronym Transistor is known worldwide. As well known as the Cat's Whisker, in fact!

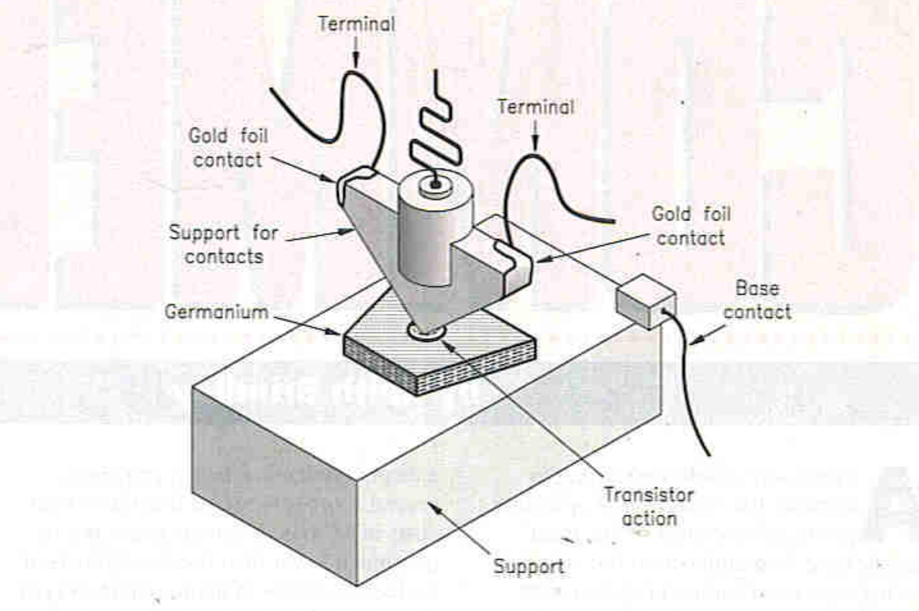
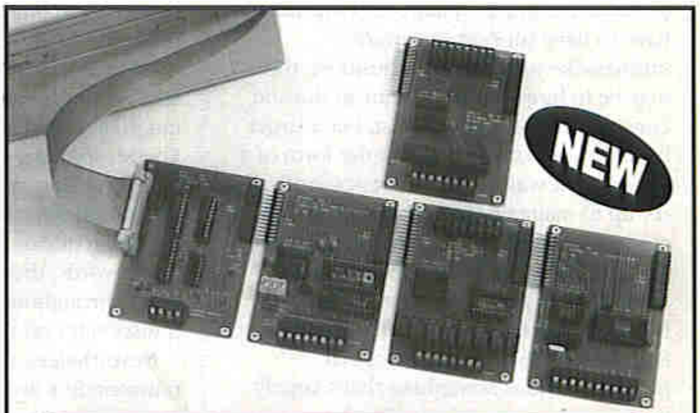


Figure 2. The world's first transistor.



COMMENT

by Keith Brindley

At long last, people are starting to consider the total costs of operating personal computers. While most people have long understood the cost of having a personal computer is the actual cost of buying it, it's finally coming to light that this is purely the first cost in a long line of costs incurred by the user over the lifetime of the computer.

Put into perspective, this means that users should be aware that the cheapest personal computer to buy may not be (and in many cases, simply isn't) the cheapest personal computer to have. PCs are renowned for problems, and the problems often require specialist (read expensive) help to put right. Where a lone user may have to grapple with the problems alone (often involving only the user's own time), personal computer systems in a business have to have support in a more businesslike way. For small business, this may be in hiring support from an outside consultant or repair specialist. For a larger business, this often comes in the form of a department within the business specifically set up to maintain the computers. Other costs associated with computer ownership are administrational, and under-usage.

In terms of true cost of ownership of a PC, this all adds up to a significantly higher figure than the cost of the original purchase. This is something that's largely been ignored (or swept under the carpet) in the past, but the Network Computer dreams of Oracle's Larry Elison should open the debate up a little. The whole idea of the Network Computer (NC), after all, is to lower total ownership costs. The NC concept is based on a distributed processing principle, in which individual NCs have very little power themselves (at least, in modern-day personal computing terms). Instead, they are wired together in a network and access the programs and power they need from a central server. The common name which has arisen for NCs is thin client, which helps to differentiate them from the more traditional fat client type of personal computer in current usage.

To date, thin clients are assumed to be less expensive to maintain than fat clients, because they are, after all, much simpler in hardware and software terms. However, at a recent conference in San Francisco, several sources reported that the overall costs of NC-based systems might not be that much lower than the overall costs of PC-based systems. A figure of just £30 per device was the lowest margin reported.

What it all boils down to is that nobody yet knows what the final costs will be.

On the Up

Satellite television systems go from strength to strength. There are now, apparently, some 6 million homes in the UK wired for satellite television. That's around one in four houses. Some 720,000 new systems were installed last year alone, and the rate appears to be increasing steadily, with nearly 2·5 million people expecting to buy a satellite dish or to subscribe to the services with cable this year.

Of course, one of the main reasons for subscribing to satellite channels is the wide range of channels available. A total of 56 English-speaking channels are available at the time of writing, with more to come online shortly. Admittedly, some of the channels are co-broadcast at a single frequency (in other words, they are broadcast at selected times throughout the day, from a single transponder on the satellite).

Nevertheless, there are still 32 different transponders involved, so however you cut it, there's quite a choice – with 32 channels of diverse programming at any one time.

Many of these program schedules are controlled by British Sky Broadcasting (BSkyB). Indeed, BskyB was really the first large broadcaster to enter the satellite television fray, but of course, it's not the last. Other broadcasters are looking to increase their presence in satellite television. Relative newcomer, FlexTech, is looking increasingly likely to become a major force in satellite television broadcasting, and already owns outright channels such as Bravo, TCC, Trouble, UK Living, and has stakes in many others. Further channels are planned under the Flextech banner with the BBC.

Much rides on the introduction planned at the end of the year for digital broadcasts on the Astra satellites (the satellites that carry the BSkyB and Flextech channels). Up to 200 channels could be broadcast by the satellites then, and channels are apparently queuing up to be included.

Some might say that having so much choice is not a good thing. Proponents against multi-channel television argue that the good television programming is spread so thin that you can still never guarantee being able to watch a program that interests you at any particular time. Maybe, maybe not. For every proponent against, there is a proponent for multi-channel choice.

Whatever. Satellite television is here, and here to stay. While it's been creeping up on the nation so far over the last ten years, a density of one in four homes means that it is about to reach critical mass. Within the next ten years (and probably by the turn of the millennium), the acceptance of digital, multi-channel, satellite programmes will be total.

While all is looking well with the new digital service programmes to date, the main thing of concern currently is the availability of a satellite to do the actual broadcasting. It was planned that Astra 2A would be the satellite to broadcast all the channels from day one of the new services, but that's looking unlikely now, as it's had to shift launch date to October, with operational status only being achieved by December at the earliest. This is a little too late for system suppliers to hit the vital Christmas period, so SES intends to launch one of its lower-powered satellites (Astra 1G) to the new position (28·2° east, instead of the current 19·2° east spot of the existing services) with an August launch date. While broadcast power will be less than that of the newer Astra 2 series of satellites, it will suffice till Astra 2A joins it in operation in December.

Finally, on a more traditional analogue note, viewers who can't yet receive Channel 5 by terrestrial means (and there's quite a few of them by all accounts) can now receive the channel from the current Astra services. Tune into transponder 63 (10·92075GHz, horizontal polarisation, with audio at 7·02 and 7·20MHz, in unencrypted PAL) to receive the station.

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

Surface Mount TECHNOLOGY

Today and Tomorrow

by Ian Davidson

Surface mount technology (SMT) is now firmly established in electronics. It is only necessary to look inside any television or video to reveal a mass of minute components. Cellular phones also use it and have benefitted greatly from the reduction in size which it offers. The small top pocket phones would not be possible without the use of SMT.

Whilst it is still possible to obtain conventional wire-ended components, and this, no doubt, will be possible for many years to come, the surface mount revolution will affect anyone interested in electronics increasingly in the near future. Currently, it is estimated that over 80% of boards manufactured in the UK are surface mount and this proportion is still rising. The benefits of the technology are so large that manufacturers cannot afford to stay with older technologies.

Why Surface Mount?

Surface mount technology arose out of the need to put more automation into the manufacture of electronic equipment. Standard leaded components do not lend themselves to automation. Although many machines exist to automatically insert leaded components into boards, they are far from ideal. Components need to be bent to the required shape or preformed. This needs to be done so that the leads can be inserted into the holes in the boards. Placing these components is not easy and often the leads do not pass through the holes properly because even small inaccuracies can cause failures in the process.

To enable board manufacture to become more successful, people started to look at the requirements for electronic components again. Whilst leads had been essential for components with earlier methods of construction, with printed circuit boards this was no longer the case. It would be possible to place components straight down onto a pad on the board. By removing the need for holes for component leads, the cost of the bare printed circuit boards was reduced. In addition to this, components could be made much smaller and cheaper, and finally, automatic assembly was greatly assisted.

Manufacture with traditional leaded components still occurs, but the advantages of surface mount technology for mass production are so great that virtually all large volume items use this technology. Even where volumes are not as large, the advantages are still great enough to force most manufacturers along this route.

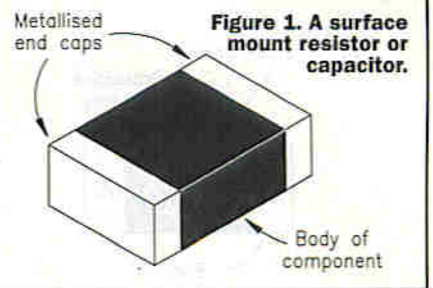
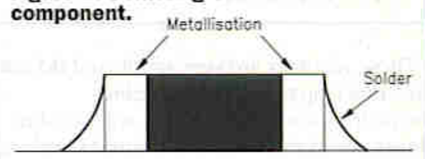


Figure 1. A surface mount resistor or capacitor.

Figure 2. Soldering of a surface mount component.


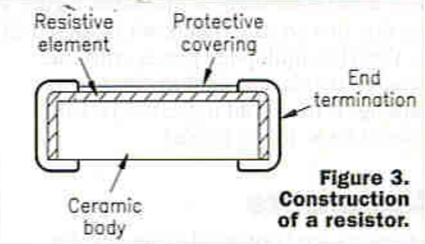


Figure 3. Construction of a resistor.

Resistors and Capacitors

Passive devices like capacitors and resistors are the most straightforward components to describe. They simply consist of a rectangular box, as shown in Figure 1. Instead of having leads at either end, there are areas of metallisation which act as the contact when they are placed onto the board. Solder from the pads on the board flows around the metallisation, and also up the side, as shown in Figure 2.

The resistors are constructed using thick film technology. A ceramic base is used and a resistive paste is placed onto this, as shown in Figure 3. This layer is then covered by a protective glass layer. Finally, the end caps are added to enable contact to be made to the resistive elements.


Comparison of package sizes (photo: left 0805, middle 0603, right 0402).


A selection of SOT23 diodes.

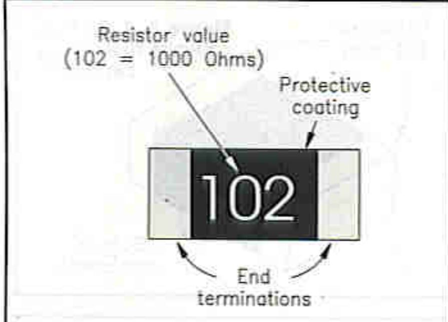


Figure 4. Resistor marking.

These resistors are very small, and do not have much space for any markings. Fortunately, some are marked with a value. This is not in the form of coloured bands in the case of normal leaded resistors. Instead, three figures are used, as shown in Figure 4. The first two are the significant figures, and the third is a multiplier, just as with the coloured bands on a leaded resistor. A marking of 10² would indicate a resistor value of 10 × 10² or 1,000Ω.

Capacitors

Capacitors are contained in similar size packages to resistors. Most of the values below about 220nF are multi-layer ceramic capacitors made up as shown in Figure 5. They contain alternate layers of plates separated by a dielectric material, and they are very similar to conventional leaded multi-layer ceramic capacitors, although they are much smaller.

The end cap on capacitors is particularly important. Early varieties used a cap made from silver palladium and this was not at all easy to solder, particularly if the capacitors were old stock and the metallisation had started to oxidise. What made matters even worse was that the silver could be 'leached' out of the end cap if the heat was left on the component for too long. This left the end caps non-conductive and meant the component became useless. Many engineers working on surface mount boards will have encountered this problem when trying to solder the components manually with an iron. Now a nickel barrier is used to help overcome the problem. This has made the end electrode far more resilient, but care still has to be taken not to damage it by applying too much heat.

Sizes and Packaging

Resistors and capacitors come in a variety of sizes. Numbers like 1206, 0805 and the like all describe the sizes. The first two figures in the number indicate the length of the package in hundredths of an inch and the last two give the width. The 1206 package (3·2 × 1·6mm) was the most common style in the early 1990s, whereas the 0805 package is the most common now. However, manufacturers are now looking to the smaller sizes, and the 0603 is set to become the new standard in a few years time. Eventually, it is expected that the 0402 package will be widely used, and even now, many small products from the Far East use them.

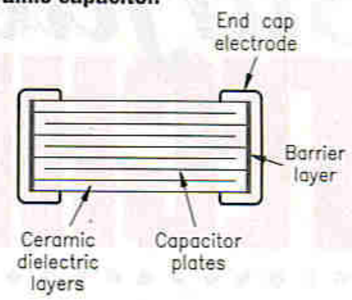
The rate at which technology is moving forwards can be seen by the changes in package size. The 1206 was one of the first standards, and it reached its peak usage in the late 1980s. Next came the 0805 package. This reached a maximum usage around 1993, and is giving way to 0603 and 0402 varieties. The percentage of 0603 components which are being used is much greater than the smaller 0402s. The trends for resistors and capacitors follow very similar lines, only varying by a few percent in terms of their market shares.

There are a number of reasons for the slower take up of 0402 components. One is that the availability of the 0402 parts is less, especially in Europe. Also, the advantages in terms of space saving are not as significant as might be expected. They are just as dependent upon PCB technology and the track sizes.

Even though there is a space saving of around 20% by using 0402 in comparison to 0603, tracks still need to be run on the board, and there are other restraints which reduce the overall saving to less than this figure. The actual saving is difficult to quantify as it is dependent upon each individual board and the percentage of the smaller components which can be used.

A further reason for the slower take up of the smaller components is that ranges are limited. This is not so critical for resistors, although power dissipation may be reduced. However, for capacitors, it causes major limitations to the capacitance which can be contained within the package. For values of 100nF which are commonly used for decoupling, working voltages of 6·3V appear to be about the maximum available at the moment.

Figure 5. Multi-layer ceramic capacitor.



To address this problem, capacitor manufacturers are developing new dielectrics for their components. The COG dielectric is still preferred in many instances, because it performs well at radio frequencies and is stable. For higher values, X7R and now Y5V are becoming far more common. These are considerably less stable and are certainly not suitable for filter or oscillator applications.

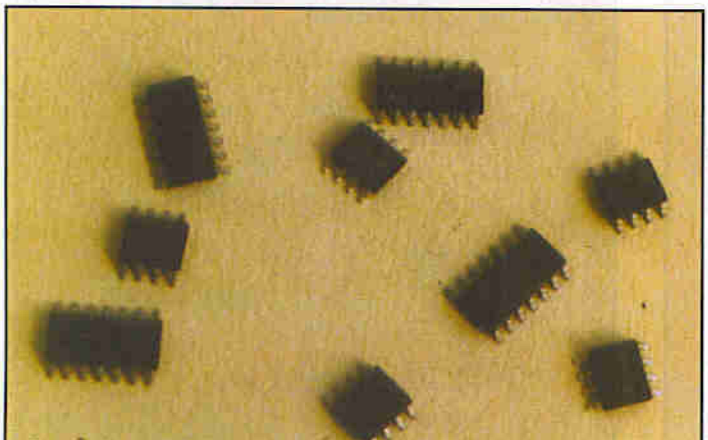
No Electrolytics

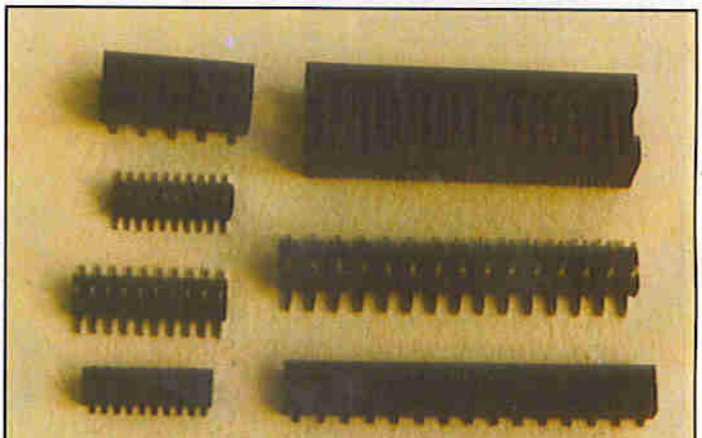
Electrolytic capacitors are not available for surface mounting – the temperatures the components have to endure during solder damages them. If they are required, then they have to be fitted manually later, and as a result, they are conventional leaded parts.

For high value surface mount parts, tantalum is generally used. These are naturally very popular and at the moment, there is a shortage, bringing with it an increase in price and some very long delivery times. To overcome this problem, some component manufacturers are offering high value ceramic capacitors. With values of several microfarads, these seem an attractive alternative to tantalum. At the moment, they are still a little more expensive than tantalum, but as their production increases and manufacturing methods are refined, they are likely to become much cheaper.

Inductors

Small wound inductors are widely used in many RF products, including cellular phones. Chip sizes of 1812, 1206, and 1008 are popular, but like all other components, they are shrinking as well, and some


A selection of ICs.


A selection of surface mount connectors.

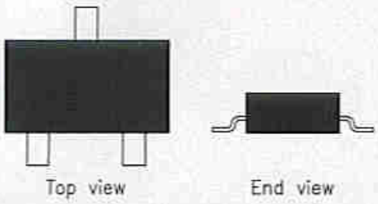


Figure 6. Transistor and diode SOT32-style package.

Figure 7. Gull wing leads on an IC package.

inductors are available in 0805 packages. Here too, there are physical limitations to the size reduction because the wires still have to be wound on a former. However, values up to several microhenries are available in the 1206 package, although the maximum values in the smaller packages are naturally more limited.

Transistors and Diodes

Semiconductors have also been affected by the revolution. New packages have appeared for transistors and diodes, and like their passive counterparts they are much smaller then there conventional predecessors. One of the most popular packages is the SOT23. This is possibly the equivalent of the TO18 can used for many leaded general-purpose low power devices. Instead of having metallised areas on the side, this package like most other semiconductor packages has small wires like those shown in Figure 6. These leave the package and are bent so that they sit on the pads on the board.

Diodes also use this package. As they only need two connections, one is left disconnected, but serves to indicate the orientation of the package.

These devices are so small that their full part numbers cannot be marked on them. Instead, a short code is usually added. This is normally defined in the manufacturer's data sheet.

The SOT23 package is, by no means, the only one in use. It is now well established and as might be expected, smaller ones are beginning to hit the market. Another style which is becoming more popular is the SOT223. This has the advantage that it can handle extra power, and as a result, many devices are adopting this package.

Integrated Circuits

Integrated circuit packages have shrunk in line with all the other components. There are two major styles of package which are characterised by the type of leads they have.

The first is the gull wing lead, which is shown in Figure 7. It can be seen that these leads are very similar to those used on the transistor package, and the name is derived from the similarity to the wing of a gull. This is the most common form of connection, and all the common digital ICs are available in packages with this type of lead.

The most common package, replacing the familiar DIL package is called the SO or small outline. Like the DIL package, there are a number of varieties, depending upon the number of leads required. As the package itself is smaller, the spacing between the leads is also reduced. Instead of the standard 0·1in. used for DIL packages, the spacing for SO chips is only 0·05in.

Not all chips can be contained within SO packages. Modern microprocessors give one common example. Some chips require in excess of a hundred leads, and it is clearly unacceptable to extend the SO package to accommodate all these pins. Instead, a package called a quad flat pack like that shown in Figure 8 is used. Here, a square package is used, and leads taken out from all sides. To reduce the area taken up by the chip, the pin spacing is also reduced, and spacings of 0·02in. are quite common. As may be imagined, these chips need very careful handling. It is very easy to bend the fragile pins and once bent, it is impossible to return them exactly to their original state. Even small inaccuracies will mean that they will not mate up with the pads on the board properly, causing short circuits as the pins straddle two pads.

The other style of connection is known as a 'J' lead for obvious reasons, as shown in Figure 9. For most applications, manufacturers prefer the gull wing lead because it is easier to solder, the joints are more visible so that any defects can be seen, and finally, it is easier to rework if there are any problems. The J lead package does have a number of advantages. As the leads are bent around under the device, it takes up less board area, and this can be particularly important when space is at a premium. Another advantage is that J lead devices can be socketed. This is very useful for EPROMs which may need to be changed, particularly in a development environment where software may be changing all the time.

In the field of integrated circuits, the number of connections being made to some chips is rising. As the quad flat pack is very vulnerable to damage, new ideas are springing up. The one which is starting to arrive on the market is called the ball grid array or BGA. Instead of having leads at the side of the package, the BGA has a matrix of connections in the form of solder balls on the underside of the chip, as shown in Figure 10. When the chip is placed onto a board and undergoes infrared reflow, the solder balls melt and solder it to the board. The advantage is that the solder balls are very robust and because the whole of the underside of the package is used, the spacing between connections can be increased, reducing the possibility of solder splashes and short circuits.

Even though some components are seeking to have more connections, others are moving the other way. Operational amplifiers are often needed in analogue circuits. Whilst it is possible for two or even four to be mounted in a single package, this is not always desirable. It may be that the circuit performance is degraded by having several sections too close to one another, or it may be that additional tracks have to be routed across the board. As a result, some operational amplifiers in packages the same size as transistors and diodes are becoming popular. These packages, called the SOT23-5 (a five leaded SOT23 package), are very small and are very convenient for dropping into the smallest corner of a board. In view of their growing popularity, more will be seen on the market.

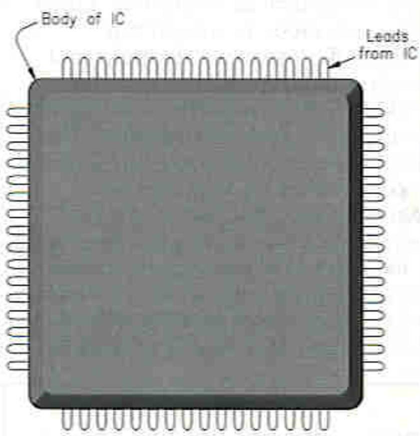


Figure 8. A quad flat pack.

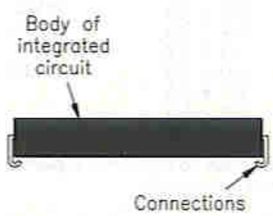


Figure 9. A J-leaded IC.

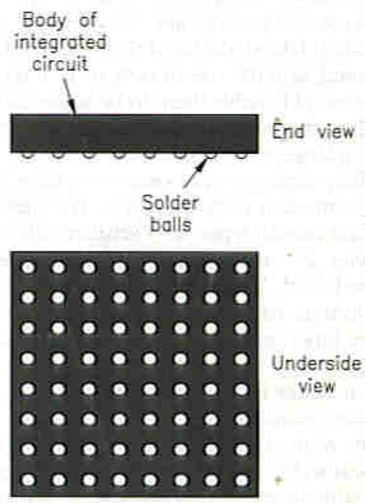


Figure 10. A ball grid array.

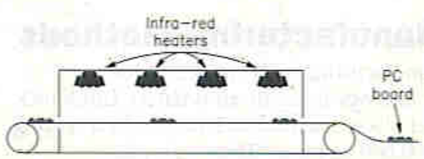
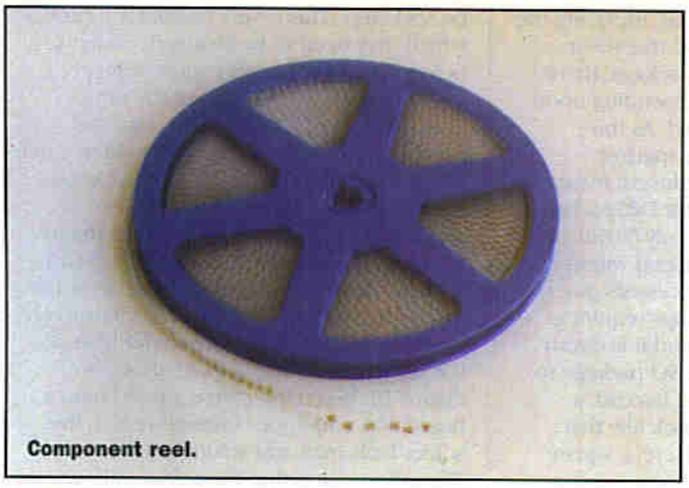
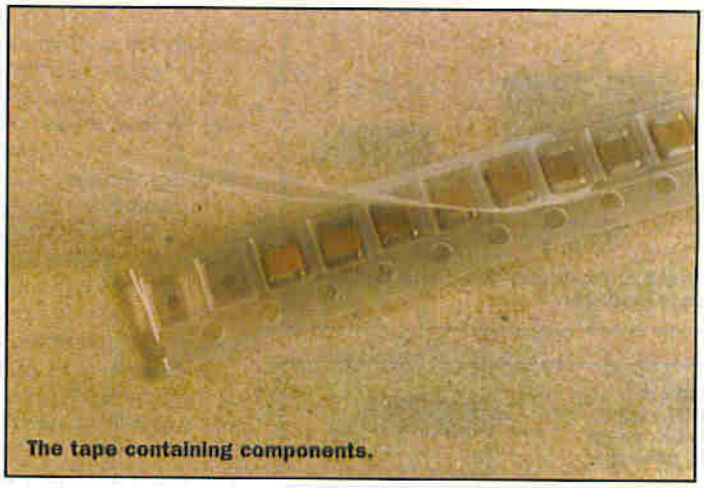


Figure 11. Infra-red solder machine.



Component reel.



The tape containing components.

Other Components

One of the main requirements these days in the manufacture of electronic equipment is to ensure that as many components as possible are surface mount varieties. By ensuring there are as few leaded devices as possible, the amount of hand insertion is kept to a minimum and costs are reduced. Whilst not all the more unusual ones are available in this format, it is surprising what is.

The major thrust for the conversion to surface mount obviously comes from the large manufacturers. Consumer products like televisions, video recorders, cellular telephones and the like are produced in vast quantities. Manufacturers use many thousands of particular components every week, and they have an enormous sway with suppliers. With these sorts of pressures, many components, including crystals, batteries, ceramic filters and a host of other components are available.

Many new types of connector are being launched. These promise great savings in space as well as enabling manufacturing methods to be improved. Often, some of the large connectors like the industry standard DIN41612 need to be soldered in by hand, and the use of new surface mount types would enable them to be soldered with all the other surface mount components, saving large amounts of time and cost.

Many conventional connectors take up large amounts of board space. The new surface mount types are considerably smaller, giving the possibility of saving even more board space, and allowing the equipment to be made even smaller, or for more functionality to be placed in the same space. These advantages mean that considerably more surface mount connectors will be seen in the coming years. At the moment, the market does not appear to have firmly stabilised on styles to the same degree that the conventional types have. This is only a matter of time in view of the enormous usage which is envisaged, and the natural requirement to have second sources to ensure supply is maintained.

Manufacturing Methods

Manufacturing with surface mount technology is highly automated. Large pick and place machines are used, often costing £500,000 or more. These can place components at a rate of many hundreds an hour, and with today's complicated circuitry, there is no other way of placing components onto boards. Manual placement would take days for each board, and the person doing the job would soon get eye strain.

Pick and place machines are also having to cope with the trend to smaller components. Vastly reduced tolerances in component placement mean that optical methods have to be incorporated into the machines to ensure that the components are in exactly the correct position. Errors of only a few thou can result in very costly rework. As a result of the very tight tolerances, costs of the machines have risen.

The components themselves generally come on reels, as shown above. These tapes come in standard sizes of 8, 16mm, etc., depending upon the size of the component. This tape can either be plastic or card and has sprocket holes to enable it to be advanced by the correct amount each time. The components are contained within cutouts in the tape. To prevent the components falling out, there is a thin retaining tape attached over the top as shown. In the machine, the top layer is peeled back and the tape advanced to expose a new component each time one is used.

The reels used can contain large numbers of components. Resistors and capacitors often come in reels of three thousand whilst some other components are supplied in reels of a thousand. This can represent a considerable investment if the components are at all expensive.

Although the 1206, 0805 and 0603 components come in reels, the 0402 styles are too small to be packaged in this way. Instead, they come in a small box which is loaded onto a feeder, enabling them to be orientated and fed to the head ready for placement. This is one further complication which is holding some manufacturers from using the 0402 style.

Often, ICs come in reels, but in many cases, they may come in tubes. These are mounted onto the machine in what is called a 'ski' slope. The tube is angled so that the chips run down the tube and can be picked up as required. The disadvantage of this method is that the tubes hold comparatively few chips and need reloading relatively frequently.

Once all the components have been placed onto the board, the next stage is for them to be soldered. The most popular method nowadays is called infra-red reflow. Here, the pads on the boards are coated with a thin layer of solder paste, prior to having the components added. The loaded boards are then heated with a series of infra-red heaters, as shown in Figure 11, to steadily bring them up to a temperature where the solder paste melts and solders the components to the board. These machines have a number of separately controlled heaters so that the correct heat profile can be generated for each type of board. This ensures that each type of board is soldered correctly.

Power Dissipation	Type	Typicala Size (mm)
0402	1·0 × 0·5	0·625
0603	1·6 × 0·8	0·625
0805	2·0 × 1·25	0·100
1008	2·5 × 2·0	
1206	3·2 × 1·6	0·125
1210	3·2 × 2·5	0·425
1812	4·5 × 3·2	
2010	5·0 × 2·5	0·500
2220	5·7 × 5·0	
2225	5·7 × 6·3	
2512	6·3 × 3·1	1·000

Packages for which no dissipation is given are not normally used for resistors.

Standard outlines for SMD capacitors and resistors.

For the Future

The field of surface mount technology is far from stationary. Ever higher component densities are being required by manufacturers to make items like cellular phones and camcorders smaller or to pack more functionality into them. As a result, smaller components and higher connection densities are needed. The 0805 passive components are giving way to 0603 sizes, and in the near future, more people will start to use 0402. Further moves beyond this are not anticipated in the foreseeable future because the returns of progressing to even smaller components are less. Nevertheless, as other technologies including PCBs improve the trend for smaller and more complicated circuitry, miniaturisation is bound to continue. In the meantime, the number of surface mount boards will increase and the use of conventional components will gradually die away. This may not appear to be good news for the home constructor, but leaded components will be around for many years to come, and there is no reason why some projects using surface mount components cannot be undertaken at home.

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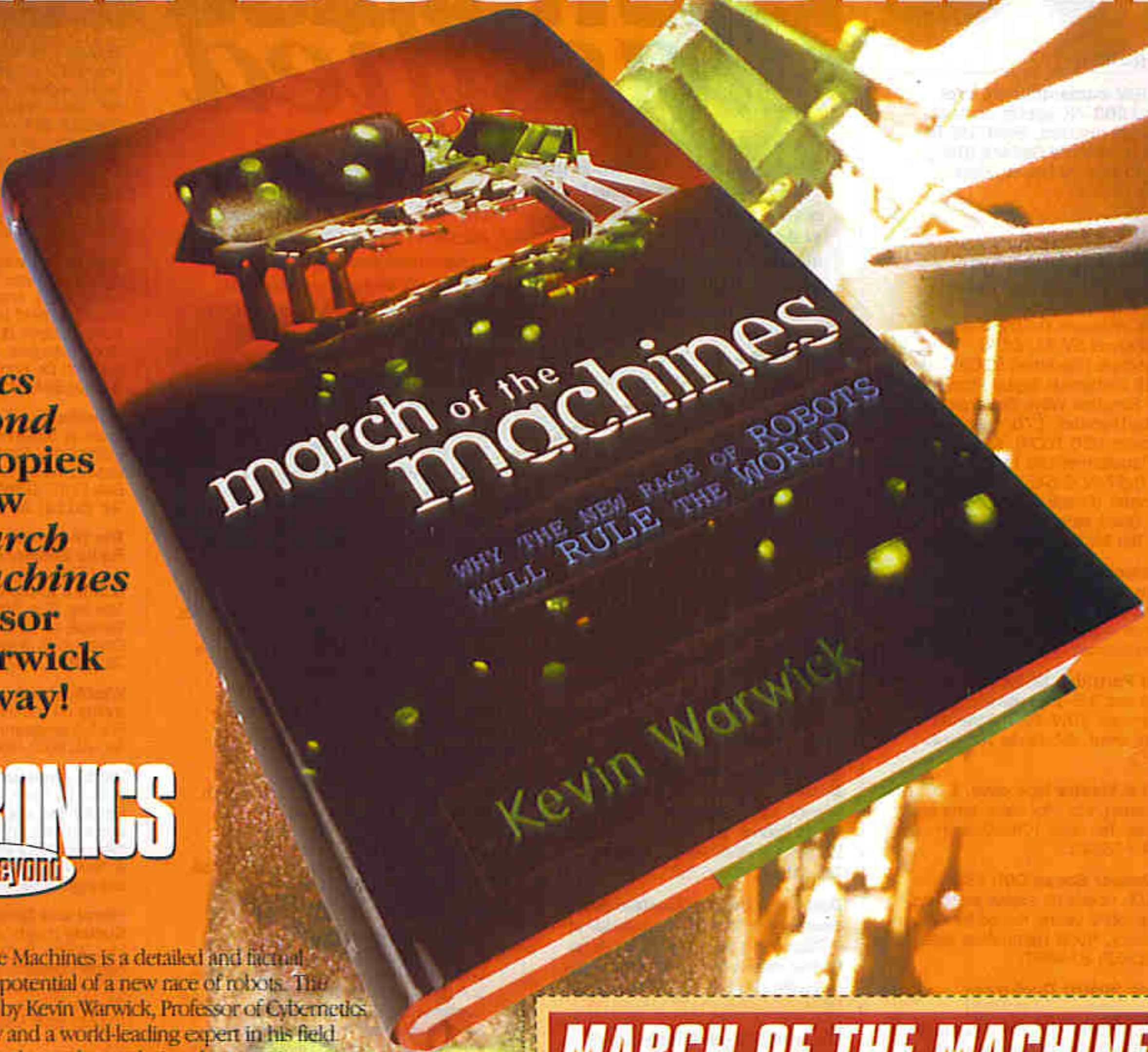

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To date, society has tried to change the boundaries of what is considered to be intelligence, to maintain humans' status as being one step ahead. Years ago, the ability to multiply large numbers, for example, was seen as being an intelligent act. Now it isn't. Industrial robots are already executing tasks that until recently, only human beings were capable of. Mankind is in danger of being taken over by its own inventions, by robots that are getting more powerful and advanced each year. Soon, robots will be faster, more reliable, quicker to learn and more robust than humans.

In his intriguing book, Kevin Warwick not only reveals the breathtaking story of one of this century's most important scientific developments, but also analyses the huge impact economically, socially and morally that robots will have. Can we control the future or will it control us?

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Club Corner

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Making Spots, Seeing Waves
DEVELOPMENT OF THE ELECTRON MICROSCOPE

by Greg Grant

Seventy years ago, an experiment which, in the course of its progress, went horribly wrong later confirmed that electrons had a wave nature. This would lead to the development of what has been termed one of the most important instruments of the present century – the Electron Microscope.

In 1878, the science of microscopy received a rude shock. The microscope, basic instrument of the profession since the seventeenth century, had a finite limit to its abilities, one determined by the wavelength of light itself. More disturbingly still, this awkward fact was pointed out by no less a luminary than the Research Director of the Zeiss Optical Company, Ernst Abbé.

A brilliant scientist, Abbé had been Professor of Physics at the University of Jena at 23 and Director of its Astronomical and Meteorological Observatory seven years later. His practical and theoretical abilities with optics led to very considerable advances in microscope design as well as a better understanding of optical magnification. He was also the inventor of the Abbé Condenser and the Apochromatic lens system, which eliminated primary and secondary distortion of light.

As Abbé pointed out, the sharpness with which small objects can be observed varies inversely with the wavelength of the viewing medium. The shorter this is, the smaller the objects that can be seen. Light wavelengths are around 0·0004 to 0·0007mm, which means that nothing smaller than that will show up clearly. In other words, light waves are big enough to 'hop over' anything smaller than themselves.

At this time, cathode rays, recently named as such by another German physicist, Eugen Goldstein, were beginning to occupy scientific minds across Europe. As the century drew to a close, the British physicist, J. J. Thompson, discovered the electron, demonstrating that this particle had mass and was sub-atomic in nature. It was probably, he concluded, the basic unit of electricity and so also, come to that, the principle constituent of cathode rays. Herein lay another shock, one that would lead to a solution for the microscope's problems.

The Double Puzzle

The route to the optical microscope's replacement lay in a paradox: that of cathode rays. If the electron – most decidedly a particle – was the fundamental unit of electricity, how could it equally be the basic component of a ray, cathode rays?

This enigma was first tackled in 1927 by the French physicist-historian, Louis de Broglie. He repeated an experiment first carried out in 1801 by the Scottish physicist, Thomas Young, in an attempt to determine the wave motion of light through interference. Young's apparatus is shown in Figure 1.

Louis de Broglie used photons, or light packets, in his experiment and found that even when one photon at a time traverses the apparatus, the same interference pattern builds up in a speckled fashion. In other words, they interfered with each other as if they were waves.

Almost simultaneously, half a world away at the Bell Laboratories, Clinton Davisson and his graduate student, Lester Germer, were studying the scattering of electrons when fired at a single crystal of nickel in a vacuum. After a short time, the vacuum tube blew up, but the pair quickly purged the nickel crystal of oxygen contamination and relocated it in another vacuum tube. Unfortunately, the purging resulted in a change in the surface of the nickel, which now had several large crystals located at intervals along its surface.

When Davisson and Germer resumed their experiment, they found electrons spreading outwards from the nickel in a distinct pattern, which consisted of alternate bands of very high, and very low, numbers of electrons. What was happening was that the crystals were reflecting the electrons in successive streams. Consequently, the electrons were interacting with each other, not unlike ionospherically-reflected radio waves do with accompanying ground waves, resulting in either greatly strengthened, or near-cancelled, signals at the receiver.

The electron interference patterns were similar to those of radio waves, which meant that de Broglie's experiment had been confirmed and electrons were found to show the phenomenon of diffraction and interference. The wave-particle duality, first tentatively suggested in 1913 by the Danish physicist, Neils Bohr, was a reality.

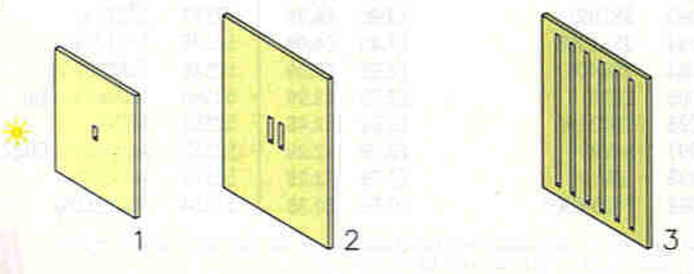
A year before Louis de Broglie's experiment, however, the German physicist, Hans Busch, discovered that a coil carrying a current acts on an electron beam in the same manner as a lens acts on a beam of light. The wavelength of a moving electron, of course, is smaller by many orders of magnitude than the shortest wavelength of light, all of which suggested that what light could no longer see, a properly focused electron beam could.

The Electron Microscope

Like other universally useful devices, for example, the spectroscope, the telescope and the optical microscope, the electron microscope appeared, for much of this century at least, to have no universally acknowledged discoverer.

The German physicist-engineer, Ernst Ruska, had studied electronics at Munich's Technical Institute, from where he transferred to Berlin's Technical University in 1927. It was here, whilst working on Hans Busch's concept of the electron lens, that he realised that if the lens was encapsulated in iron, the focal length could be shortened.

Figure 1. Thomas Young's famous experiment of 1801, which Louis de Broglie repeated.



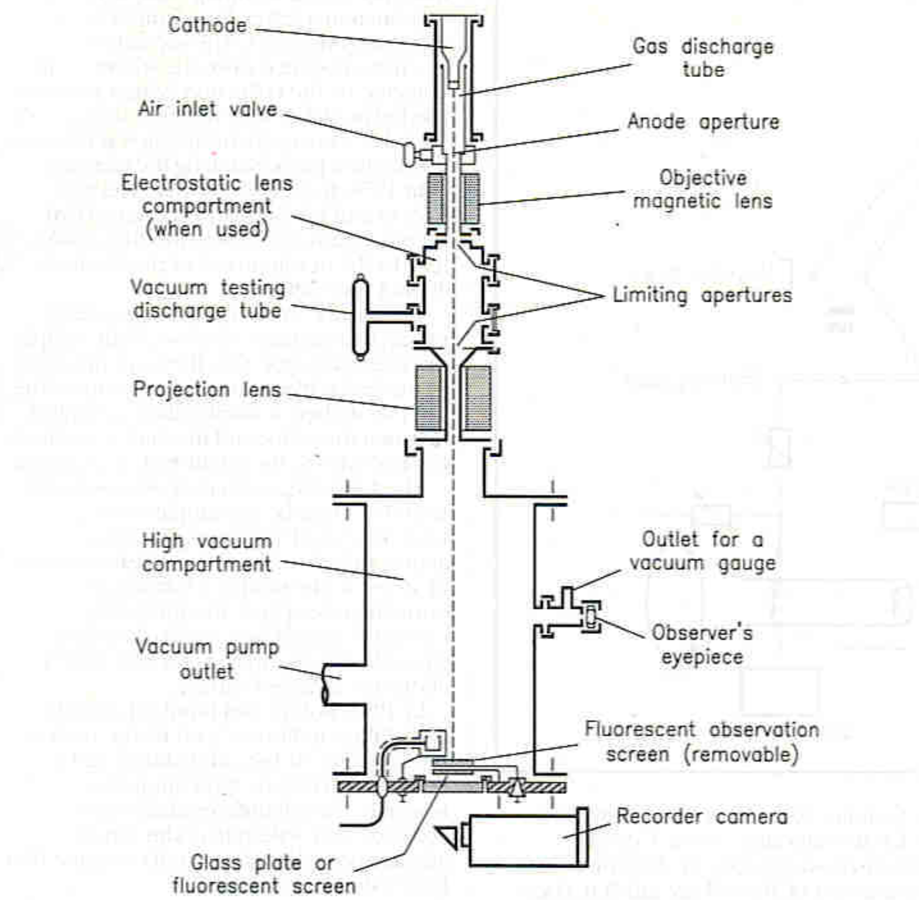


Figure 2. Knoll and Ruska's first two-lens electron microscope.

In the following year, Max Knoll joined the university's staff to direct basic research on cathode ray oscillographs and electron beams. Ruska's area of research was designated as beam focusing.

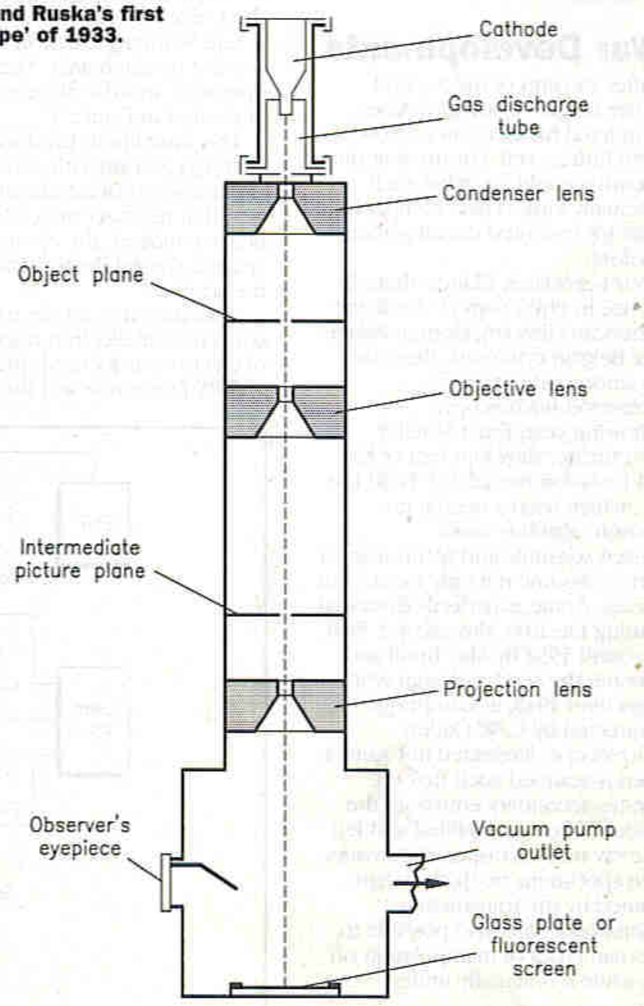
Ruska began by thoroughly examining Hans Busch's theory that an electron lens could do what an optical lens had been doing for so long. He varied the ratio of object-to-image distance, the cathode voltage and the anode-to-screen distance, all of which established that Busch had been on the right track. With Knoll, he extended the focusing coil's encapsulation by adding an inner cylinder, shortening the magnetic field. This meant that less ampere-turns were required for a given focal length.

The pair then turned to examining apertures, experimenting with T-shaped apertures, metal mesh and multiple apertures, all of which demonstrated that magnetic lens abberations could be made far smaller than anybody had hitherto suspected. So, good resolution was possible.

In 1931, Knoll and Ruska built an electron microscope with two magnetic lenses, shown in Figure 2. This could best be described as a first prototype which, although the magnification achieved was hardly exciting, demonstrated that the theory and its practical application were sound.

Although Knoll left the Technical University in 1932, Ruska continued with his work on the electron microscope and in December 1933, he published a paper outlining the first 'Super-microscope,' shown in Figure 3. In this paper, Ruska presented pictures in which magnifications of 8,000 and 12,000 were obtained. Knoll and Ruska had, therefore, developed the electron microscope to a point at which its resolution was greater than that of the optical microscope.

Figure 3. Knoll and Ruska's first 'Super-microscope' of 1933.



On the 31st May 1931, Reinhold Rudenberg, at that time Director of Research at the Siemens Schuckert Werke, filed patents in Germany for the principle of combining several electron lenses, either electrostatic or electromagnetic, to obtain magnification surpassing those obtainable with optical microscopes.

And this at a time when Knoll and Ruska were completing their paper on their first model!

In fact, Rudenberg filed four additional patent applications on electron microscopes over the next nine months which, in tandem with the original one, resulted in the granting of four further foreign patents.

All this, of course, took place *after* Knoll and Ruska had themselves published several papers on their achievements and after a lecture given by Knoll on 4th June 1931. Rudenberg attended, although he took no part in the later discussion, somewhat surprising for someone in his position. Yet so far as is known, Rudenberg did not produce so much as a prototype.

By 1936, the German-American physicist, Erwin Mueller, had developed the Field Emission microscope, which observed a needle tip by using the electrons it emitted as it was heated to create an image on a fluorescent screen.

In the following year, the Canadian-American physicist, James Hillier and his colleague, Albert F. Prebus, improved the electron microscope to the point where it could magnify 7,000 times, compared to the best optical microscope's 2,000 times.

At this time, Ruska and his team had

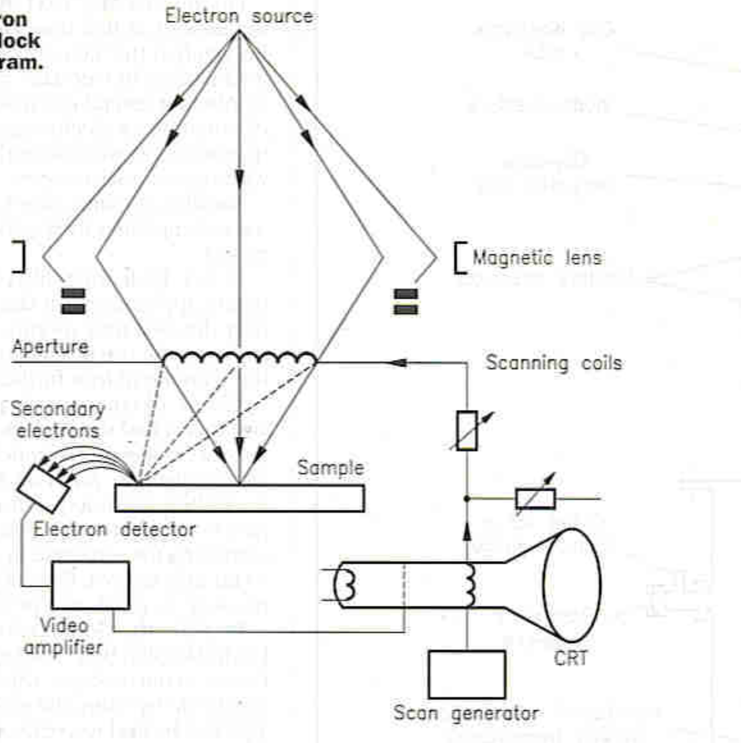


Figure 4. Scanning Electron Microscope – block schematic diagram.

achieved magnifications of up to 30,000 times. In America, Vladimir Zworykin, inventor of the first television camera tube, the Iconoscope, improved upon an earlier electron microscope model.

In three of the future combatant countries, therefore, electron microscopy was well advanced.

Post-War Developments

Five years after the end of the Second World War, the Belgian cytologist, Albert Claude, completed his electron microscope studies of the human cell. For the first time, medical scientists could see what such structures actually looked like, compared to the painstakingly executed drawings that had gone before.

Twenty-four years later, Claude shared the Nobel Prize in Physiology or Medicine with the American clinician, George Palade and another Belgian cytologist, René de Duve, for – among other things – advancing electron microscopy!

In the following year, Ernst Mueller announced a further development of his earlier Field Emission model, the Field Ion Microscope, which used a needle tip cooled almost to absolute zero.

That modern scientific and technological developments consume not only money but also a great deal of time, is perfectly illustrated by the Scanning Electron Microscope. First proposed around 1934 by Max Knoll and M. von Ardenne, the serious design work did not begin until 1948, at Cambridge University, directed by C. W. Oatley.

In this microscope, illustrated in Figure 4, the specimen is scanned such that the beam generates secondary emission, the current produced being amplified and fed to a cathode ray tube to display the image. Not only can specimens be thicker than those examined by the transmission electron microscope, it is also possible to carry out certain types of manipulation on a specimen while it is actually under observation.

This British development was followed by Scanning X-ray Microanalysis in 1960 and, four years later, by the Geoscan instrument, developed by the University's Department of Mineralogy and Petrology.

Throughout this period, the Cambridge Instrument Company were involved in improving the Microscan's resolution, which led to their merging their work with that of the University's Engineering Department, where Scanning Electron Microscopes were a major research area. The result of this co-operation was the Stereoscan Microscope, illustrated in Figure 5.

This instrument produced photographs of rough and smooth surfaces that were nothing short of astonishing, so much so in fact, that microscopists found them hard to believe. Indeed, the company had to arrange special demonstrations to convince the sceptics!

Operating in a similar manner to a conventional electron microscope, a beam of electrons is focused onto a specimen as a VERY fine probe and then, under the influence of the scanning coils, views the specimen in a raster, long familiar to all television engineers. The secondary electrons liberated from the specimen are detected by the collection system and then used to modulate the brightness of a cathode ray tube, whose synchronisation is linked to the electron probe scanning the specimen.

In 1978, the Swiss physicist, Heinrich Rohrer and his German colleague, Gerd Binnig, began a collaboration that would lead to the development of the Scanning Tunnel Microscope.

This device works by locating a sharp probe, in a vacuum, so close to the sample under examination that the wave functions of the probe electrons overlap those of the sample. If, then, a small voltage is applied between the probe and the sample, it causes the electrons to tunnel through the vacuum.

The tunnelling current is extraordinarily sensitive to probe tip-sample surface separation, and such sensitivity gives almost unbelievably precise measurements of atoms in the sample's surface. As sampling takes place, the tunnelling current is sensed by a feedback system which keeps the tip at a constant height above the sample's surface.

In 1986, Rohrer and Binnig shared the Nobel Prize in Physics with Ruska, then in his 80th year. At last, after almost half a century of constant application and research, the scientific establishment accepted that – despite dodgy patent applications – the electron microscope DID have a discoverer after all!

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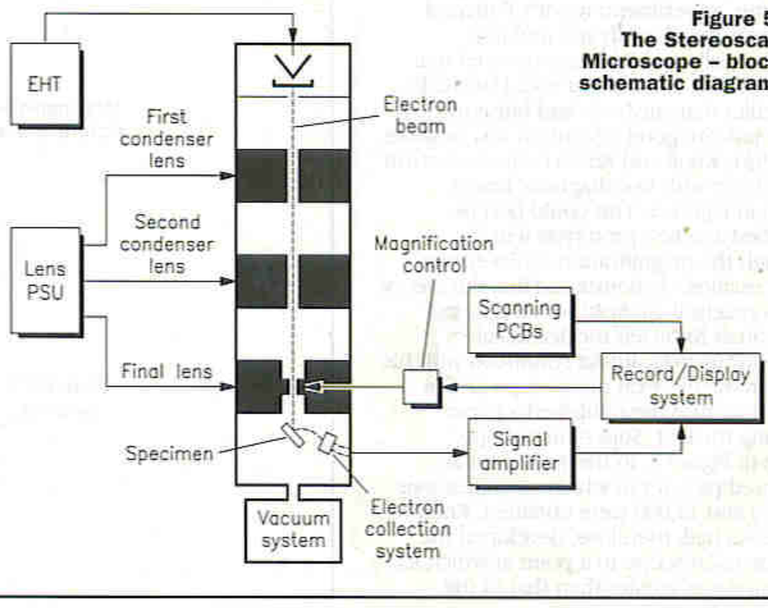


Figure 5. The Stereoscan Microscope – block schematic diagram.

Users guide to SPECIAL AUDIO PROCESSING IC'S

PART 1

Ray Marston looks at practical ways of using three special types of audio processing IC in this opening episode of a new 3-part series.

Modern audio systems and Hi-Fi units are built mainly around simple analogue ICs such as pre-amp and power amplifier types, but often also make use of various special types of audio signal processing circuitry such as filters and tone controls, electronic channel selectors, dynamic range manipulation or noise-reduction systems, etc. Sometimes, these 'special' circuits are built around general-purpose devices such as standard op-amp or operational transconductance amplifier (OTA) ICs, but often they are built around special, dedicated, types of audio processing ICs. This new 3-part series of articles explains the basic theory and practical working details of some of these dedicated audio signal processing ICs, including the MC3340P electronic attenuator IC, the NE570/571 dual 'compander' ICs, several multi-way 'analogue switching' and voltage- or digitally-controlled 'gain' and 'tone-control' ICs, and the ever-popular MF10C universal dual switched-capacitor filter IC.

The MC3340P

The Motorola MC3340P is an old but very popular dedicated 'electronic attenuator' ICs. Figure 1 shows the outline, pin notations and basic details of the device, which is housed in an 8-pin DIL package; only six of these pins perform useful functions, and two of these are used for power supply connections. Of the remainder, pins 1 and 7 provide input and output signal connections, pin 6 controls roll-off of the device's frequency response, and pin 2 is the device's gain-control terminal.

The MC3340P is really a simple operational transconductance amplifier (OTA), but is configured as a voltage-controlled amplifier. Its basic action is such that it acts as a linear voltage amplifier with 13dB of signal gain when its pin-2 CONTROL terminal is tied to ground via a 4kΩ resistance or is connected to a DC potential of 3·5V. This gain decreases if the control resistance/voltage is increased above these values, falling by 90dB (to -77dB) when the values are increased to 32kΩ or 6V. The device's attenuation (or gain) can thus be controlled over a wide range via either a resistance or a voltage.

Figure 2 shows a practical example of a voltage-controlled MC3340P electronic attenuator, together with its performance graph, and Figure 3 shows a resistance-controlled version of the device. In each of these circuits, C2 is wired to the control terminal to eliminate control noise and transients, thus giving a 'noiseless' form of gain control and enabling the control resistance/voltage to be remotely located. 680pF capacitor, C3, is wired to pin-6 of the IC and limits the upper frequency response of the circuit to the high audio range. Without C3, the response extends to several MHz, but the circuit tends to be unstable. Note that this IC gives only slight signal distortion at low attenuation levels, but that the distortion rises to about 3% at maximum attenuation values.

The NE570/571 IC

The Signetics NE570 is known as a dual 'compander' (compressor-expander) IC but is really a rather sophisticated dual VCA (voltage controlled amplifier). Each half (channel) of the IC contains an identical circuit, comprising a current-controlled variable gain cell (actually a high-quality OTA), an electronic rectifier that converts an AC input

Parameter	Min.	Typ.	Max.
Supply volts	+9V		+18V
Control pin sink current			2mA
Input voltage, rms			0.5V
Voltage gain		13dB	
Attenuation range		90dB	
Total harmonic distortion		0.6%	

Figure 1. Outline and main characteristics of the MC3340P IC.

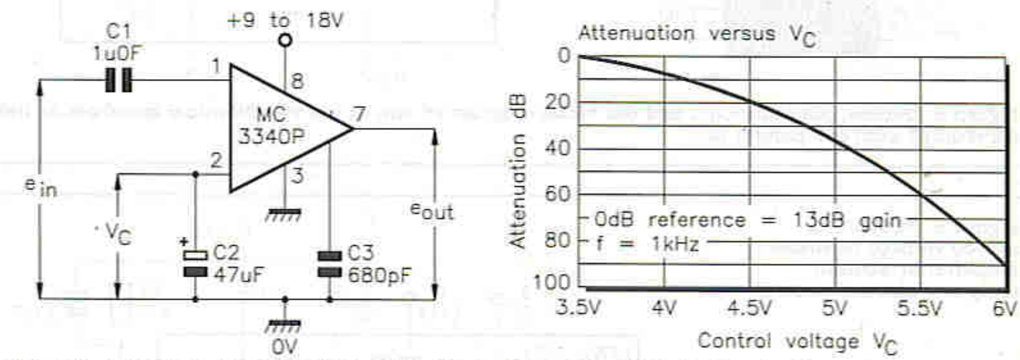


Figure 2. Circuit and performance graph of a voltage-controlled electronic attenuator.

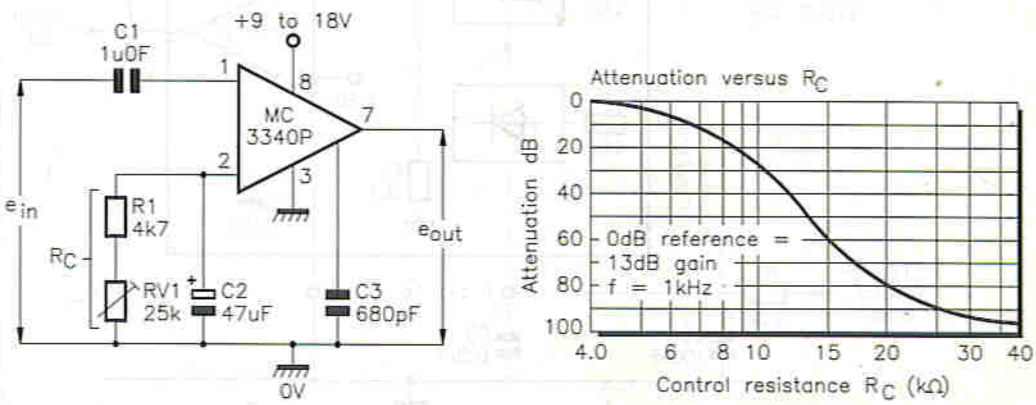


Figure 3. Circuit and performance graph of a resistance-controlled electronic attenuator.

Parameter	NE570	NE571
Supply voltage range	6V to 24V	6V to 18V
Supply current	3.2mA	3.2mA
Output current capability	±20mA	±20mA
Output slew rate	0.5 V/uS	0.5 V/uS
Gain block distortion:		
Untrimmed	0.3%	0.5%
Trimmed	0.05%	0.1%
Internal reference voltage	1.8V	1.8V
Output DC shift	±20mV	±30mV
Expander output noise	20uV	20uV

Figure 4. Basic characteristics of the NE570 and NE571 'compander' ICs.

signal voltage into an OTA gain-control current, an op-amp, a precision 1·8V reference, and a resistor network. These elements can be externally configured so that each channel acts as either a normal VCA, as a constant-volume or VOGAD (Voice-Operated-Gain Audio Device) amplifier, as a disco voice-over or 'ducking' unit, or as a precision dynamic range compressor or expander.

The Signetics NE571 is identical to the NE570, but has a slightly relaxed specification. Figure 4 lists the basic characteristics of the two ICs. Each IC is housed in a 16-pin DIL package, as shown in Figure 5, which also shows the block diagram of one IC channel. Note in the block diagram (and in all following NE570/571 circuits), that pin numbers relating to the left-hand channel of the IC are shown in plain numbers, and those relating to the right-hand half are shown in bracketed numbers.

NE570/571 Circuit Description

The operation of the individual elements of the Figure 5 block diagram are fairly easy to understand. Dealing first with the 'rectifier' block, input signals that are AC coupled to pin 2 (or 15) are full wave rectified by this block and fed – in the form of a proportional current – to pin 1 (or 16), where they can be smoothed by an external capacitor. The resulting DC current is then applied to a built-in current mirror, which directly controls the gain of the IC's 'variable gain' block.

Dealing next with the variable gain block, input signals that are AC coupled to pin 3 (or 14) are fed to the input of this block, which is a precision temperature-compensated OTA with its gain controlled directly by the rectifier block's current mirror, and thus indirectly via the pin 1 (or 16) voltage; the gain block's output takes the form of a current, but is converted into a proportional output voltage via the IC's op-amp stage. The gain block's signal distortion is quite low, and can be minimised by feeding a 'trim' voltage to pin 8 (or 9).

The channel's op-amp is internally compensated and has its non-inverting input tied to a 1·8V precision band-gap reference; the inverting input is connected to the gain block output, and is externally available. The inverting input is also connected to the R3-R4 resistor network, which can be used (either directly or with the aid of external resistors) to set the op-amp's AC and/or DC gain, using normal op-amp output-to-input feedback techniques. The op-amp output is available at pin 7 (or 10).

A Stereo VCA

Figure 6 shows how a NE570 or NE571 can be used to make a stereo voltage controlled amplifier/attenuator. Here, the internal rectifier is disabled via C2, and a 0 to 12V DC control voltage is fed to pins 1 and 16 via R6 and C3, to give direct control of the rectifier's internal current mirror and thus of the variable gain block. The output of the gain block is fed to pin 7 (or 10) via the op-amp, which has its AC and DC gain set at ×2·56 via R4-R7 and thus generates a quiescent output of 4·62V (= 2·56 × 1·8V). Both channels of the circuit are identical (the control voltage is fed to pins 1 and 16), and give about 6dB of gain with a control input of 12V, or 80dB of attenuation with a control input of zero volts.

A Stereo VOGAD Unit

Figure 7 shows a NE570/571 IC used to make a stereo constant-volume amplifier or VOGAD unit, in which the mean audio output amplitude varies by only ±1dB when the input signal amplitude is varied over the range +14dB to -43dB (the '0dB' reference value is 0·9V rms). This type of circuit is

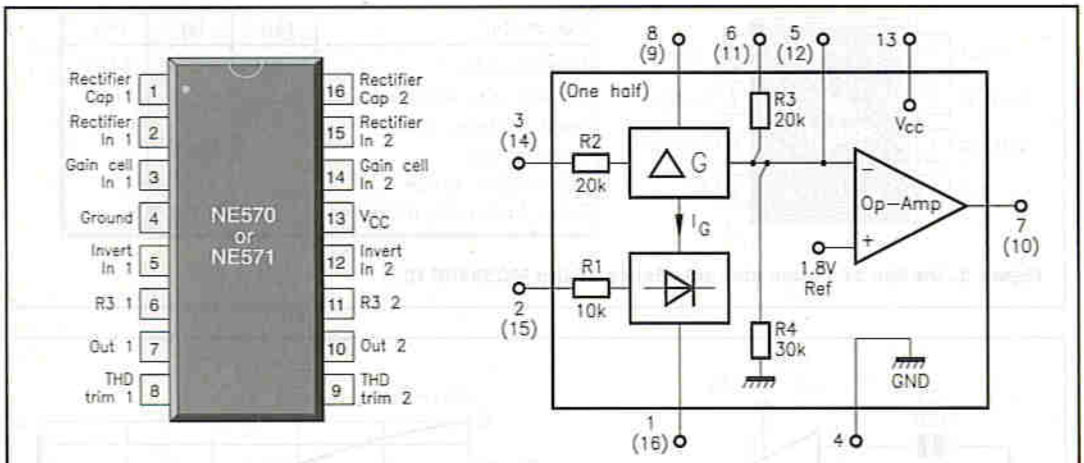
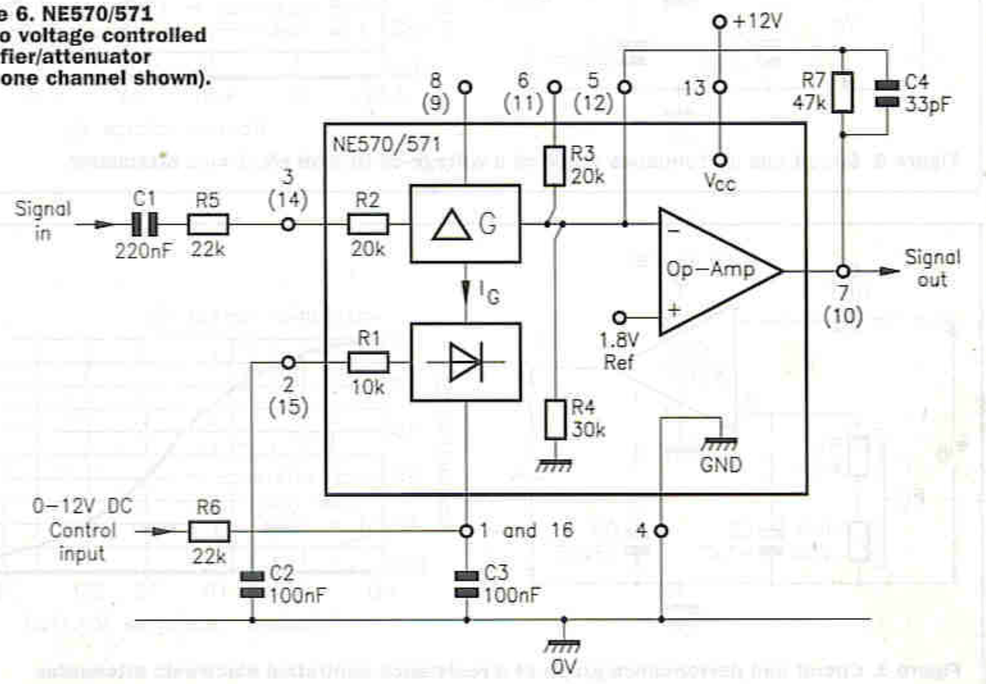


Figure 5. Outline, pin notations, and the block diagram of one of the two identical channels of the NE570/571 dual compander IC.

Figure 6. NE570/571 stereo voltage controlled amplifier/attenuator (only one channel shown).



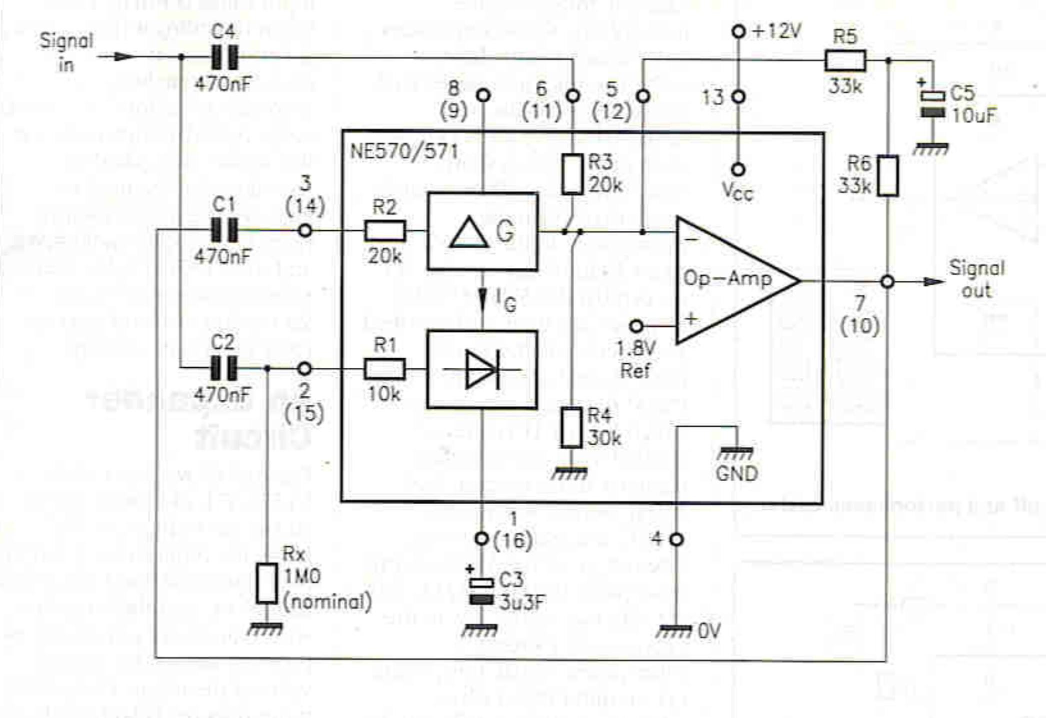


Figure 7. A NE570 or NE571 IC used to make a stereo constant-volume amplifier or VOGAD unit.

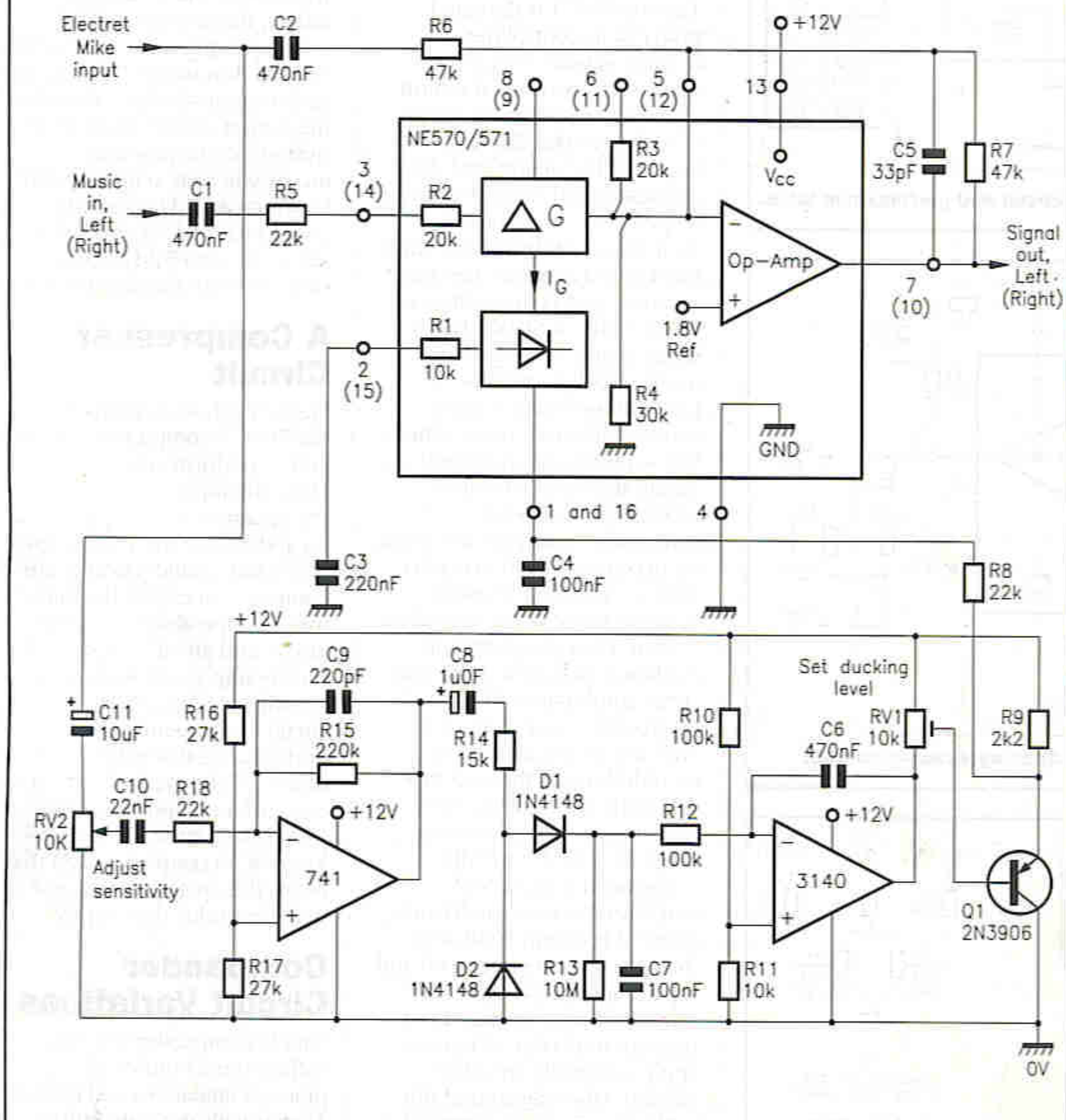


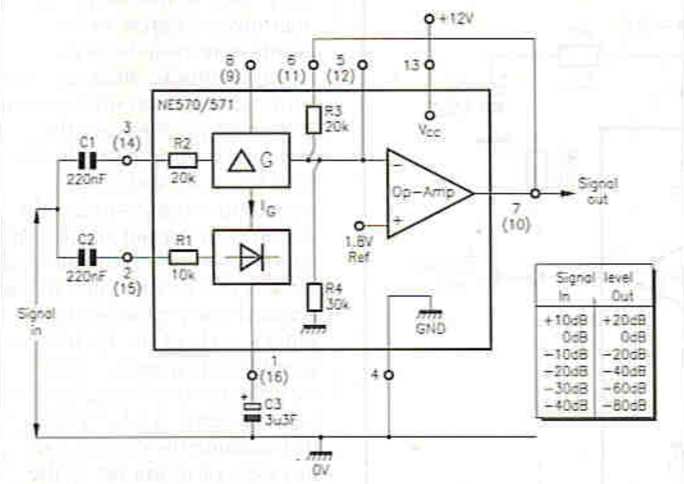
Figure 8. Basic circuit of an NE570/571 disco voice-over or 'ducking' unit

often used to feed amplified microphone signals to the inputs of telephonic (wire or radio) communication units or sound distribution or recording systems, and eliminates the need to fiddle with amplitude-level controls. The circuit operation is quite simple. The pre-amplified input signal is AC-coupled directly to the input of the internal rectifier, and to the op-amp's inverting input via pin-6 (or 11) of the IC, but the gain block is wired in series with the op-amp's output-to-input negative feedback loop, thus making the overall gain inversely proportional to the input level. Consequently, an 'x'dB fall in input level causes an identical dB increase in gain, thus giving zero change in the circuit's mean output amplitude. Resistor Rx is used to limit the unit's maximum gain, so that the unit does not generate an excessive noise output in the absence of a useful input signal. The Rx value can vary between 100kΩ and 10MΩ, the 'ideal' value (usually about 1MΩ) being found by trial-and-error.

A Voice-over (Ducking) Unit

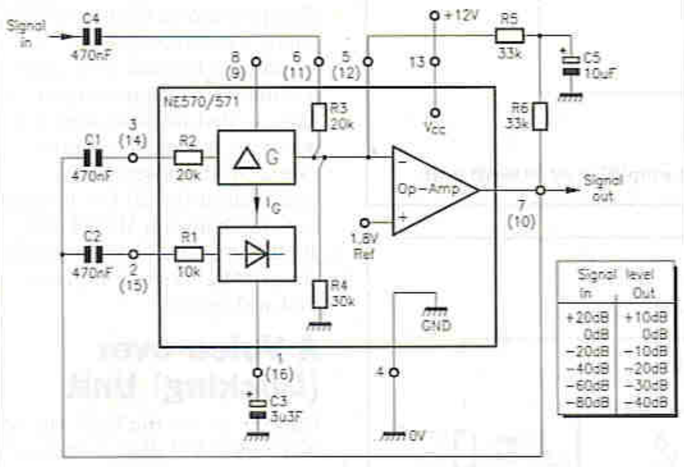
Figure 8 shows the basic circuit of a NE570/571 disco voice-over or 'ducking' unit that automatically fades the music down when the DJ talks into his microphone and gently restores the music again when the chatting is finished. In this design, each channel's op-amp is used as a 2-input audio mixer that has one input taken directly from the microphone input signal and the other taken from the music input signal via the channel's gain cell. Note that each channel's rectifier unit is disabled via C3, and the gain cell is controlled via transistor Q1, which is used as a simple electronic switch that is activated via the microphone input signal. In the absence of a strong microphone signal, Q1 is cut off and the gain cell is driven fully on via R8-R9, giving maximum amplification to the music signal, which appears at full volume at the pin 7 (10) output terminals. In the presence of a strong microphone signal, however, Q1 is driven on, and the gain cell attenuates the music signal, causing the microphone signal to dominate the pin 7 (10) output.

In practice, the actual ducking or music-attenuation level of the circuit can be fully controlled – from near-zero to - 80dB – via RV1, enabling the



Signal level In	Signal level Out
+10dB	+20dB
0dB	0dB
−10dB	−20dB
−20dB	−40dB
−30dB	−60dB
−40dB	−80dB

Figure 9. NE570/571 'Expander' circuit and performance table.



Signal level In	Signal level Out
+20dB	+10dB
0dB	0dB
−20dB	−10dB
−40dB	−20dB
−60dB	−30dB
−80dB	−40dB

Figure 10. NE570/571 'Compressor' circuit and performance table.

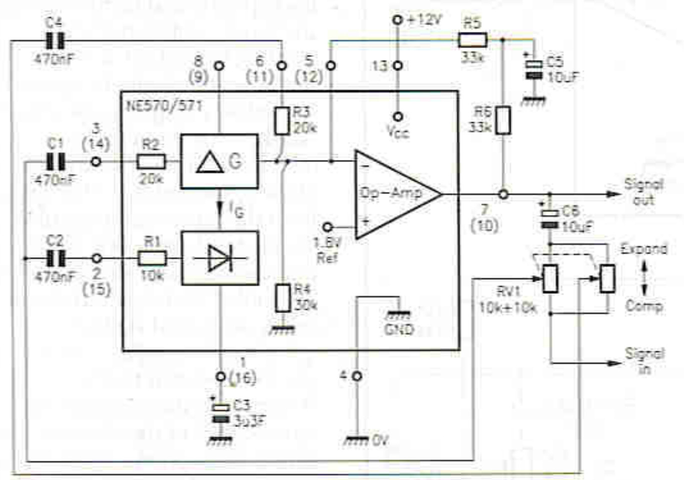


Figure 11. Variable-slope (2:1 to 1:2) compressor-expander.

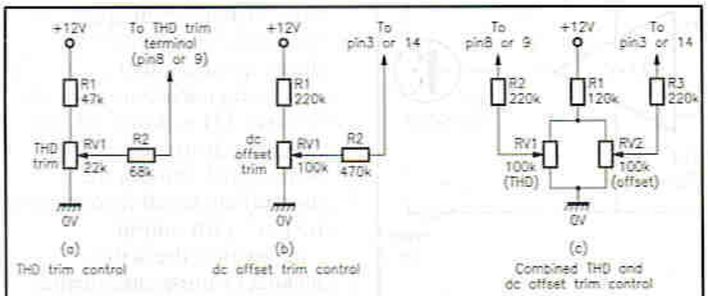


Figure 12. NE570/571 trimmer networks for minimising THD and DC offset shifts.

'ducked' music and the microphone signal amplitudes to be mixed in any desired ratio. The microphone-derived gain-control signals are designed to give a smooth fade-over, rather than a sharp switching action. These signals are derived from the microphone input via RV2, are given 20dB of gain via the 741 speech-band (350Hz-3·5kHz) amplifier, are then peak-rectified and filtered via the D1-D2 network, and are used to activate the 3140 voltage comparator, which has a 1·1V reference applied to its non-inverting terminal and is given a 'slow swing' output action via its C6-R12 integrating network. The output of the 3140 op-amp is normally high (and Q1 is thus cut off), but swings low in the presence of a strong microphone signal, this pulling Q1's emitter down (thus attenuating the music signal) by an amount determined by the RV1 control setting.

Compander Theory

The NE570/571 is designed primarily to control the dynamic ranges of various circuits. In acoustics, the term 'dynamic range' can be simply described as the difference between the loudest and the quietest sound levels that can be perceived or recorded. Typically, a healthy human adult has a useful dynamic 'hearing' (acoustic perception) range of about 90dB (= 50,000:1). This range greatly exceeds that of most recording systems. All practical recording systems generate inherent noise, which limits the minimum strength of signals that can be usefully recorded, and this factor (in conjunction with practical limits on maximum signal strength) places a limit on the useful dynamic range of the recording system. Thus, if a recording medium can handle maximum signal amplitudes of 1V rms, but produces a 'noise' output of 1mV rms in the absence of a recorded signal, the system is said to have a signal-to-noise ratio or maximum dynamic range of 1,000:1, or 60dB.

Simple tape recorders typically have a useful dynamic range of less than 50dB, and thus can not directly record and replay high quality music or other analogue signals (these restrictions do not, of course, apply to digitally encoded signals). One way around this problem is to use a compander system to compress the 90dB dynamic range of the analogue input signal down to 45dB when recording it (thus giving a 2:1 compression ratio), and then use a matching 1:2 expander to restore its dynamic range to 90dB when replaying the signals. This same basic technique can be used to improve the quality of many types of analogue audio signal, and the NE570/571 ICs were originally designed specifically for use in low-fi and medium-fi versions of such systems.

An Expander Circuit

Figure 9 shows a practical NE570/571 'expander' circuit and its performance table. Here, the input signal is fed to both the rectifier and the variable gain block, and their action is such that circuit gain is directly proportional to the average value of the input. Thus, if the input rises (or falls) by 6dB, the gain also rises (or falls) by 6dB, so the output rises (or falls) by 12dB, giving a 1:2 expansion ratio. Note in this circuit that (because of the R3 and R4 ratios), the op-amp output takes up a quiescent value of 3V, and can thus supply only modest peak output signals. If desired, the output can be raised to 6V (giving a corresponding increase in peak output levels) by wiring a 12kΩ resistor in parallel with R4 via pins 5 (or 12) and 4, or a 51kΩ one in series with R3 via pin 6 or (11).

A Compressor Circuit

Figure 10 shows a practical NE570/571 'compressor' circuit and its performance table. Here, the input signal is fed to the op-amp's inverting input via C4 and R3, but the variable gain block and rectifier circuitry are connected in exactly the same way as in the above expander design and are AC coupled into the op-amp's output-to-input negative feedback loop. The circuit consequently gives a performance that is the exact inverse of the expander, i.e., it gives a 2:1 compression ratio. R5 and R6 form a DC feedback loop (AC decoupled via C5) that biases the op-amp output at a quiescent value of about 6V.

Compander Circuit Variations

Simple compander systems suffer from a number of practical limitations and defects. They usually generate rather high levels of noise, total harmonic distortion (THD), tracking distortion, DC-tracking shifts, and form a rather annoying phenomenon known as 'breathing' or 'pumping'. These problems may reach intolerably high levels if the system's 'compression' or slope ratio is raised significantly above the basic 2:1 ratio, but can be greatly reduced by using slope ratios of less than 2:1. Anyone wishing to experiment with high-slope compander systems can do so by simply cascading NE570/571 compression or expander circuits. Each IC contains the basics of two of these circuits, and can thus provide an overall 4:1 compression ratio or 1:4 expansion ratio and can, for example, thus compress an 80dB (10,000:1) range of input signals into a 20dB (10:1) output range.

Figure 11 shows how one half of an NE570/571 IC can be used to make a variable-slope compressor-expander in which the slope is fully variable from 2:1 compression to 1:2 expansion via dual-gang 10kΩ potentiometer RV1, which has its two sections wired in anti-phase. When the potentiometer is in its central position, the circuit has a 1:1 slope, and acts as a simple amplifier that gives neither compression or expansion.

The circuits shown in Figures 6 to 11 are simple designs which can all be improved with the addition of various trim controls, such as those shown in Figure 12. The THD trimmer networks shown in (a) or (c) can be used to minimise an NE570/571 circuit's total harmonic distortion figures. To use this trimmer, feed a fairly strong 1kHz sinewave to the input of the main circuit, and then adjust RV1 for minimum output distortion. Note that, if the THD trim facility is not used, pins 8 and 9 of the IC should be decoupled to ground via 220pF capacitors, to eliminate HF instability. The DC offset trimmer networks shown in Figure 12 (b) or (c) can be used to minimise any DC output voltage shifts that occur when a circuit's input signal voltages are varied between their maximum and minimum values.

The NE570/571 IC's rectifier elements each consume input bias currents of about 100nA. In the simple Figure 6 to 11 circuits this current is derived from the rectifier's input signal, thus limiting the actual dynamic range of the rectifier (and also the IC's gain cells) to about 60dB. This snag can be overcome, thus expanding the rectifier's actual dynamic range to its full 80dB+

Figure 13. Rectifier bias current cancellation network (a), and rectifier performance graph with and without cancellation (b).

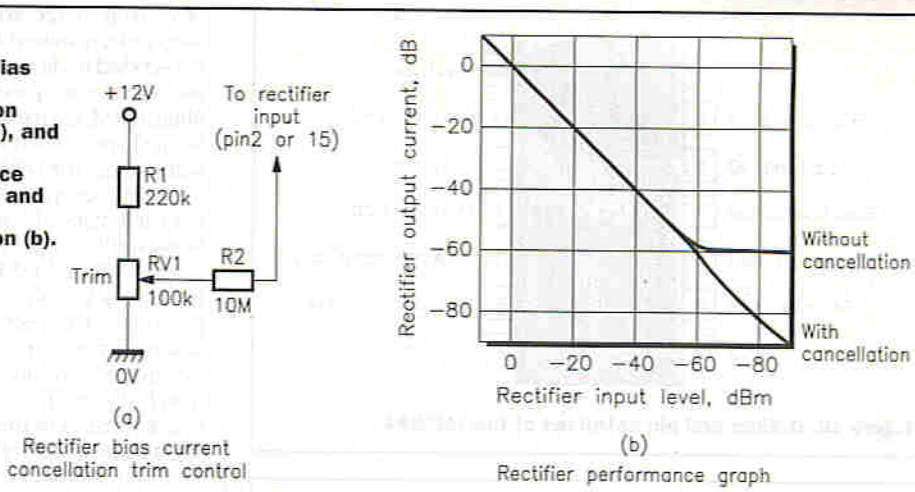
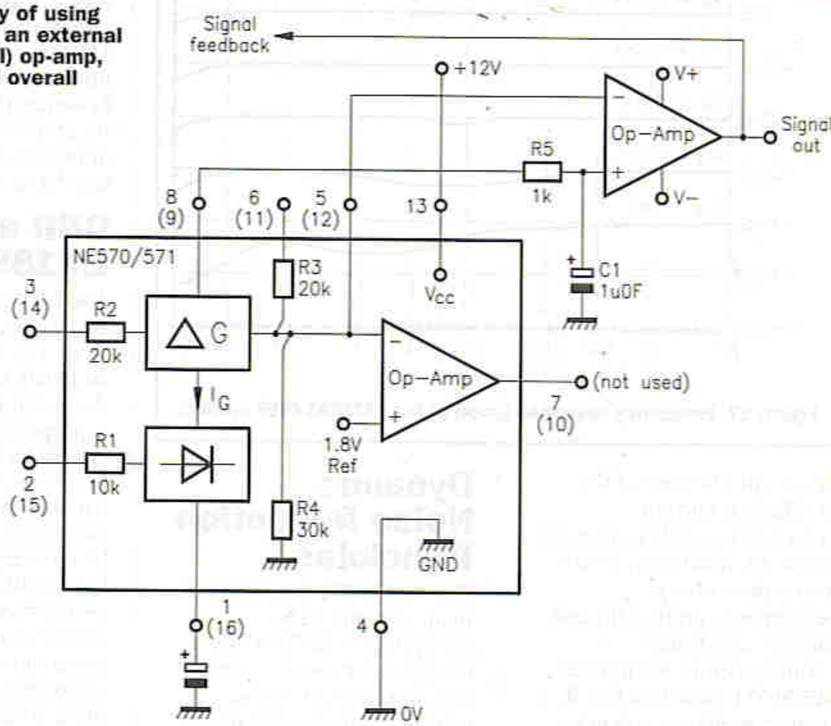


Figure 14. Basic way of using the NE570/571 with an external (rather than internal) op-amp, to give an improved overall performance.



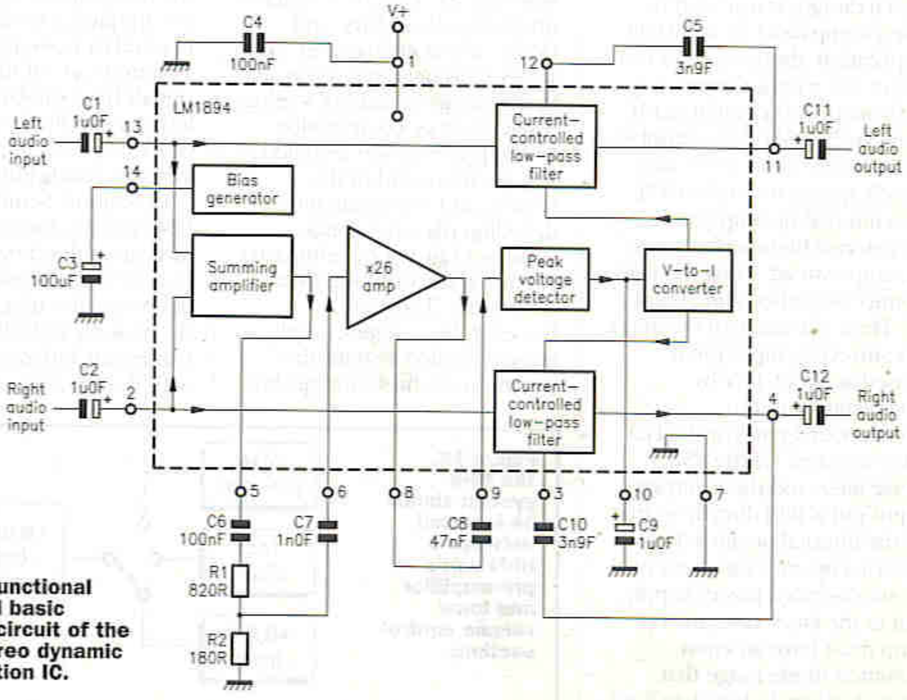


Figure 15. Functional diagram and basic application circuit of the LM1894 stereo dynamic noise reduction IC.

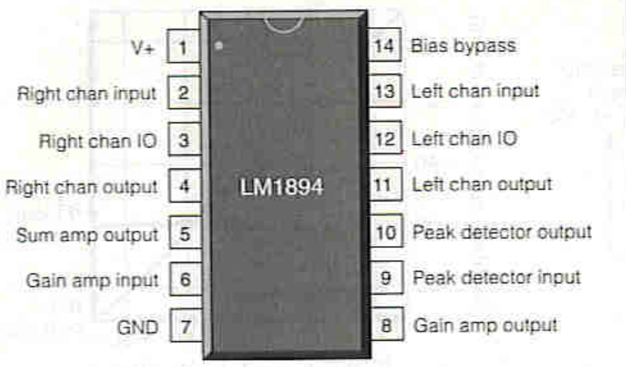


Figure 16. Outline and pin notations of the LM1894.

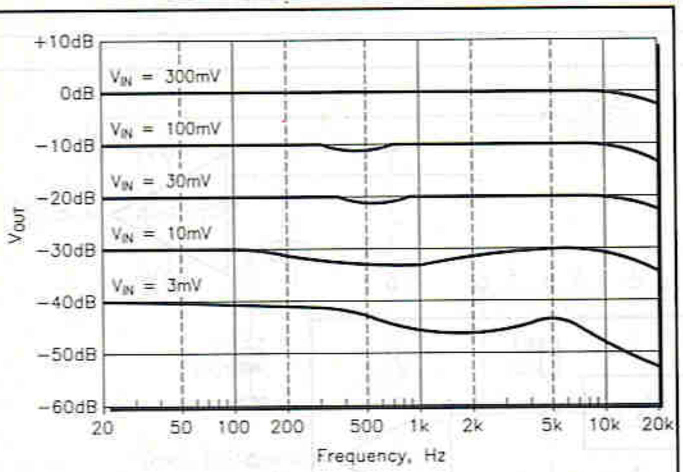


Figure 17. Frequency response graph of the LM1894 DNR system.

value, with the help of the rectifier bias current cancellation network shown in Figure 13, which also shows the rectifier's basic performance graph with and without cancellation.

Finally, before leaving the NE570/571, note that this IC's greatest weakness lays in its internal op-amp, which is a very simple and rather noisy mid-fi design. If you wish to use a compander IC in a Hi-Fi application, therefore, you can either use a rather expensive dedicated Hi-Fi compander IC such as the SSM2120 (available from Analog Devices) or can simply ignore the NE570/571 IC's internal op-amp and use an external high-performance op-amp instead, using the basic connections shown in Figure 14. Here, the external op-amp's non-inverting input pin is biased at about 1·8V by connecting it to the compander's pin 8 or 9 'THD trim' terminal via the R5-C1 noise filter, and the inverting input pin is tied directly to that of the internal op-amp. The external op-amp can use a dual or single-ended power supply, but in the latter case, the op-amp must have an input common mode range that extends down to less than 1·8V.

Dynamic Noise Reduction Principles

The NE570/571 is just one of many dynamic range manipulation ICs that are designed for use in systems that aim to improve the acoustic reproduction quality of material that is recorded on – or transmitted via – inherently noisy media. Most such systems (including dBx, ANRS, and Dolby) are 'double-ended' and achieve this noise-reduction aim by encoding the material – using dynamic range compression and/or pre-emphasis techniques – at the input end of the system, and using matching decoding (dynamic range expansion and/or de-emphasis) circuits at the output end of the system. There are, however, two 'single-ended' noise reduction systems that can improve the sound quality of virtually all recorded (tape or disc) or transmitted (AM or FM) non-coded audio material. The two systems in question are the Philips DNL (dynamic noise limiter) system and the National Semiconductor DNR (dynamic noise reduction) system ('DNR' is a trademark of National Semiconductor Corporation).

The DNL and DNR systems both work by using psychoacoustic techniques that automatically adjust the system's bandwidth and gain to match the instantaneous characteristics of the audio signals that are being processed. The DNR system is of special interest, and is described in detail in the next section of this article, together with application details of a special IC – the LM1894 – that is designed to implement the system. Note, however, that this is a custom IC, and is available only to approved professional 'bulk purchase' consumers.

DNR and the LM1894

The DNR system makes use of two simple psychoacoustic facts. The first is that the audibility of white noise (the dominant type of system noise) is proportional to the mean energy level of the noise, which in turn is proportional to the bandwidth of the system. Noise audibility can thus be reduced by reducing the system bandwidth. The second psychoacoustic fact is that, if a simple tone signal and a white noise signal are present at the same time, the tone signal will mask (swamp) the noise signal if the tone's power level is significantly greater than that of the noise signal. Thus, if a low-frequency tone signal is masked by noise in an audio system it can – if the two signals have similar power levels – usually be unmasked by simply reducing the system's bandwidth.

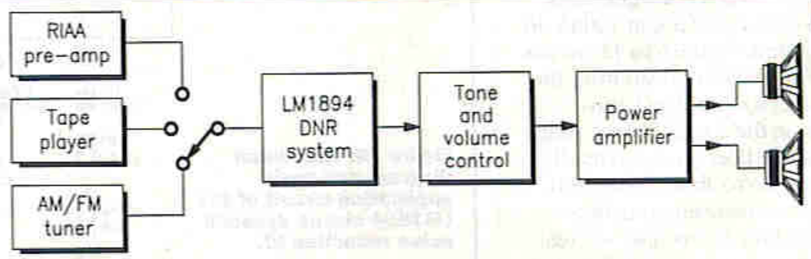
In National Semiconductor's DNR system, these two sets of facts are utilised by feeding normal audio signals through a filter-amplifier unit that dynamically self-adjusts its bandwidth and gain in sympathy with the instantaneous mean frequency and amplitude of the input signal, thus effectively reducing noise levels by an average of about 10dB, i.e., by a factor of three. All of the active components of a stereo version of this system are contained in the LM1894 IC, and Figure 15 shows the full functional diagram of this device, together with its basic application circuit, and Figure 16 shows the outline and pin notations of the IC. The system functions as follows.

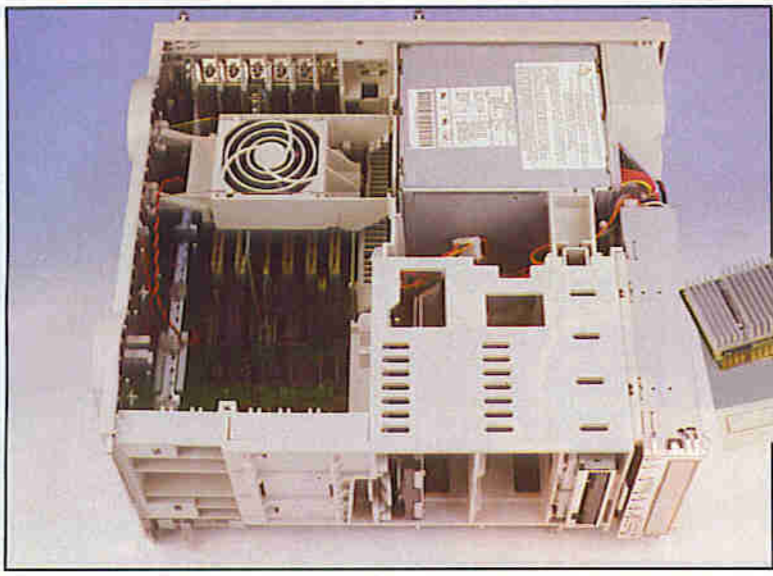
On entering the IC, the stereo audio channel signals are each passed from input to output via a current-controlled low-pass filter that has its gain controlled via an input-driven bandwidth-control generator circuit. In the latter circuit, the two input signals are added together and then attenuated and filtered via the C6-R1-R2-C7 network; the resulting signal is then amplified, filtered via C8, peak-amplitude detected (rectified), filtered (smoothed) via C9, and finally converted into a proportional current that is used to control the gains of the IC's two current-controlled low-pass filters. Each of the filters, in fact, consists of an OTA gain cell (of the type used in the NE570/571) plus an op-amp output stage that has its frequency response tailored via C5 or C10. The net result of all this is that each stereo channel exhibits the input-to-output frequency response shown in Figure 17.

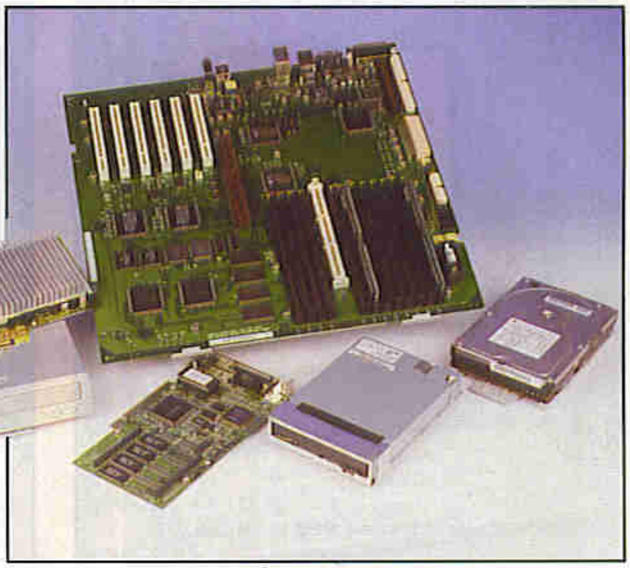
Note in Figure 17, that the frequency response is almost linear when input signals have amplitudes greater than 30mV (and can thus easily swamp system noise), but is subject to fairly heavy noise-attenuating top cut when the input signal amplitudes are less than 10mV. Finally, note that the LM1890 DNL system is intended to be inserted in the middle section of a Hi-Fi system, between its pre-amplifier and tone/volume control sections, as indicated in Figure 18, where it will be driven by reasonably strong input signals.

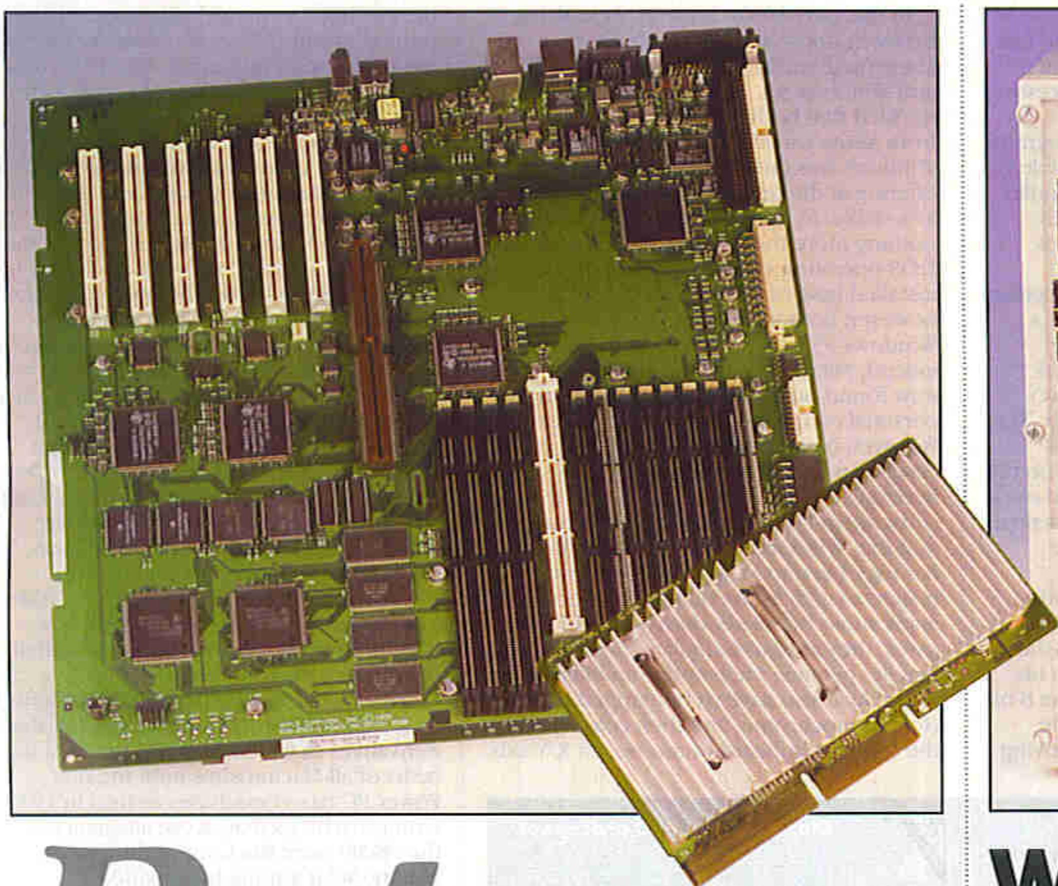
Next month's episode of this 3-part 'how to use it' series will look at a selection of Hi-Fi electronic 'selector switch' ICs.

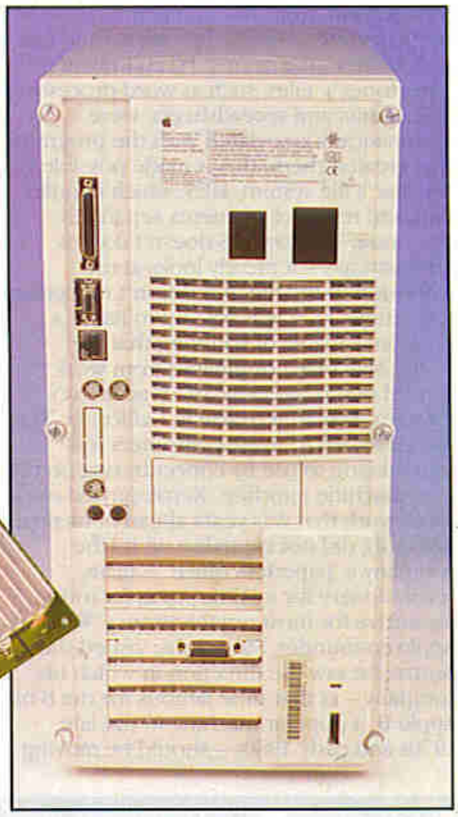
Figure 18. The DNR system should be inserted between a Hi-Fi unit's pre-amplifier and tone/ volume control sections.











Return OF THE MAC

PART 1

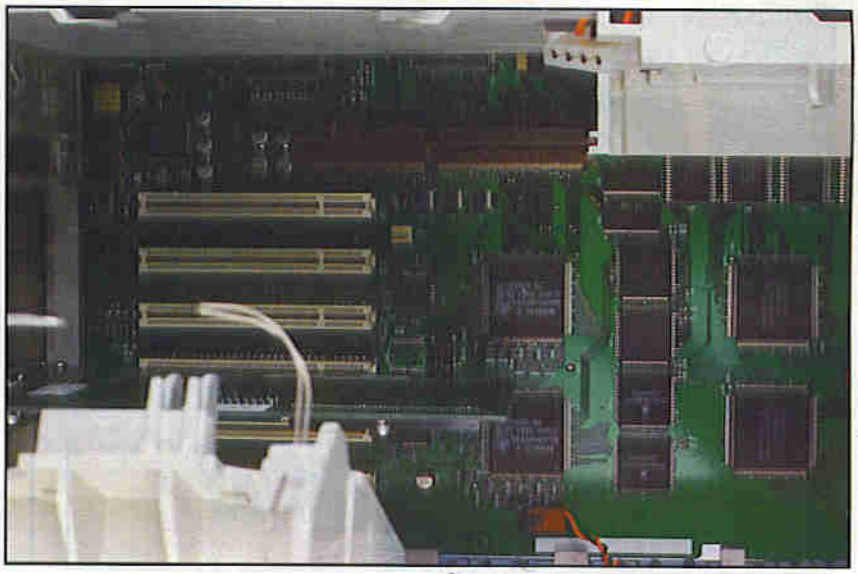
by Martin Pipe

Martin Pipe looks at the history, technology and current state of Apple's Macintosh.

We now take GUIs (Graphical User Interfaces) for granted. In 1984, though, they were a revelation. Until the launch of the Apple Mac that year, computer users had to put up with a user-unfriendly command line and error messages that were nonsensical (even after you found them in the manual!). The Mac, heralded as a 'computer for the rest of us', did away with that – albeit at a price. More than 26 million Macs have apparently been sold around the world, and Apple claim that one of their machines – the Mac LC – is the best-selling computer ever. These machines are supported by around 14,000 programs, although this figure is significantly lower than the number that's around for the PC. There may be fewer programs for the Mac, but according to Symantec, there are less viruses too; only 35, in fact – against the PC's 10,000 (and rising).

System, as the Mac's operating system (MacOS) was then called, introduced us to the desktop, within which could be found

Motorola demonstration PPC machine.



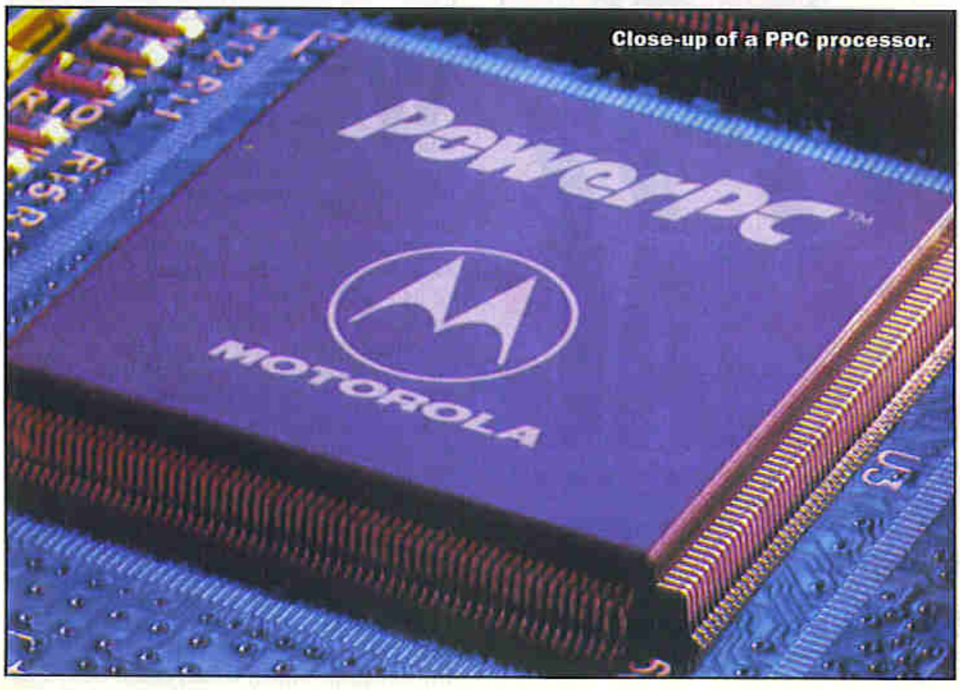
the program 'windows' and graphical 'icons' (representing unopened programs and files) and 'folders' (the nearest PC equivalent is 'directories'). Files, such as word-processing documents and spreadsheets, were automatically associated with the programs that created them; this is made possible by the Mac's file system, HFS, which handles data and resource elements separately. Even now, Windows 95 doesn't do this automatically – it merely looks at the extension of the file. If it doesn't recognise the extension, it will ask you to name a program capable of handling that file.

The Mac's GUI originated from work carried out in the early 1970s at Xerox's Palo Alto research centre in California. This was designed to make computers less intimidating to use by concentrating on the man-machine interface. Xerox carried out a lot of work that was years ahead of its time, but sadly, did not capitalise on it (the company's 'paperless office' – again, revolutionary for its time – was far too expensive for most organisations). When Apple co-founder, Steve Jobs, visited the centre, he saw the direction in which his company – at that time famous for the 8-bit Apple II, a popular machine in the late 1970s and early 1980s – should be moving.

In the early 1990s, lawsuits were flying between Apple and Microsoft over conceptual similarities between MacOS and Windows 3.1. In the end, it was decided that both drew their influence from Xerox's work. The 3.1 release of Windows was grossly inferior to the Mac's offering at the time, being clumsier and less stable. In any case, Windows 3.1 was nothing more than a 'front-end' for the MS-DOS operating system. Because of the installed base of IBM-compatible PCs, however, both it – and its successor, Windows 95 – became very popular; indeed, Microsoft's operating systems are now found on the majority of the world's personal computers (by volume, at least). But even now, Windows 95 does rely on certain 16-bit bits and pieces of DOS heritage; this will only be fixed with a subsequent release of Windows. It must be said that Windows 95 is closest Windows has ever been to MacOS, and in some respects (such as the quantity of decent applications bundled), does better. In some cases, they are quite similar – neither handles genuine pre-emptive multi-tasking.

The Mac also gave us bitmapped displays (first monochrome, and then colour) and the hitherto unheard-of mouse, an X/Y axis device that – as we all know now – moves a pointer around on screen in order to select menus or open programs. The 3·5in. disk drive – pioneered by the Mac (originally with 800k-byte capacity, now with 2M-byte) – has a motorised eject mechanism that is intelligently used when loading or installing software. As soon as you insert a disk into a Mac, it's recognised and displayed (along with volume name) at the top right of the screen. An 'opened' disk will also tell you – in plain English – the amounts of used and remaining disk space. When installing software from floppies, the Mac will eject a disk and prompt you to insert the next one in the series. Oh yes, and the HFS file format has always supported long names. Most Macs will also read and write PC-format disks; sadly, Microsoft hasn't seen fit to reciprocate, and third-party products (such as Macsee) have to be employed if Mac disks are to be read on a PC. Even then, only the high density 2M-byte ('Superdrive') disks can be read; the older low density Mac drives work at variable speeds which are incompatible with their fixed-speed PC counterparts.

The original Mac's processing was handled by a 16-bit Motorola 68000 processor, the derivatives of which could be found at the heart of all Macintoshes until the first Power PC-based machines arrived in 1994. Other machines that swore allegiance to the 68000 were the Commodore Amiga (still popular among home video enthusiasts, thanks to decent graphics and software that allows you to add titles) and Atari's ST (for a while, the musicians' computer, on account of its built-in MIDI ports). The first Mac had 128k-byte of memory – unlike the 8-bit processors common in 1984-vintage machines, the 68000 could address all of that (and a lot more besides) without recourse to paging. Subsequent Macs used the 68020 (Mac II, 1987), 68030 (Mac IIfx, 1990) and 68040 (Quadra, 1991) that provided increasing degrees of performance improvement. This family of processors is often referred to as the 680x0 series. The various Amiga models also made use of them.



Close-up of a PPC processor.

PowerPC logo.

Taking a RISC

The PowerPC chip, co-developed by Apple, IBM and Motorola, uses RISC (Reduced Instruction Set Computing) technology, rather than the CISC (Complex Instruction Set Computing) found in the 680x0 and Intel x86/Pentium ranges. RISC uses a streamlined set of basic instructions; the more complex instructions implemented in RISC hardware are generated in software from the basic elements within the CISC instruction set. This offers many benefits over CISC; they consume less power and run cooler, are cheaper to manufacture and offer higher potential performance. The RISC approach is taken by Silicon Graphics and Digital (at the high end), and by ARM and PIC chips (at the consumer end).

Another advantage of the PowerPC is that it provides support for the sharing of RAM by multiple processors; today, it is possible to purchase multiple-processor Macs for high-end applications. This scalable architecture is used to spectacular effect; IBM is creating a $93 parallel PowerPC-based computer, capable of working at 3Tflops, for the US government to model the effects of nuclear explosions. The first Power PC processor, the 601, was used on the 6100, and ran at 60MHz (faster versions of this chip are available in some current Macs). The 603, which has a 32-bit address bus and a 64-bit data bus, gave four times the performance of the 68040 processors then in use by Macs like the Quadra range, and beat the then-new 60MHz Pentium hands-down. Current top Macs employ the latest generation of 604e chips running at speeds of 200MHz or more. The PowerPC consortium is working on faster and more powerful sub-0·1μm devices that will work at clock speeds of over 1GHz. PowerPC-based Macs can use emulation techniques to run the older 680x0 programs.

Power and ease of use are both important, but Apple also paid attention to other areas. Other than a few of the earlier machines (with RJ-45 phone-jack keyboard connectors), all have used the same connections for peripheral devices, making the upgrade of equipment much easier. Where multiple-pin jacks are employed, it's the more robust female gender that's employed (it's cheaper to replace a lead than it is to replace a motherboard!). Ergonomics are also a strong point, a factor that complements the intuitive user interface. Controls are accessible, displays are readable and keyboards have a decent feel. In many cases, you don't even need a screwdriver to get inside the machine in order to upgrade the memory and so on.

Looking Good for your Money

In terms of physical appearance, Macs always looked good in a domestic or office environment, with their elegant sculpted cases. Why, after all, does a computer have to look something that fell out of the mad professor's lab? Similar thoughts have obviously gone through the minds of the designers employed by the 'big name' PC manufacturers, such as IBM and Olivetti. The portable 'notebook' version of the Mac, known as the PowerBook, set standards for years with neat compact design, well-designed keyboard and clear, readable display. PowerBook was also the first laptop to integrate a trackball as a pointing device, something that was cloned by the PC manufacturers for years. Indeed, there was a time when practically every Wintel notebook looked like a Powerbook. Interestingly, a barely recognisable (at least, in terms of the display) PowerBook was featured in the hit movie, Independence Day.

Macintosh was the first personal computer to make use of the then newly ratified high-performance 8-bit (later 16-bit, and now 32-bit) SCSI (Small Computer Systems Interface) standard. Just about every Mac has a 25-pin 'D' SCSI port at its rear. Macs use SCSI where high-speed applications are envisaged; no Mac ever produced has had a 8-bit parallel port (printers are connected via a RS422 serial interface). The Mac's SCSI implementation allows seven individually accessible devices (one of which is the computer's SCSI interface or 'host adaptor') to be daisy-chained together.

The first such devices were 20M-byte hard disks; today, however, we have CD-ROM drives, magneto-optical drives, tape streamers and scanners amongst other peripherals. Unlike PCs, most Mac peripherals are built into external boxes with their own power supplies (it's deemed easier than messing around with the innards of the machine, although it must be said that many Macs don't have internal space for second hard drives, magneto-optical disks and the like). It must be said that all those adjunctive boxes do spoil the neat and uncluttered lines of the partnering computer, and make extra mains points necessary.

SCSI is backwards-compatible, and it's fast – its latest incarnation (the 32-bit Ultra-Wide) is sufficiently speedy to be able to handle digitised TV-quality video at low compression rates. Indeed, digital non-linear video editing is currently a popular application for the Mac. The Mac implementation of SCSI is easy to use – select an ID that doesn't clash with that of another device within the system, insert it in the chain and ensure correct termination. Apple devices are automatically recognised because they are equipped with special firmware; unfortunately, non-Apple devices need special drivers (known as 'extensions'). Non-Apple hard disks need formatting by third-party software, the best known of which is FWB's Hard Disk Toolkit. FWB also produce a program that allows non-Apple CD-ROM drives to be recognised. On the positive side, the Mac benefits from selectable boot drives. This makes multiple boot options and recovery far easier (on which subject, there are much fewer Mac viruses than there are PC viruses).

Other SCSI-connected products, such as CD-Recordable drives and scanners, tend to be supplied with specific extensions. Unlike the PC, the Mac makes it easy to manage extensions – which, like their PC-equivalent drivers, eat up memory. The extensions are displayed as icons on the bottom left-hand side of the screen at boot-up. MacOS includes a program known as the 'extensions manager', which allows you to easily create custom sets of extensions that can be loaded up when the machine is re-booted. This is an extremely useful feature that is sadly missing in Windows 95.

The Mac introduced us to the concept of decent-quality in-built digital audio. The hard disk-equipped 16MHz 68020-based Mac II, launched in 1987, had 8-bit stereo playback capability when all the PC had was a speaker that emitted painful bleeping noises. Even these days, Macs have 16-bit stereo audio inputs and outputs as standard; unlike PCs, there are no soundcards to mess around (but then again, no MIDI capability, which a soundcard offers at a modest price. MIDI interfaces and sequencing programs are available for the Mac, albeit at a price).

AppleTalk, a Mac original, allowed users to network their machines together via the serial port, and (thanks to AppleShare) share files with each other. It is a little bit similar to the Direct Cable Connection that ships with Windows 95 – although the Microsoft variant does allow you to use the parallel port, which is several orders of magnitude faster than serial. Many Macs these days are, however, provided with in-built Ethernet capable of talking at 10M-bps. Unfortunately, not even the brand new top-of-the-line Macs (such as the 9600) include Fast Ethernet (100M-bps). What's more, Apple has always insisted on 10-base-T (and AAUI) connectors, and not the 10-Base-2 coax/BNC terminals present on PC network cards. To hook a Mac to a PC-based coaxial network, an adaptor unit is needed.

The groundbreaking Mac II also introduced a daisy-chainable serial interface known as ADB (Apple Desktop Bus), to which could be attached keyboards, mice and graphics tablets without wasting serial ports. ADB remains a standard fixture on all Macs. These days, some Mac monitors (such as the Apple 1710 17in. model) also have an ADB connector for communication with the computer. When you choose the 'monitor' control panel to change graphics resolution, only the modes that can be safely supported by the monitor can be chosen. It will also power up and down the monitor at boot-up and shutdown, and during power-saving 'sleep' states that cut in when the computer hasn't been used for a definable period. Recent PCs and compatible monitors use similar systems known as DDC (monitor/PC) and Green PC (sleep modes). In the case of PCs, monitors and graphics cards use two spare pins on the 15-pin high density VGA connector to communicate DDC data and clock signals.

Plug and Play

Another Mac first is plug and play – something that only arrived on the PC with the introduction of Windows 95. With Windows 95, the computer automatically recognises that new hardware had been added, and if the drivers are not present, then an on-screen prompt invites you to insert the appropriate disks. Insert a Mac peripheral card, such as a graphics adaptor, however – and that's it; the operating system recognises it automatically. Plug and play Mac expansion cards go back to 1987, and the Mac II's original NuBus card slots – the first 32-bit expansion bus on any personal computer. The current generation of PowerPC-based 'Power Macintoshes' have adopted the PCI (Peripheral Component Interconnect) bus that's also found on PCs. Because the firmware on PC and Mac PCI cards is so different, the two are not interchangeable. The introduction of PCI does mean that manufacturers are more willing to support the Mac; for example, Matrox (the Millennium graphics card) and Miro (the DC20 Motion-JPEG video capture card).

TO BE CONTINUED...

PPP for Macs

As a treat for Mac users, we're looking at a handful of PPP tools here, all of which help the connection process when linking up to the Internet.

The basic process in a standard dial-up connection is usually handled by a built-in control panel utility. Traditionally, this has been ConfigPPP, which uses the Mac's classic networking system. More recently, with Open Transport – the Mac's new networking architecture – the control panel involved is OT/PPP. Both these (and other third-party control panels such as FreePPP) simply control the point-to-point protocol needed to get the Mac onto the Internet. In such a typical connection, you open the control panel involved and click the connect button to log on to the Internet. Logging off is a simple matter of clicking the disconnect button. Auto-logging on by way of an Internet application is standard.

Now, while this is a straightforward system, there are some neat tools which can help make it even easier. Many of these have timers within them, so that you have an instant indication of time spent on the Internet. All of them are pretty neat. They're in three basic groups: control panels, control strips, and small applications.

PPPFloater happens to be the only control panel here. It has a neat ability in that it only does its stuff on screen when you access the Internet. So, after your browser or e-mailer automatically logs onto the Internet, the PPPFloater palette shows up. When you want to log off, you only have to hit the scissors button. Also displayed on the palette is a timer showing your online time. Click anywhere in the palette except the scissors button and cumulative time is displayed.

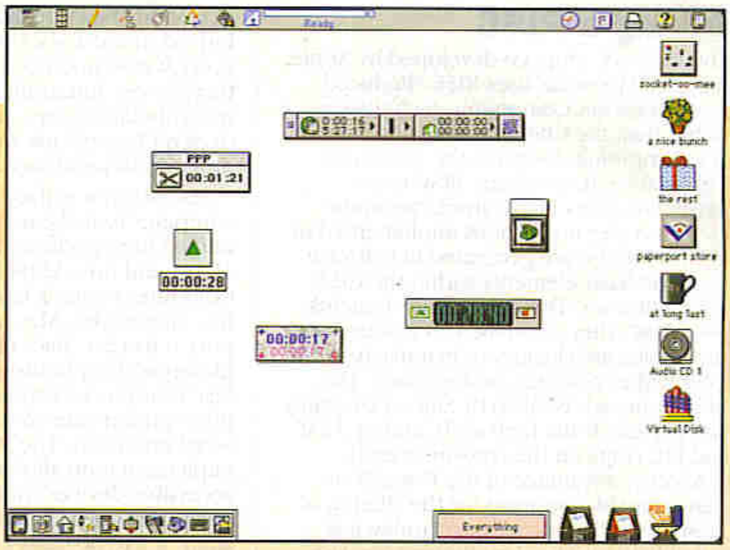
One of the Mac's clever in-built tools is the Control Strip – a selection of utilities you can display along the screen bottom at will. As such, it's no surprise that there are several control strip modules which allow PPP control.

Control PPP lets you connect and disconnect from its pop-up menu, as well as letting you open whichever PPP and TCP control panels you have, whether you use Open Transport or classic networking. OT/PPP CSM lets you do the same, but also lets you open the modem control panel though it's specifically for the OT/PPP control panel. Also, both let you display or hide a timer.

csPPP is intended for use with FreePPP so only gives access to that control panel, but it does let you control your various Internet applications. FreePPP actually comes with a control strip, but has nothing like the power of csPPP. When you use csPPP to open the FreePPP link to the Internet, the applications you specify are launched automatically. So, a single operation from the control strip pop-up menu opens the PPP link and has your e-mail, browser, and whatever other application ready for you in seconds.

Last control strip module is PPP Strip. This one simply lets you log on to the Internet with one click, then log off with another. Simple, yes, but ever so powerful.

On to the application utilities. PPPThang merely displays a floating window with a single button which connects and disconnects the Mac to the Internet by toggling your PPP control panel on and off. Very simple, but very effective.



The PPP utilities – shown from top, clockwise: the four control strip modules (shown in an Extension Strip palette) Control PPP, csPPP, OT/PPP CSM, PPP Strip; applications PPPThang, PPPremier Timer, MacPPP Timer, PPPop; and the control panel PPPfloater.

MacPPP Timer floats a palette from which you can log on, log off, open the MacPPP Timer preferences, or quit. A nice touch; the palette can be a standard Mac window (that is, drop to the background when another application is in focus), or be globally floating – over all applications. The timer can't be disabled, however.

PPPremier Timer is a similar application with a floating window. Make sure, though, that you get the correct variant. If you use the OT/PPP control panel, get OT/PPPremier Timer, otherwise just use the basic PPPremier Timer. You can control the display appearance and button positions somewhat, and you can choose to open the PPP link upon launching, or to hide the window until PPP opens (so an automatic log on from an Internet application displays the window automatically too). It has a nice touch in that sounds can be programmed as you connect and disconnect to the Internet.

Finally, we come to PPPop. Probably the most adaptable of all these utilities, this one's worth its weight in gold. It comprises a single button to toggle PPP on and off, and a timer. However, from the application you can open all relevant control panels, set connect and disconnect sounds, launch and kill applications upon log on and log off, and – a superb feature – change server from the menu bar. This last trick prevents a trip back to your PPP control panel to change the Internet service provider you want to connect to (essential if you have more than one provider).

All these utilities (and, indeed, there are others) are shareware or freeware and available for download from most public sites. They're worth trying out to see which one (or more) suits you, and they're all worth any shareware fee you should pay.

UUNET UK First to Trial 56k-bps UK-wide

UUNET UK is now offering its PIPEX Dial customers the opportunity to trial access to the Internet at 56k-bps across the UK. This speed, made possible using US Robotics' x2 technology, is almost twice as fast as any typical analogue dial-up Internet service.

In May 1996, UUNET was first to provide 33.6k-bps access via its UK dial-up network. Now, UUNET is once again upgrading its UK dial-up network, allowing users with US Robotics flash upgradeable modems access to the Internet at the fastest modem speeds available.

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

Contact: UUNET, Tel: (0500) 474739.

UK AutoWeb Site Wins Top US Award

Anyone who's tried to track down car information on the Web knows it's a frustrating and time-consuming business. Carlounge at www.carlounge.com provides international car enthusiasts as well as industry professionals with an easy way of tracking down useful and detailed information on absolutely anything automotive.

Carlounge has been developed by mi2g, a UK-based Web development company specialising in the design of high-speed libraries of links. mi2g is not affiliated with any particular carmaker or publication, so Carlounge is guaranteed to have an impartial overview of what's going on in the world of motoring.

Games Publishers go Online with E-On

More top game publishers are choosing Entertainment Online as their partner in the emerging online market. Ocean and Maxis have signed licensing agreements with E-On, and the channel has agreed terms with Virgin.

The agreement with Ocean covers four games, including the best-selling flight simulation, F29 Retaliator. Maxis has licensed E-On to distribute two of its most popular titles: SimCity for Windows and SimAnt. Both are available in multiple languages, making them ideal for distribution via E-On, which has local language channels running in Germany, France and Italy.

Discussions with Virgin Interactive Entertainment Europe, now nearing completion, cover a number of games, the first of which is expected to be Jimmy White's Whirlwind Snooker.

Launched in 1996, E-On is the world's first dedicated online entertainment channel. E-On delivers the best choice of PC entertainment on the Internet direct to the home via telephone or cable. Priced at a flat rate of £5.99 per month, the channel provides exclusive access to single-player games that can be downloaded and then played off-line as well as some of the world's leading edge multi-player games.

For further details, check: **www.e-on.com.**

Contact: E-On, Tel: (0116) 2240000.

Yahoo! Hits One Million Page Views per Day

Yahoo!'s Web sites in France, Germany, and the United Kingdom are together serving an average of more than one million page views per day. Yahoo!'s European sites, **www.yahoo.co.uk, www.yahoo.fr,** and **www.yahoo.de,** were launched in September 1996.

European countries can expect rapid adoption of Internet use in 1997, according to US-based research firm, Intelliquest. Market studies by Intelliquest indicated 1·4 million Internet users in France, 4·7 million in Germany, and 2·5 million in the United. More than 20 million individuals across the three countries indicated their intention to use the Internet within 12 months, according to Intelliquest.

Yahoo! recently announced its world-wide traffic grew to an average of more than 30 million page views per day during the month of March 1997, a 50% increase over the 20 million page views per day average reported in December 1996. A page view is defined as one electronic page of information displayed in response to a user request.

Intel Unveils Audio '98 Roadmap

Intel has released its Audio '98 Roadmap outlining its vision and future direction of next generation PC audio on its developers' Web site.

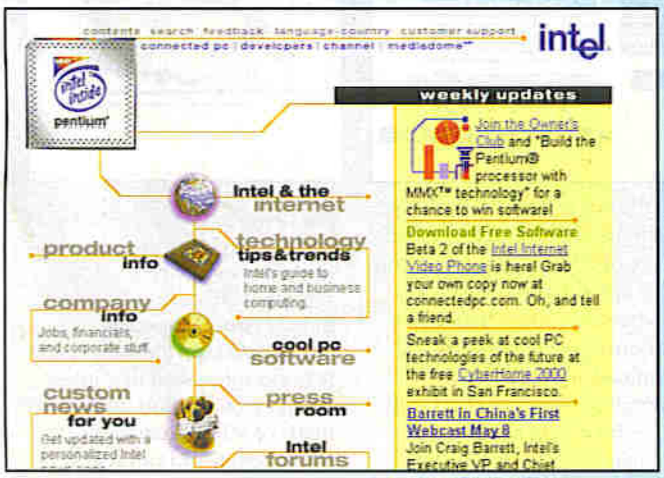
Recognising that excellent audio enriches the multimedia PC experience, the Audio '98 Roadmap discusses the impact of general trends and highlights specific technologies that bring high performance, built-in, quality analogue support to the consumer PC.

It also outlines how 'Digital Ready' capabilities, such as USB and IEEE 1394, complement the Audio '98 Roadmap and will enable peripherals and consumer equipment.

Dan Russell, marketing director for Intel's platform marketing group, told Electronics and Beyond, "Intel's Audio '98 Roadmap follows in the tradition of last year's collaborative Audio Codec '97 (AC '97) specification and previous Codec '96 guidelines. Based on extensive feedback from leading industry audio chip and peripheral vendors, and PC manufacturers, this Roadmap is intended to highlight the technical ingredients to deliver audiophile-quality audio to the PC."

Many leading audio chip companies have announced support of Intel's Audio '98 Roadmap with their AC '97-compliant products which are key building blocks of the next generation PC audio.

Analog Devices **(www.analog.com/new/new.html),**
Creative Labs **(www.creativelabs.com),**
Crystal Semiconductor **(www.crystal.com),**
Oak Technology **(www.oaktech.com),**
SigmaTel **(www.ccsi.com/~sigmatel),**
TriTech **(www.tritech-sg.com),**
VLSI **(www.vlsi.com),**
and Yamaha **(www.yamaha.com)**
all intend shipping products in 1997.



BM Clean Up Persil's New Media Image

Persil, one of the UK's leading detergent brands, is pursuing an aggressive new media strategy with the launch of a Web site at **www.persil.co.uk** and an interactive CD-ROM.

The Persil site provides surfers with style, fashion and clothes care advice presented in an interactive format, while the Persil CD-ROM includes a brand new game featuring two cartoon characters, Max and Sparky, as well as a section on clothes care and a virtual reality gallery.

Persil has been working with IBM since the project's inception. Julie Sawyer, spokesperson for Persil, told Electronics and Beyond, "IBM was chosen because it is one of the leading companies in multimedia with considerable experience in developing Web sites and CD-ROMs for major brands such as Persil".

Contact: Persil, Tel: (0800) 243 131.

Increase Modem Utilisation by up to 90%

Net.Jet, a new application from software re-publisher, Cross Atlantic Software, increases browsing speed to frequently visited Web sites, accelerates real-time browsing at new sites, and increases modem utilisation.

The unique software application is the only real-time Web accelerator that makes surfing the Web faster by utilising the modem connection to an ISP constantly, even when the user is not actively requesting information.

Net.Jet increases the speed of travelling from Web site to Web site, and can substantially reduce waiting time when downloading pages and links. The performance improvement varies, depending upon the users' browsing patterns.

Net.Jet carries a recommended retail price of £39.99. A free

30-day trial is available from Cross Atlantic Software's Web site.

For further details check: **www.crossatlantic.com.**

Contact: Cross Atlantic, Tel: (0171) 228 7036.

Apple Helps Connect Children in Cyber-Community

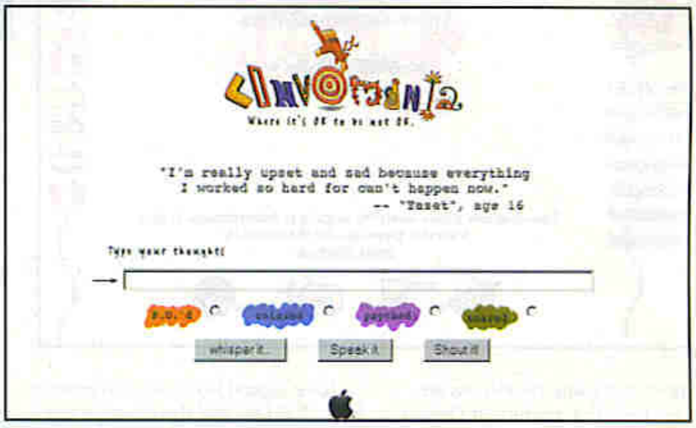
Apple Computer has announced Convomania at **www.mania.apple.com**, a Web site designed for children who are seriously sick or disabled. Convomania gives kids the opportunity to use the Internet to share their feelings and ideas in a cyber-community setting.

Alan Brightman, head of Apple's world-wide disability solutions group, told Electronics and Beyond, "Convomania is designed to provide kids with a place where they can share their thoughts and emotions candidly with other kids who are in similar situations".

"The kids who spend time on Convomania spend weeks and months at a time disconnected from their homes, their schools and their friends. Convomania intends to reconnect these kids", added Brightman.

The Web site has six areas designed to enable children to share their thoughts and ideas, and to get connected to others who are going through similar experiences:

- Say It – a place where kids participate in online chats.
- Stick It – a digital magnetic poetry game that helps facilitate expression.



- Share It – a message board for kids to share ideas 24 hours a day.
- Solve It – a place to ask questions and receive answers about what it's like to live with chronic illness.
- Sketch It – a digital art gallery focusing on illness-related themes.
- Show It – a forum for kids to express themselves using theatre art skills.

National Semiconductor Redesigns Web Site to Aid Engineers

National Semiconductor Corporation has given its Web site a facelift at **www.national.com**, to help engineers make faster and better decisions based on timely and detailed information. Since the first launch of the National Web site in 1995, traffic has rapidly increased to 20,000 visitors per day.

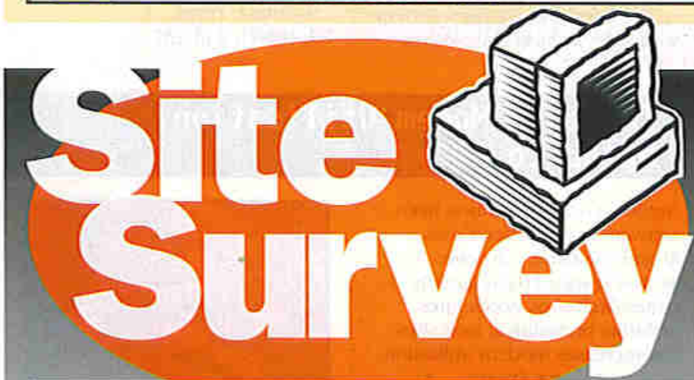
For the site redesign, the company conducted extensive market research with design engineers to understand how National's site can better meet the needs of today's engineer.

Phil Gibson, director of interactive marketing at National Semiconductor, told *Electronics and Beyond*, "Because we strive to maintain a close one-on-one relationship with every engineer, we have listened to what they are looking for and incorporated their needs into our Web site".

"One of the key findings to come out of the research was that a Web site should offer a range of navigation tools that reflect the varied needs, searching preferences and expertise within the engineering community", added Gibson.

To address this requirement, National added a pictorial search engine to its redesigned site, giving the engineer a total of four different ways of finding information.

National's research shows that today's engineers still depend heavily on hardcopy information, but these same engineers also believe that Web sites will eventually replace hardcopy information such as the traditional data book.

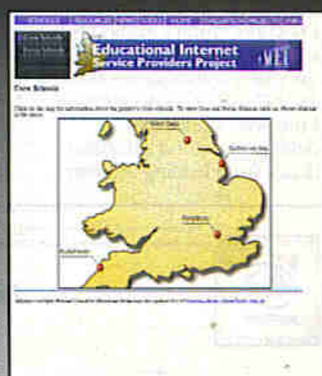


The month's destinations

Finding information about current versions Web browsers isn't easy these days – new versions of your favourite browser come and go almost weekly, it appears. Two sites which can help you keep up-to-date are **http://browserwatch.iworld.com/** and **http://www.browsers.com.**

The first is a pit-stop for all things to do with browsers, and you'll get a host of information regularly updated. The second is part of CNET's download.com (and, indeed, you'll find your Web browser auto-changes to the corresponding Mac or PC download.com Website depending on which platform you're browsing from.

Finally, if you're in schools education, check out the National Council for Educational Technology's Educational Internet Service Providers project Website at **http://www.lavender-ndt.com/eisp/** for information. Schools interested in joining the project can find links to see maps of schools currently in the scheme, and can register to join also.



ELECTRONICS and Beyond

next issue

Don't miss another great assortment of entertaining and easy-to-make projects and essential electronics information aimed at the novice constructor.

Digital Soldering Iron Controller

A superb fast-responding temperature controlled soldering iron featuring a wide range of tip heat settings and LCD temperature readout.

PLUS Stephen Waddington reviews the Electronic Servicing Manual, an encyclopedia of electronics maintenance and servicing.

Bob Norfield describes the operation, programming and applications of Programmable Logic Controllers (PLCs).

Part 3 of Cave Electronics by Mike Bedford examines underground photography methods.

Chris Lavers details the 1997 Mars Global Surveyor and Mars Pathfinder, with which NASA will be further exploring the Red Planet.

Douglas Clarkson examines the role of Metals in Technology.

Part 6 of Greg Grant's series What's in a Name investigates how many of the laws governing electronics engineering came to be passed.

Ray Marston looks at practical ways of using Hi-Fi analogue switching ICs in Part 2 of his User's Guide to Special Audio Processing ICs.

Oil Tank Level Controller

Avoid running on empty by using this project to gauge oil levels. Features a PIC microcontroller and analphanumeric LCD display.

Bob's Mini Circuits

Another selection of useful and fun to build small projects from Robert Penfold.

Issue 116 on sale Friday 4th July

ELECTRONICS and Beyond

BRITAIN'S BEST MAGAZINE FOR ELECTRONICS

Project Ratings

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

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

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

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

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

Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked at Maplin can be easily obtained in a number of ways: ❶ Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, telephone (01702) 554002. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance; ❷ Write your order on the form printed in this issue and send it to Maplin Electronics PLC, P.O. Box 777, Rayleigh, Essex, SS6 8LU. Payment can be made using Cheque, Postal Order, or Credit Card; ❸ Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554000; ❹ If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (01702) 552941. If you do not have a customer number, telephone (01702) 554002 and we will happily issue you with one. Payment can be made by credit card; ❺ If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place your orders directly onto the Maplin computer 24 hours a day by simply dialling (01702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system; ❻ Overseas customers can place orders through Maplin Export, P.O. Box 777, Rayleigh, Essex SS6 8LU, England; telephone +44 1702 554000 Ext. 376, 327 or 351; Fax +44 1702 554001. Full details of all the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Internet

You can contact Maplin Electronics via e-mail at **<recipient>@maplin.co.uk** or visit the Maplin web site at **http://www.maplin.co.uk**.

Prices

Prices of products and services available from Maplin shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%). Prices are valid until 28th February 1997 (errors and omissions excluded). Prices shown do not include mail order postage and handling charges. Please add £2.95 to all UK orders under £30.00. Orders over £30.00 and MPS Account Holding customers are exempt from carriage charges.

Technical Enquires

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics and Beyond*, the Technical Sales Dept. may be able to help. You can obtain help in several ways: ❶ Over the phone, telephone (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays; ❷ By sending a facsimile, Fax (01702) 554001; ❸ Or by writing to Technical Sales, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Don't forget to include a stamped self-addressed envelope if you want a written reply! Technical Sales are unable to answer enquires relating to third-party products or components which are not stocked by Maplin.

Maplin 'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini-Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service return the complete kit to: Returns Department, Maplin Electronics PLC., P.O. Box 777, Rayleigh, Essex, SS6 8LU. Enclose a cheque or Postal Order for the servicing cost (minimum £17) as indicated in the current Maplin Catalogue. If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost, plus parts.

TECHNOLOGY WATCH

with Martin Pipe

At the end of March, Britain's fifth terrestrial channel started broadcasting to the sound of the Spice Girls. Unfortunately, not everybody was able to enjoy this landmark in broadcasting history – even if they wanted to. At the time of launch, only 10 million UK households in major urban areas were within reach of Channel 5; compare this to the extensive UK coverage offered by other terrestrial channels. The main problem behind this is radio spectrum – or the lack of it. Because the UHF TV broadcast band is so congested – the band plans were drawn up before even Channel Four went on-air in 1982 – the number of frequencies available to the new kid on the block are few and far between. In many instances, the frequencies allocated clash with those used by UHF modulators (notably, channel 36).

As a result, Channel 5 had to employ an army of retuners to visit people, and adjust their equipment so that co-channel interference didn't affect them. Indeed, Channel 5 was under a legal obligation to ensure that "at least 90% of the households" in the reception areas were unaffected by interference – before broadcasts could begin. In some cases, the transmitters used by Channel 5 are less powerful than those used by existing terrestrial channels. Pictures can be quite grainy, unless viewers live relatively close to the transmitter. It's not been unknown for the results to be quite unwatchable, because the aerial has poor gain at the Channel 5 frequency chosen for that area. Channel 5 has quite a task ahead if it wants to achieve the coverage that BBC, ITV and Channel Four viewers take for granted.

Consequently, the fledgling has taken another approach to expand its reach quickly. On April 21st, it quietly started broadcasting from a transponder on the Astra satellite – presumably, to feed the cable operators with a good signal. If you have a modern satellite system and don't yet know, you'll find Channel 5 on Astra transponder 63 (10·921GHz, horizontal polarisation). It's broadcasting in soft-encrypted Videocrypt, which means that you won't need a smart card in your decoder. Interestingly (and unofficially), many Europeans with imported Videocrypt receivers will be able to tune into the channel – something that will appeal to British expatriates, many of whom live in Spain and have satellite receivers. The use of 'dual' satellite/terrestrial broadcasting is a common practice in Europe. Many of Germany's terrestrial channels, for example, adopt this approach.

I don't know why the other terrestrial broadcasters don't follow Channel 5's lead. Perhaps they will in due course – particularly when digital satellite broadcasting arrives at the end of the year – but for the moment, they're keeping mum. DVB, which is based around MPEG-2, is already being used by satellite broadcasters in some parts of Europe. As many as 10 channels can be squeezed onto a single transponder; this greatly reduces transmission costs (Astra charges around £5million per year for the lease of each transponder). The terrestrial broadcasters have committed themselves to a MPEG-2 based digital terrestrial system, which will occupy six UHF channels.

The drawback of any terrestrial approach is that it cannot offer coverage to everybody without significant expense. Compare this to satellite, which gives everybody reception provided that they live within the footprint and have a clear view of the sky. With satellite coverage, the small proportion of the population not served by a decent terrestrial signal strength might be able to get reliable reception at last. After all, their licence fees should give them the right. A few years ago, I can remember watching a news story in which helicopters were despatched to remote islands to look out for licence dodgers – what an insane waste of public money! If they could actually make out a picture amongst all the noise, good luck to them! Ironically, viewers in these outlying areas – which rely on satellite for TV entertainment – will get better Channel 5 reception than many of those in built-up areas!

But all UK dish owners could benefit when the Big Four come to their senses. Satellite broadcasting also allows viewers to enjoy high-quality transmissions that are unaffected by weather conditions, as long as the dish is of the correct size and set up properly. I'm sure that terrestrial viewers in the UK are familiar with the extremely annoying phenomenon of co-channel interference from European terrestrial broadcasters – notably Dutch ones, at least here in the south-east of England. Such effects are associated with high-pressure weather systems, which are responsible for the radio propagation phenomenon of tropospheric ducting. This doesn't affect satellite broadcasting.

Residents of built-up areas would also benefit from dual broadcasting. For a start, poorly suppressed car alternators and domestic electrical equipment gives rise to random interference; the AM system used by terrestrial TV is susceptible to this. In comparison, satellite TV uses FM, and so isn't. In areas with a high density of buildings, TV pictures tend to suffer from 'ghosting', which is caused by multipath distortion. Here, the TV aerial picks up not only the directly broadcast line-of-site signal from the transmitter, but also 'delayed' ones that have been reflected from metal objects such as the frames of tall buildings. When Canary Wharf was built in London's East End, local residents complained that their TV reception had dropped noticeably in quality.

Although most are scrambled and require a subscription, there are a few in the 'clear' channels on Astra apart from the soft-scrambled Channel 5. You'll find many more, however, on other satellites. Eutelsat's Hot Bird cluster, for example, carries around 30 channels in a variety of European languages (French, Turkish, German and Italian, amongst others) and themes (news, music and general entertainment). Some satellites are less busy, but no less interesting. Intelsat K, for example, carries 'raw' news-feeds for use by broadcasts. At the time of writing, the General Election is imminent, and we can expect many such news-feeds.

These satellites, and the often fascinating programmes that they carry, can be received if you have a motorised, 'steerable' dish that can track the arc upon which they're located. Although pukka multi-satellite systems based around such dishes tend to be expensive, there is another option – motorise your existing dish. Maplin sells one of these devices, which is known as the Satwalker. It's a DIY-installation mount upon which your dish sits, and is controlled by an indoor 'positioner' unit that stores the location of each satellite. Within the mount is a reed switch, which is periodically tripped by a magnet coupled to a driven gear. As the gear revolves, the reed switch generates a pulse train which is used as positional feedback by the indoor unit.

These days, most of the European satellites can be picked up adequately by an 60cm dish provided that the microwave electronics (the LNB) is quiet. A 1m dish will pull some of the weaker channels in better, however. Your receiver does need to be a good modern one, however. It should offer an extended tuning range (at least 950 to 2,050MHz), a large number of channel stores and tunable audio channels. If the receiver offers 22kHz tone switching, you will be able to replace your LNB with a 'universal' one, which is capable of tuning into the higher frequencies used by some satellites – notably the French Telecom ones, which will appear in black and white if your TV cannot handle SECAM colour. Although many channels and feeds are going digital, a motorised dish will offer plenty of enjoyment and interest for some years to come.

Martin Pipe welcomes comments and ideas.
E-mail him as: whatnet@cix.compulink.co.uk.

ELECTRONICS and Beyond

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