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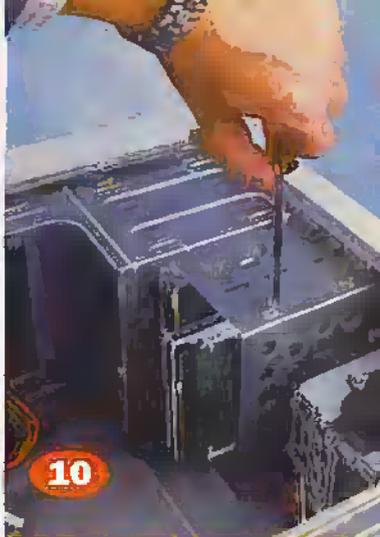
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ELECTRONICS

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Sales of the April Issue of 'Electronics and Beyond' with the free Maplin Catalogue CD-ROM have exceeded our expectation with virtually all Maplin and W. H. Smith stores selling out. For those readers who missed this issue, there are still copies available by mail order – but hurry they are selling fast. In order to avoid disappointment of any future offers why not take out a years subscription. Over the next three months we will be giving away two exciting prizes each month in a subscription draw. Full details can be found on page 80.

This year sees the centenary of Marie Curie coining the term 'Radiation' and to commemorate the occasion, we begin a short series on radiation. In a similar vein, we take a look at the history of weighing starting with Egyptian methods and finishing next month with the latest technology.

Since computers feature just about everywhere in our lives, this month sees the start of a two part series on sound cards, and Mark Brighton continues his series by showing you how to assemble all the computer parts and make a working PC. We hope to bring more articles and projects on computers and software in future issues.

In the August issue we will announce the winner of the Quickroute 4.0 competition from issue 125, so hurry the closing date for entries will be Friday 29th May 1998.

Paul Freeman-Sear, Publishing Manager



Britain's Best Magazine for the Electronics Enthusiast

NEWS

REPORT

Sun Unveils Computer Rings at Java Conference



Sun Microsystems' JavaRing made its debut at the Java Developer Conference on March 23 in San Francisco. The first 'computer in a ring' holds the user's identification and preferences, and was used by the 14,000 conference attendees to register, log in coffee orders, enter contests, and check messages. By connecting their personal computer rings to the network, the attendees created a virtual supercomputer from the combined computing power of their rings.

For further details, check: www.sun.com.
Contact: Sun, Tel: (01276) 20444.

FoneBook Overcomes Challenge of Programming Numbers into Mobile

FoneBook PLUS, is a PC-based address book that shares address information with mobile phones from Newbury based start-up Paragon Software.

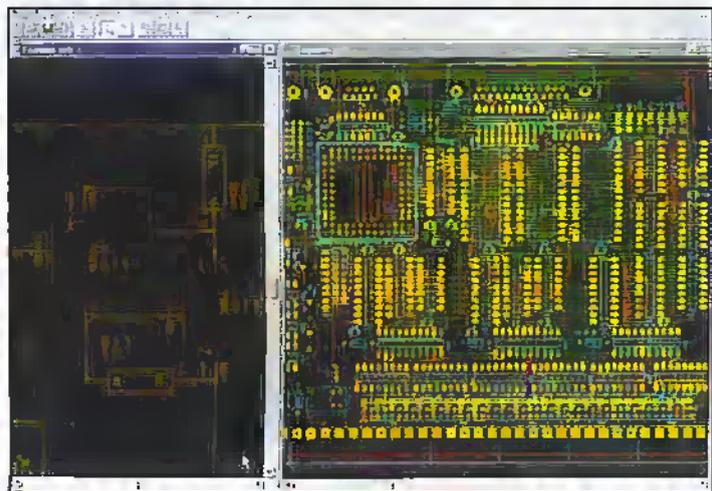
FoneBook PLUS integrates the PC and mobile phone seamlessly using a simple cable connection, allowing users to exchange name and phone number information between a PC and a mobile phone.

"How many mobile phone users know how to store names and numbers on a mobile phone? Research shows that it's less than 1 in 10 and even less regularly update or amend their numbers. We believe FoneBook will change the way people make use of the features on their phone, helping them to stay connected and stay in touch," said Colin Calder founder and managing director of Paragon Software.

For further details, check: www.paragonsoftware.com.
Contact: Paragon Software, Tel: 01635 524909.



Work Station CAD Performance at PC Price



Easy-PC for Windows 95 is the fourth generation printed circuit board (PCB) and schematic design system from Number One Systems. The computer aided design system is shipped

with a full set of component libraries. New components can quickly and easily be added to existing libraries.

The use of technology files, similar to style sheets in a word

processor, makes it easy to configure new designs. The technology file also contains all the manufacturing information relating to the design minimising the chances of costly errors occurring when the board is made.

Easy-PC can be linked to a full range of optional circuit simulators including Analyser and Pulsar from Number One Systems.

Easy-PC can manage complex design projects including multi-sheet schematics, and copying and renaming all the associated files automatically if a layout or schematic is saved under a different name. This makes it very easy to re-use older projects as templates for new designs.

For further information, check: www.numberone.com.

Contact: Number One Systems, Tel: (01480) 461778.

Dane-Elec Launches Internet Sharing Box Solution for Multiple Users

A cost effective modem concentrator from Dane-Elec allows multiple computer users to connect to the Internet using a single modem and single Internet service provider (ISP) account. Using the ISB100, PC or Apple Mac users connected to a local area network (LAN) are able to dial-up to an Internet Service Provider (ISP) for e-mail and access.

The ISB100 enables users to

utilise the full bandwidth of a single modem. The maximum data connection speed is over 230kbps using a digital ISDN connection to an Internet Service Provider (ISP), or 56kbps using a high-speed analogue modem, over a conventional telephone line.

For further details, check: www.dane-elec.co.uk.

Contact: Dane-Elec, Tel: (0181) 391 6900.



Philips Establishes Light Emitting Polymer Unit

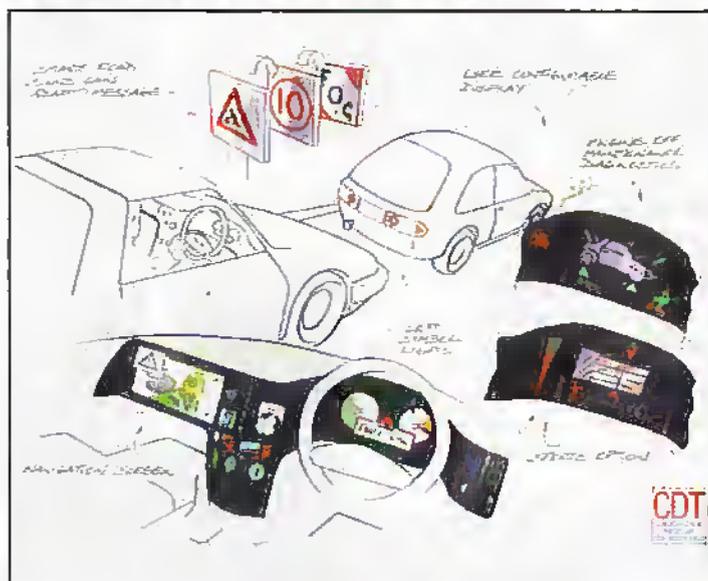
Philips Electronics is set to establish a new business unit for the development, manufacture and sale of light-emitting polymers (LEPs), used in small and medium-sized displays.

LEPs, made by sandwiching a thin film of semi-conducting plastic between two electrodes are set to replace Liquid Crystal Displays (LCDs) and other technologies for use in handheld phones, calculators and car dashboards.

The technology was originally discovered by Cambridge Display Technology (CDT) in 1992, who licensed the technology to Philips in 1996.

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

Contact: +31 40 272 20 91.



Diet Pentium from Intel

Intel's new Celeron processor is intended for use in low-end PCs. The device is essentially a Pentium II device without the Level 2 cache, which is ultimately the feature, which makes it run so quickly. A full specification and first products based on the device are expected to be announced in April.

For further information, check: www.intel.com.

Contact: Intel, Tel: (01734) 403000.

Wireless Marriage

US start-up, RF-Link Technology has developed a Wireless PC@TV product that allows an Internet link via a PC in one room to be displayed on a television in another.

A scan converter translates the PC's video display signals into signals that a TV can process, and sends the audio and video signals using a radio-frequency transmitter and receiver.

The signals can travel up to 100 feet, and a wireless keyboard allows the user to manipulate the PC while watching the action on the TV in another room.

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

Contact: RF-Link Technology, Tel: +1 310 787 2328.

Lucent Technology Speeds Data Over Light

New optical technology from Lucent Technologies will give fibre optic networks a boost, moving the equivalent of 90,000 sets of encyclopaedias per second.

The technology called dense wavelength division multiplexers (DWDMs) acts like a prism to increase the number of light streams, by an order of magnitude, capable of carrying data.

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

Contact: Lucent, +1 888 584 6366.

Be Unveils Intel Operating System

Be has announced a new version of its BeOS operating system software, designed to work with Intel-based machines. Release 3.0 for Intel is still primarily for programmers and enthusiasts, but a Release 4.0 version for general consumers is scheduled for a September.

The BeOS is built from the ground up to be a multimedia system, with streaming audio and video support designed into the kernel. Be's goal is to capture 25 per cent of the multimedia publishing market with its Release 4.0.

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

Contact: Be, Tel: +33 1 49 06 73 77.

More Small Businesses Use Computers

An IDC poll indicates the number of small businesses that use PCs rose to 78 per cent in 1997, up from 73 per cent in 1996. The increase ends several years of flat or minimal growth. IDC tied the rise to lower PC prices, easier-to-use software and a new crop of computer-literate business owners.

For further details, check: www.idc.com.
Contact: (0181) 987 7100.

Apple Demos 400MHz Mac Apple Computer

CEO Steve Jobs last month demonstrated a Macintosh running on a 400MHz copper-based chip based on technology developed by IBM. The new microprocessor, which will be produced under joint arrangement by IBM and Motorola, will be available for Macs in early 1999.

For further details, check: www.apple.com.
Contact: (0181) 569 1199.

TDK Introduces Reference Grade Audio Recordable CD

TDK will introduce its new CD-RXG, a reference level recordable CD (CD-R) for digital audio recording with consumer CD-R recorders.

The new medium delivers an impressive sound performance and ensures optimum record/playback compatibility with any of today's CD-R recorders and CD players through an extremely low error rate over a wide range of write laser power.

For further details, check: www.tdk-europe.com.
Contact: +49 231 9077 0.

3Com Delivers Third Generation Palm Pilot

The third generation of the Palm Pilot, Palm III combines infrared capabilities, increased memory, and enhanced user interface and industrial design with the original Palm Pilot concept.

With the Palm III organiser's IR capability users can share records and applications wirelessly by simply 'beaming' information into another user's Palm III organiser at the touch of a button. This provides new data communications opportunities both for individual users and organisations.

With 2MB of RAM, users have ample room to add a wide array of applications, allowing greater expandability and customisation. The Palm III organiser is flash upgradable, making it easy for users to upgrade the Palm OS software without replacing the memory card.

For further details, check: www.3com.com.
Contact: 3Com,
Tel: (01189) 228200.

Chip-Tracking Foils Thieves

The Electronic Industries Association has adopted technology from Data Matrix that enables chipmakers to mark each semiconductor with a microscopic code that identifies the vendor and includes individual serial numbers. Chip thieves will not be able to remove the code without ripping off the casings, which will have the effect of destroying the chips.

For further details, check: www.eia.org.

Contact: Electronic Industries Association, +1 703 907 7500.



BBC Signs Up Discovery for Science Coverage

The BBC has signed an agreement with US media company Discovery to create the largest global force in factual science broadcasting. The agreement will see the creation of a worldwide network of quality channels as well as the BBC's own network in the US.

The global alliance between BBC Worldwide, the commercial arm of the BBC, and Discovery Communications Inc (DCI) will lay the foundation for: a joint venture to co-produce and commission factual programmes; and a family of quality factual television

channels around the world, drawing on the production, archive and commercial strengths of BBC and DCI.

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

Contact: BBC,
Tel: (0181) 743 8000.



Cornell Researchers Rotate Single Molecule

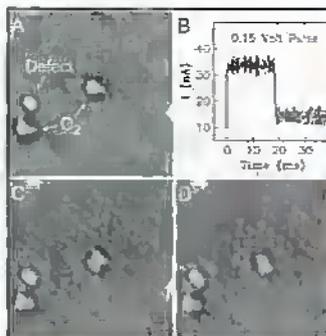
As electronic devices grow ever smaller, single molecules could one day become components of electronic circuits or even moving parts of tiny machines. Cornell University researchers have now demonstrated one way this could be done, by isolating a single oxygen molecule and causing it to rotate on command.

Brief voltage pulses applied to the molecule cause it to rotate between three orientations spaced 120 degrees apart, something like a radio knob that clicks into one of three stops. If the voltage pulse is not stopped, the molecule continues to rotate between the three orientations, turning like a tiny motor.

In addition to demonstrating a concept that could be used in ultra-small electronic devices, the experiment provided basic research information about the nature of the chemical bond formed when an oxygen molecule is adsorbed to a platinum surface and how electrons can cause the motion of the molecule. Platinum is widely used as a catalyst to speed oxidation reactions, for example in automobile catalytic converters.

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

Contact: Cornell University,
+1 607 255 3651.



National Launches World's Smallest Integrated Circuit

National Semiconductor has introduced a new microchip, so small that the packaged device is about the size of a flake of coarse-ground pepper. The tiny package houses an integrated circuit called an operational amplifier, which is used as a basic building block in a wide variety of electronic systems ranging from cellular phones to full-size computers.

The chip, identified as the LMV321, is the industry's smallest ever-operational amplifier and is the first integrated circuit to be packaged in the miniature SC70-5 package. This package is only 2.0 x 2.1mm and has previously been used only to house 'discrete' devices such as single transistors.

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

Contact: National Semiconductor,
Tel: (01475) 633733.



With only twenty months to the end of the century a satisfactory outcome to the computer date-change problem is now impossible, Robin Guenier head of Taskforce 2000 warned the government this month. "Damage is inevitable," he believes, potentially affecting millions of people.

Taskforce 2000 believes that successful damage limitation will depend on two factors: openness and personal accountability. Also, the widespread involvement of ordinary people is critical, as is using common sense to cut corners and take calculated risks.

Taskforce 2000's recent contact with business has demonstrated that fixing the date-change problem is proving to be an extraordinary challenge and that businesses that are getting on with it are, almost without exception, finding it to be more difficult than they expected.

Furthermore, budgets are escalating rapidly and many large companies are a long way behind where they should be by now, and are struggling, for example, with unexpected supply chain and embedded software problems, and with the massive difficulties of testing their systems.

Taskforce 2000 claims that the public sector is way behind the private sector leaders. Big computer jobs are usually late. This one – the biggest ever – is made worse by two factors: rapidly reducing time and too few skilled people.

"It is now fanciful to pretend that the problem will be solved," said Guenier, executive director of Taskforce 2000. "It is, put quite simply, too late. However, if we start now, a great deal can still be done to minimise the inevitable disruption to people's lives."

"Taskforce 2000 has clear proposals to deal with this. This is a classic example of a problem where the best is the enemy of the good – there is no time for bureaucratic detail and delay. Indeed, a patchwork job that mitigates the worst of it is all that is practicable," he continued.

Key features of the Taskforce plan are:

- ◆ The Government should unambiguously confirm that we are now dealing with an emergency – advising people of the possible consequences and encouraging wide co-operation to avoid an unacceptable outcome.

NEWS

REPORT SPECIAL

The Millennium Bomb – It Is Now Too Late?

- ◆ Ministers should publish lists of the critical systems in their departments affected by the problem – stating levels of confidence of achieving compliance, budget details, the names of the people responsible for compliance and details of the contingency plans being put in place where there are any fears of failure.
- ◆ The chief executives of all major utilities should be requested by Government to provide a public assurance that there will be no service interruption as a result of the date-change – the executives having responsibility for ensuring this should be named.
- ◆ The Stock Exchange should require all listed companies to provide full details of compliance budgets and

plans including those relating to dependencies. An outline of any contingency planning should be included together with the names of the executives responsible.

- ◆ The Bank of England and the Financial Services Authority should extend their current activities in this area to ensure that any potential failures in the financial sector are contained.
- ◆ Details of national contingency plans should be made publicly available by August this year. This is so that business people and others can relate them to their own planning
- ◆ The Prime Minister should call an urgent meeting of the CEOs of the largest IT businesses in the UK. The objective would be to

determine what special measures can be taken to make more resource available to help minimise the problem

- ◆ The British Government should, with the US Government, call an urgent international conference to encourage action throughout the global economy and recommend the emergency measures that are necessary to minimise international disruption.

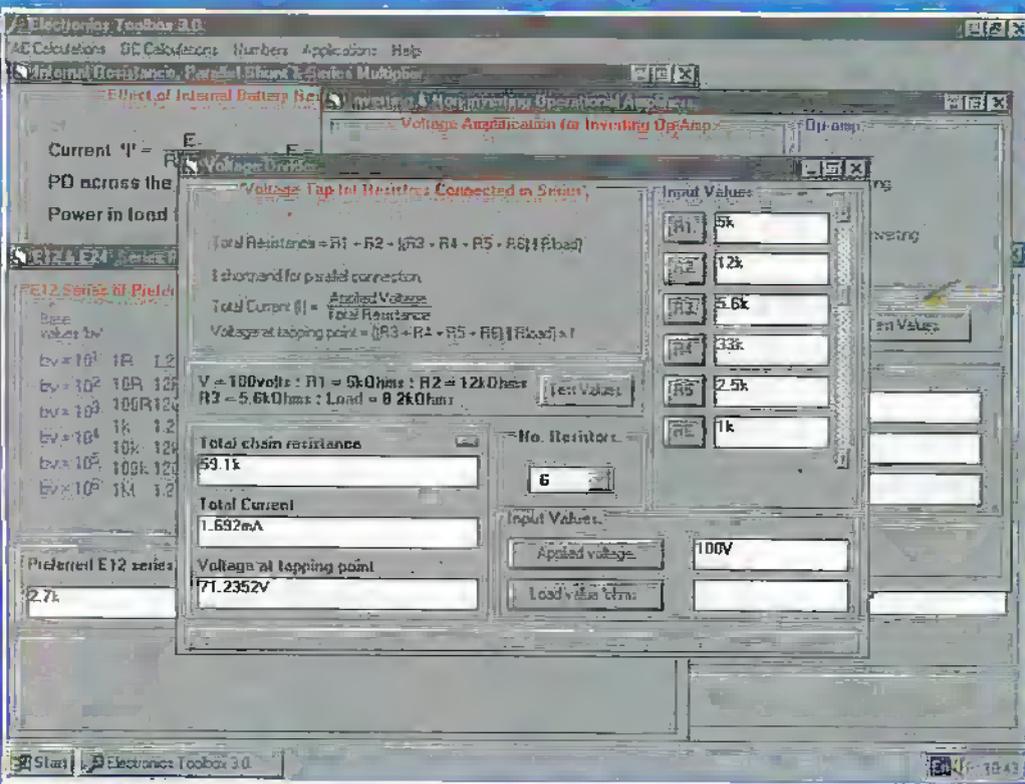
Taskforce 2000 has been saying for months that the single most effective contribution to a reduction in potential damage would be for the European Union to postpone the introduction of the single currency. That recommendation has been ignored and, in any case, Europe's rush towards EMU seems almost unstoppable. But, to get the debate into the open, the Government should call for the European Commission to publish a report now on how, given the extreme shortage of skills and resources to do either job, it believes both can be accomplished in time

"Taskforce 2000 is ready and waiting to co-operate with Government and others in considering these proposals in more detail and in putting them into effect. The nature of this emergency is such that all interested and knowledgeable parties must work together to tackle this unprecedented challenge," concluded Guenier.

For further details, check: www.taskforce2000.com and www.year2000.com. **ELECTRONICS**

Electronics Toolbox 3.0

A quick and easy way to make electronics calculations.



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Numerical Accuracy.

The default setting for accuracy is four decimal places. However, up to fifteen places may be selected when the output results produce very small voltages and currents.

Inputting of values.

Selecting a particular input i.e. voltage, current, frequency etc. is via a dialogue box whereby additional number formatting is performed. Values can be input using electronics symbols i.e. Ohms, kOhms, MOhms or μA , mA and Amps.

Output Results.

Resultant values are output again using electronics symbols i.e. Hz, kHz, MHz or μV , mV, V etc. Formatted numbers are easy to read and readily identify changes. The use of scientific notation is avoided wherever possible to make the calculations meaningful.

One professional recently described the Electronics Toolbox as more useful than his scientific calculator which cost three times as much. This program is not intended to be an educational package as is the case of the Electronics Principles 5.0 title. Its appeal is for a quick and easy calculating solution, without the user having to try to remember or look up a particular formula and where individual component values can be changed to see the effect on the result.

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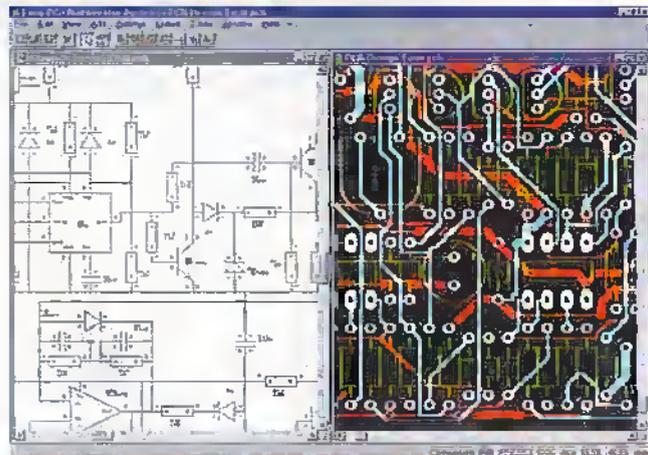
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Science Line



Why is a scientist called a scientist?

The word scientist comes from the Latin verb 'scire' which means to know. So a scientist is one who knows or learns. Before the word scientist was used a couple of hundred years ago, scientists were called natural philosophers. Philosophy comes from the Greek words meaning 'lover of true knowledge'.

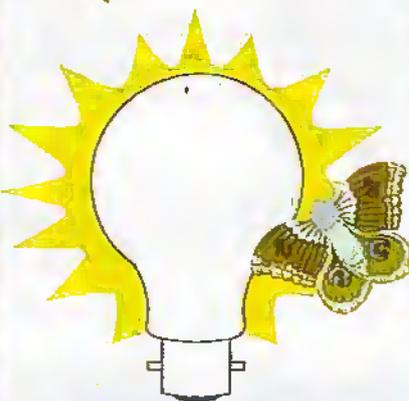
Do people grow in space?



In space, the body does not experience the same downward pull of gravity that it does on the Earth. As a result, the gaps between the vertebra in the spine expand and astronauts do actually get slightly taller. When they return to Earth, the gravity quickly squashes them back to their normal height.

Why do moths fly towards light?

Because they think it's the Moon! Moths are used to navigating by the light of the Moon - they fly keeping the Moon on one side. When a bright, artificial light is present they try to do the same thing, but to keep it in a fixed position they end up flying round in circles. The brightness of the light disorients them and their orbits get smaller and smaller until eventually they hit the light.



How long do spiders live for?

Ordinary spiders live for about a year, although up to five to six months of this may be spent in the egg stage. However, some south American tarantula can live for as long as twenty years, while some tropical jumping spiders only live for three months.



What causes hiccups?

Underneath your lungs is a large muscle called the diaphragm. When it contracts, it pulls down on the lungs making you breathe in. Hiccups are caused by your diaphragm suddenly contracting making you breathe in suddenly to make a funny sound.

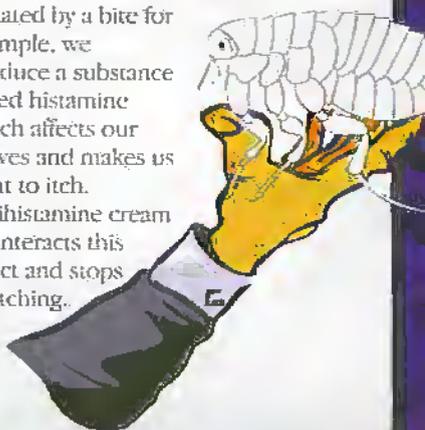


Why does it get colder as you go up a mountain even if you're getting closer to the Sun?

There are several reasons but one of the most important is the fact that as you go higher, the air becomes thinner. Air only holds onto heat because of the particles within it. The fewer the particles, the less heat can be stored in the air.

Why do we itch?

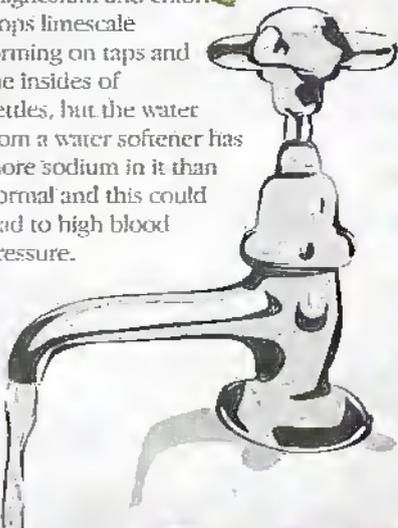
Itching is an early warning system to protect our bodies from harmful substances. When our bodies are irritated by a bite for example, we produce a substance called histamine which affects our nerves and makes us want to itch. Antihistamine cream counteracts this effect and stops us itching.



A selection of the most popular questions that people ask

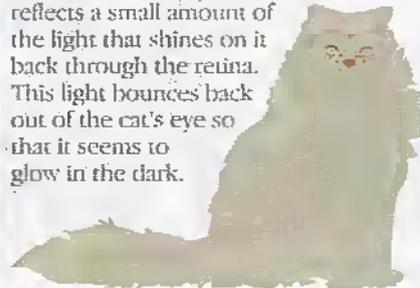
How does a water softener work?

Water softeners work using a principle called ion exchange. Magnesium and calcium in the water are taken out and replaced with sodium from the salt in the water softener. The removal of magnesium and chlorine stops limescale forming on taps and the insides of kettles, but the water from a water softener has more sodium in it than normal and this could lead to high blood pressure.



Why do cats eyes glow in the dark?

The back of the eye, the retina, has a coating behind it called tapetum. This reflects a small amount of the light that shines on it back through the retina. This light bounces back out of the cat's eye so that it seems to glow in the dark.



Why do ice cubes go white?

When ice is made in a household freezer, the freezing starts from lots of different points within the ice cube rather than from one central point. This means light that enters the cube gets scattered so much that the cube isn't transparent.



Why do men go bald?

Men go bald because of a sex hormone called testosterone which occurs naturally in all our bodies. Men all have about the same amount of testosterone (about ten times as much as women) but some are more vulnerable to its effects than others. Testosterone works by stopping some of the hair roots producing hair.



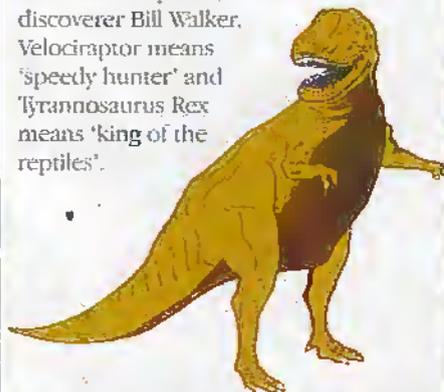
What's the poison in apple pips?

Apple pips actually contain cyanide and you can be poisoned by them if you eat too many (about a cupful).



Who invented dinosaur names?

The word dinosaur means 'terrible lizard'. Individual dinosaur species were named by the scientists who first found them, often in Greek or Latin. They named them after some unusual feature about the animal, where it came from, or even who discovered it. For example, *Baryonyx Walkeri* means Walker's heavy claw because of the discoverer Bill Walker. *Velociraptor* means 'speedy hunter' and *Tyrannosaurus Rex* means 'king of the reptiles'.



How much rubbish is there floating in space?

The bits of old satellites and rockets that orbit the Earth are a serious problem. There are about 7000 major objects orbiting the Earth and only about 100 of them are still working. There are also 40,000 smaller bits and pieces, mainly debris from exploded rockets. Then there are over three million particles, such as flakes of paint, specks of insulation and exhaust fumes. The Mir space station and the Space Shuttle have been hit by flakes of paint which have - at a speed of 18,000mph plus - pitted the windows.



ABOUT SCIENCE LINE

Science Line was started in March 1994 during the first science week, and is an educational charity funded by the National Lottery, Wellcome Trust, the Royal Society, OST (Office of Science and Technology), some of the research councils and Channel 4.



Telephones are staffed by science graduates from various disciplines, and if we are stuck for an answer, we have a database of 1000 experts who have volunteered to help us out. We can be contacted on the number shown below (calls charged at local rates), and our lines are open from 1pm to 7pm Monday to Fridays.

Just over 60% of all calls are answered on the day, with the rest normally within a week - after adequate research.

The average age of all callers is 28, with 64% of callers being male. 35% of questions are physics or astronomy related, 35% biology or medicine related, 10% chemistry, and the rest on environment, engineering, technology, geology and allied subjects.

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Building & UPGRADING PCs

PART 3

Now you have an assortment of PC parts, Mark Brighton guides you through the sequence of assembling your computer.

Last month, we took a look at each individual part needed to build a well specified multimedia PC and put together a shopping list of parts needed to make the PC. By now, you should be ready to start putting together your own PC using just your bare hands, a cross head screwdriver and a pair of pliers. Before you open any of the packages and handle the printed circuit boards, just a word or two about anti static precautions. Yes, I know, I've said it all before, but I really cannot emphasise it too often, because it does make a big difference.

Static precautions

Modern carpets and other furnishings, or even the clothes you are wearing, can cause immense static charges to build up on your body as you move about your home, especially at this time of year when the central heating is drying up the air. Wear an anti static wrist strap and attach the lead to an earthed object such as a water pipe or radiator (find a bare metal part). Make sure you are using a strap and lead with a built-in resistor though, or you could be putting yourself in danger of severe electrocution should you touch anything live! The Maplin FE29G at £9.99 is a comfortable wrist strap with a built in curly cord, incorporating a 1MΩ resistor and has a convenient crocodile clip to fix to an earthed object. If there is no earthed object handy, but there is a mains socket nearby, the AS38R at £5.38 is a special mains plug with a 10mm earthing stud on the back of the plug, especially suited to professional wrist strap and cord fittings borrowed from work!

Failing all else, if no wrist strap is available, momentarily touch an earthed object, then the metal case of the PC from time to time whilst working and try not to wriggle about too much in-between, or those nylon undies will cost you dear!

sure that all pieces are removed as a single loose screw after power is applied can do an awful lot of damage.

Turn the case upside down on your work surface. Place the four large plastic feet into the mounting holes in the bottom of the case (from the outside!) and push a plastic rivet firmly into the centre of each foot to fix it into position. These should push in with firm finger pressure, but if they prove reluctant, use the point of your cross head screwdriver on the dimple in the centre of each rivet and push it firmly into place.

All orientation instructions (top left; etc) assume you have put the case down on its right side (as viewed from the front) and are looking into it through the left side, with the front panel nearest you.

Motherboard mounting points

Now we come to the motherboard. Although only moderately static sensitive, you should take the precautions described above when handling this board. Turn the case onto its side so that you may look into the opened case. Unpack the Motherboard and offer it into place on the base plate inside the case. You will notice that there are a number of threaded holes inside the



Photo 1. Wrist strap and earthing plug. Maplin Order Codes FE29G and AS38R.

Starting construction

The obvious first item to put onto your worktop is the case. Case styles vary enormously, but the case we have suggested is a mini tower case that has removable sides for access. Note that most cases have some sharp edges inside, although the case we have suggested is a good quality one that has far fewer sharp edges than most. Mind your palms and fingers whilst working! Unwrap the case packaging and unscrew the two screws holding the left hand side of the case on. Slide the removable panel slightly back and out from the top and put it aside. Inside the case, you will find a bag containing four feet and plastic rivet inserts, a bag full of assorted screws and brass mounting pillars, and a bundle consisting of the mains lead and a plate that we will fit to the rear of the case later. The bags have been known to come open in transit. If this happens and your case is full of small screws and brass bits, spend some time to make

case and these will accept the brass threaded mounting pillars in the hardware bag in order to mount the motherboard and stand it away from the base plate.

The motherboard should be aligned with the long sockets at the rear of the case, at the left (see photo 2). Move the motherboard around slightly and you will see that a number of the mounting holes in the board align with corresponding holes in the case. If you are using the case and motherboard recommended in last month's article, five of the mounting holes on the motherboard will match with holes in the case. Take four of the hexagonal brass pillars and screw them into four of the five holes you have just identified, tightening them moderately hard with pliers. You will see that the top left mounting point on the case is in fact a slot and will use a special mounting gizmo (its in the hardware bag). Slide the gizmo into place, with its threaded hole uppermost.

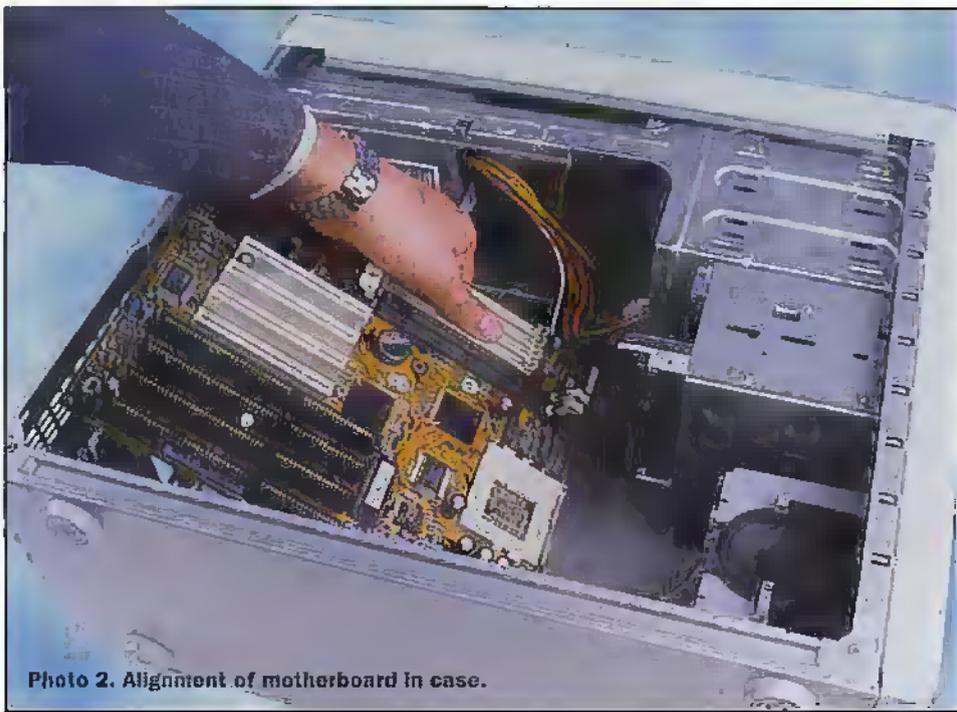


Photo 2. Alignment of motherboard in case.

Fitting the CPU

Although it is quite possible to fit the CPU at a later stage, after the motherboard is in the case, it is easier to fit it beforehand. Before you start, consider the fact that the CPU is a very static sensitive animal and may be easily damaged by the wrong sort of handling. Do not touch the CPU pins when handling the CPU. Put the motherboard and CPU, still in its packaging on the work surface in front of you. The CPU socket on the motherboard is a Zero Insertion Force (ZIF) type, which means you can just place the chip into its socket with the lever up, then push the lever down and towards the chip to lock it into the socket. Ensure that the lever is opened before you begin.

Wearing your wrist strap, or touching an earthed object before you start, sit down, open the CPU packaging and carefully remove the CPU, holding just the sides of the device. The corner with the bit clipped off of it is the corner which fits near the edge of the motherboard, furthest from the lever hinge side of the socket. To clarify that, you will see that just one corner of the socket does not have holes reaching all the way to the corner. If you turn the CPU over before fitting it, you will see a corresponding pin pattern, so that the CPU will in fact only drop into place one way around.

Once the CPU is in place and is sitting quite flush with the ZIF socket, close the lever down and hook it under the catch on the socket body (see photo 3).

Fitting the CPU heatsink/cooling fan

Having been very gentle with the CPU so far, we have to lean on it a little here! The heatsink and fan assembly is a vital component of a fast PC, removing the huge amount of heat generated by the processor as it runs. The suggested unit comes as a one piece assembly with a slightly unusual mounting clip; in that one side of the clip is a separate pivoting part. This makes it far easier to remove in the future, should you ever feel the need to upgrade again!

Although not on last month's shopping list, you may find it a wise precaution to smear a little thermal transfer compound, such as that dispensed from a syringe pack (FL79L), on the mating surfaces of the heatsink and CPU.

Unpack the fan assembly and lower it onto the CPU. Note that the assembly will only fit one way around, with the pivoting clip on the ZIF lever hinge side of the CPU socket. Lower the fan at an angle to allow the fixed clip to engage onto the hooked part of the socket, then push the assembly flat ensuring that the heatsink is located centrally over the CPU. Push the pivoting clip out and down, then under the other plastic hook on the socket, and the unit is fixed (see photo 4).

Alternative motherboard/case mountings

Now, if you are not using the suggested case, but are fitting the motherboard inside a desktop case, you may find that the area of the motherboard with the SIMM and DIMM slots is obscured by the power supply case. This is fairly easily removed if you want to go ahead and fit the motherboard now, but you may wish to refer to the section on fitting the SIMM's

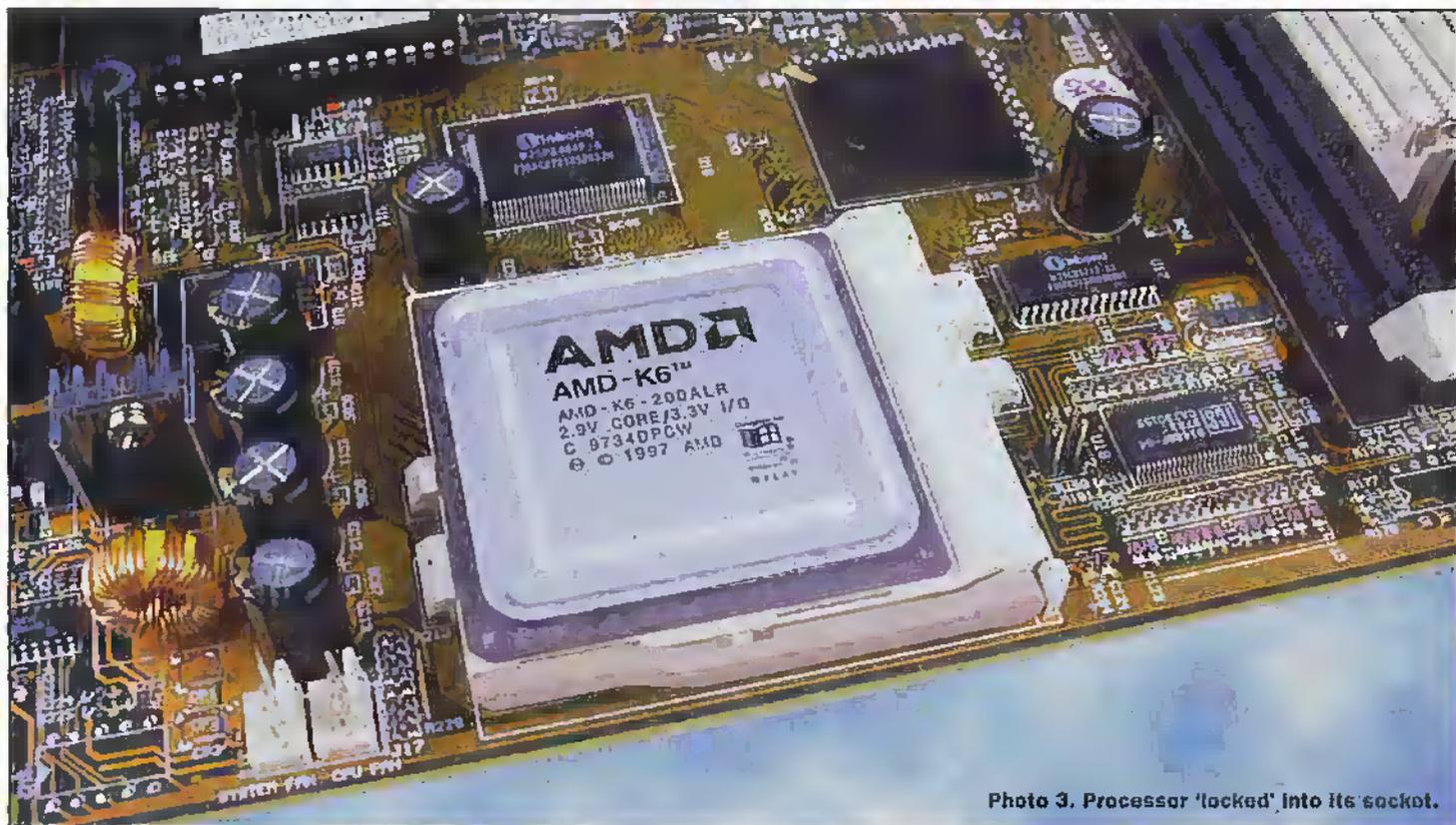


Photo 3. Processor 'locked' into its socket.

now and fit them before the motherboard goes into the case.

Those of you not using the case suggested may also find that you have a collection of mushroom shaped nylon stand-offs with broad disks built into them. All of the mounting points on the case will be slotted in this instance, except for one or two holes near the back of the case, and the motherboard is mounted as follows. After aligning the motherboard with the case to identify the mounting holes to be used, snap a mounting pillar into each of the matching mounting holes, from the underneath of the board.

At least one of the threaded holes at the back of the case should align with a hole on the motherboard and this will need to have a threaded mounting pillar screwed into the hole in the base plate. If two threaded holes match the motherboard, so much the better for a stable fixing. Fit two pillars if possible, but check carefully before you fit the motherboard and fix it that you haven't inadvertently fitted a mounting pillar somewhere under the motherboard where no hole exists, as this will short circuit motherboard components and tracks later on.

Once the board has its stand-off's fitted, lower it into the case slightly to the left of the slotted base plate holes and feed the bottom of the stand-off's into the slotted holes so that the wide disks sit just on top of the plate. This is a bit fiddly, but comes with practise. Try gently lifting each corner of the motherboard when you think you have got it into place. If one or more of the corners still lifts, slide the board back out, take a deep calming breath, and start again. When you have finished, secure the motherboard using one or two fine threaded screws into the remaining hole(s) at the back of the motherboard.

Fixing the motherboard

Lower the motherboard into place once again and make sure that you have definitely fixed the pillars into the correct holes. Then take five of the fine threaded screws (note that there are two thread pitches in the hardware bag, fine and coarse) and screw the motherboard into place (it may be easier to do the gizmo screw first before it drifts out of place). A magnetised tip on your screwdriver will be a real boon here. You can use a strong magnet to magnetise a screwdriver if you haven't already got one with such a tip. Just run the magnet down the length of the blade a few times, lifting it clear at the end of each stroke and starting again at the handle end each time. Take special care not to over tighten the screws and ensure that the motherboard is square to the back panel, with a small gap between the two.

Fitting the floppy drive

The suggested floppy drive is a standard 3½ inch type and is supplied without fixing screws. The threads are the same as those fitted to the motherboard pillars, so use four of the fine threaded screws to fix the floppy drive in the top 3½ inch bay. Note that you will need to take the other removable panel off of the case in order to

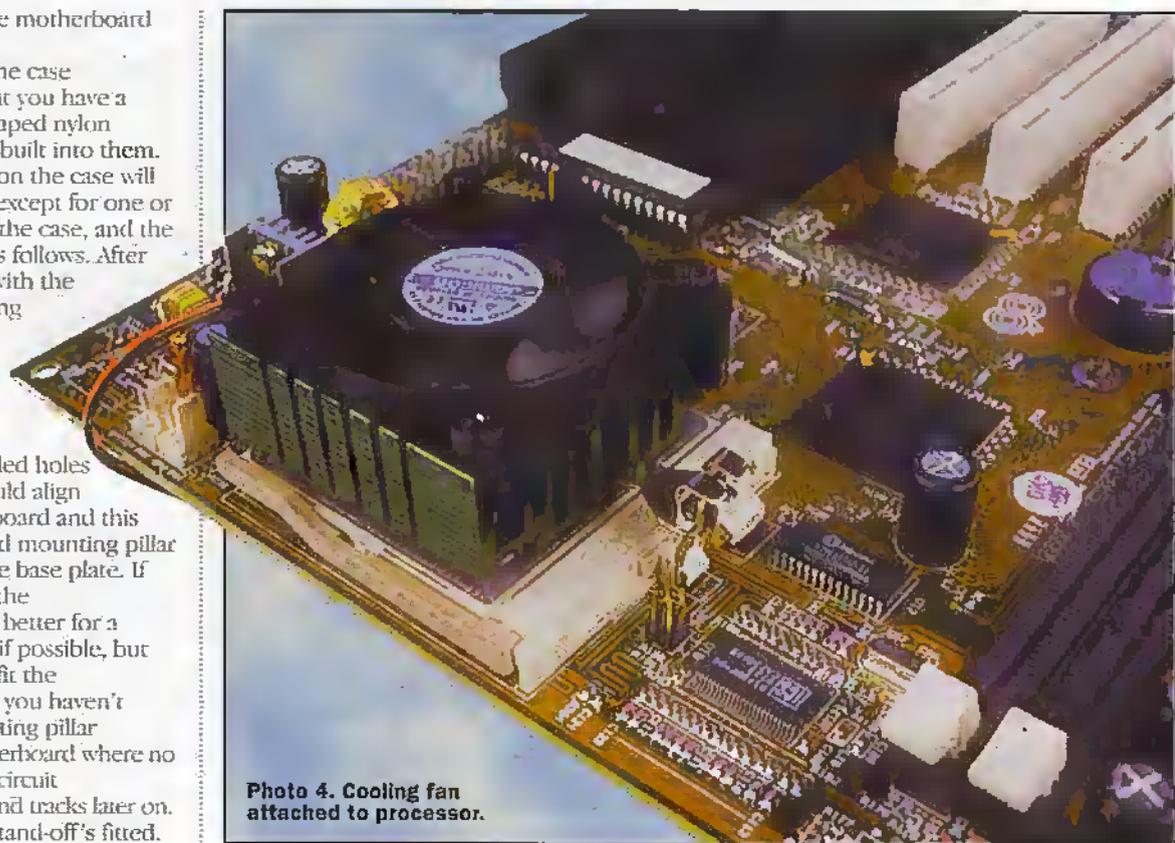


Photo 4. Cooling fan attached to processor.

get to the mountings on the right side of the drives as you fit the screws that hold them. You will find that the floppy drive, which you should carefully insert into the front of the case after popping out the blanking plate by applying firm pressure to the centre of the plate from the inside of the case, will be a very tight fit and may catch on the mounting lugs and guides inside the drive cage. Persevere and find just the right angle and pressure to clear the metalwork and the drive will sit flush with the front panel. Insert and tighten the mounting screws.

Fitting the hard drive

The hard drive should be fitted from the inside of the case, with the sockets facing into the case, and secured with the screws provided in the hard drive packaging (coarse threaded). Use either of the two spare 3½ inch bays for this. We have chosen to use the bottom bay (see photo 5). The drive will protrude some way into the case, but this is normal.

Fitting the CDROM drive

The CDROM drive is supplied in the larger 5¼ inch format and we will fit this to the very top bay in the case. As before, pop out the blanking plate from the inside. Slide the drive into the drivebay from the front and fit the short screws supplied with the CDROM drive. Fixing the CDROM drive from the inside of the case until the holes in the drive align with the slots in the case. Ensure that the front of the drive is flush with the front panel before tightening the four screws.

Fitting the SIMMs

The SIMMs also need to be handled with care as they are fairly static sensitive. Please take the same precautions as when fitting the CPU to the motherboard. Unpack the

SIMMs (must be fitted in pairs, remember) and fit them into the corresponding shallow white SIMM sockets as follows.

Looking at the SIMM circuit board, you will see that there is a cut-out or notch at one end of the edge connector (the double sided row of metal finger contacts that are used to plug the SIMM into its socket). The SIMM should be turned so that the notch is towards the front of the case before offering up to the socket. SIMMs don't plug straight into their sockets, but need to go in at an angle (see photo 6). They are dropped into the slot in the socket until they are sitting right into the slot, then firmly straightened to an upright position past the metal clips at each end. As the SIMM reaches the upright position, the clips at each end snap into the holes in the ends of it and hold the SIMM in place. The photos show the operation quite clearly. Note that SIMMs (in pairs) must be fitted to fill a complete bank of memory.

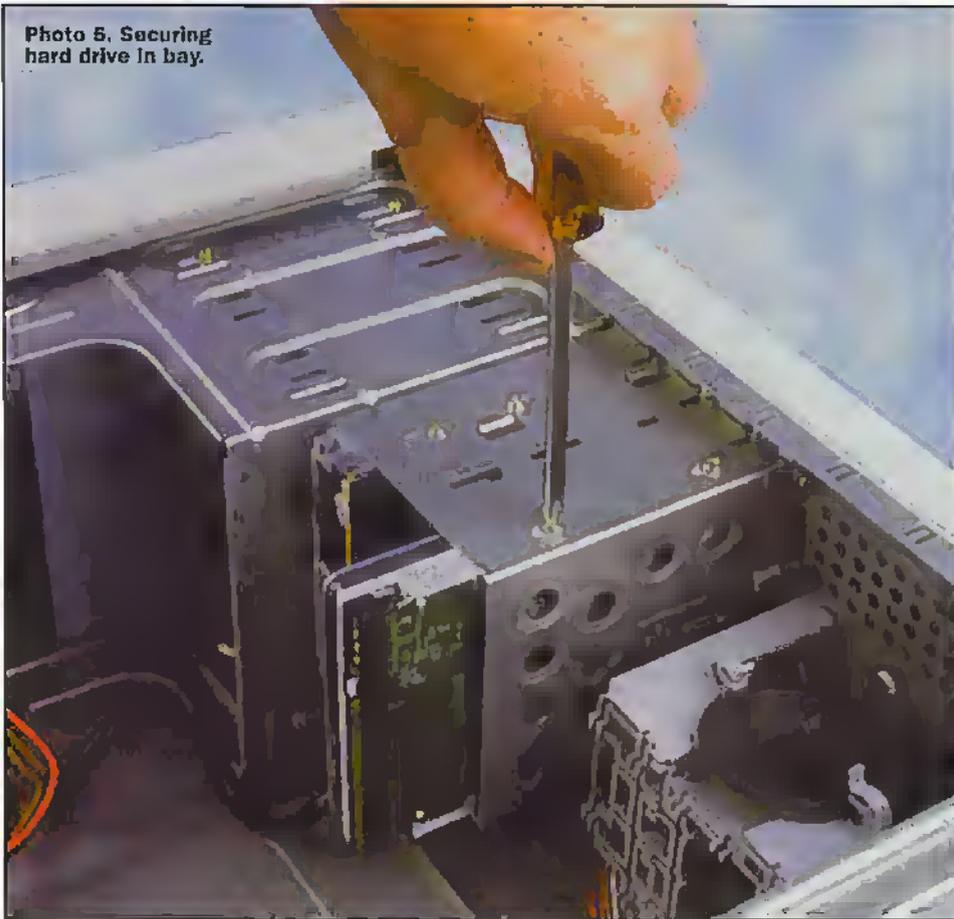
If you choose to fit DIMMs instead, they just plug straight in before closing the end clips to hold them.

Fitting the sound card

The sound card recommended has an ISA bus interface. In practical terms, this simply means that it plugs into one of the long black sockets at the rear left of the motherboard. Choose a socket to use and remove the metal plate on the back panel (Beware! razor sharp edges on these stamped plates!) just behind and to the right of the chosen socket (if fitted). Take the sound card out of its anti static bag and position it above the chosen socket on the motherboard.

Before applying pressure, ensure that the metal tab at the bottom of the rear panel socket plate has gone down between the motherboard and the rear panel and that the two part edge connector is aligned with the socket. Note that firm pressure and a rocking action may be required to get the

Photo 5. Securing hard drive in bay.



card started into its socket. Push the card fully and evenly home, until none of the edge connector protrudes from the socket (see photo 7). Use a coarse threaded screw to secure the top of the socket plate to the rear panel. Note that the top folded tab of some cards socket plates may end up a few millimetres above the chassis mounts on the rear panel. After ensuring again that the card is definitely fully home and square in its socket, tighten the mounting screw hard enough to secure the board safely, but not so hard as to stress the motherboard.

Fitting the graphics card

The graphics card suggested has a PCI bus interface and plugs into one of the white sockets in the middle of the rear of the motherboard. You may wish to use one of the sockets nearest the black ISA sockets, as we will be using the chassis plates at the outer edge of the board for mounting some I/O socket plates later on. Remove the rear panel plate behind and to the left of the chosen socket. Unpack and offer the graphics board into place, then push it firmly into the socket. Secure it to the rear panel with a coarse threaded screw.

System wiring

Now for the fun part, wiring together all those bits and pieces we have screwed into the case. Note that, with this particular case, everything is reasonably accessible when screwed into its final position. Some case designs are not so open and you may need to slide drives about while wiring them up.

There is quite a lot of wiring to do here, but most of it is fairly obvious once you get started and we will take you through it all step-by-step. We will start by connecting the various power cables to the peripherals and motherboard.

Power cables

We will start with the motherboard power cables. The motherboard suggested has two sets of power sockets, the row of flat exposed pins are the older standard AT type we will use with the suggested case.

If you look at the handful of coloured power leads that protrude from the power supply box in the rear right corner of the case, you will see that there are two plugs with six wires each. These are the motherboard power leads and should be fitted into the motherboard (J6) such that the black leads on each plug sit next to each other in the centre of the whole row of 12 wires after fitting. Note that these plugs need to hook on to their locating holes on the motherboard from a slight angle, before being pushed home. It is only possible to fit

these connectors one way around, so if they go on and the black wires end up in the middle, you have fitted them correctly.

Drive power connectors

There are two types of power connector used for the various disk drives on your PC. The larger type fits most hard drives, CDROM drives and 5 1/2 inch floppy drives (should you ever need to fit such an ancient device), with the smaller type being used for 3 1/2 inch floppy drives.

Connect a large power connector to the CDROM drive, the hard drive, and the CPU cooling fan. Connect a small connector to the 3 1/2 inch floppy drive. Note that all of these connectors are polarised and will only fit one way around. Tuck the cables out of the way of the motherboard.

Drive data cables

Now for the big one. This is the area where people have most problems. First, the floppy drive data cable. It's the one with five connectors and a twisted bit of cable in the middle. The connector on its own at one end plugs into the I/O controller (built into the motherboard on this example). The red stripe indicates pin 1, shown on the motherboard by a white arrow. Plug this plug into the connector nearest the motherboard power sockets (17). You will notice that this socket is keyed and will only fit the correct way around. Older systems, or plug in I/O cards, often used non keyed sockets that would fit either way around, as well as having no outer shell on the PCB, so you had to be careful not to plug the whole thing in one pin out in either direction (very easy to do).

Now, this leaves four connectors at the other end of the cable. If you look at these, you will see that they are of two different types. The edge connector (slotted) type is only used for 5 1/2 inch disk drives, so you can forget about those two. Of the remaining pair, the one on the motherboard side of the twist in the cable is for a 'B' drive and the farthest from the motherboard (beyond the twist) is for your 'A' (bootable) drive. Connect this 'A' drive connector to your Matsushita 3 1/2 inch drive, with the red stripe on the cable furthest from the power connector (this is unusual, many drives will have pin 1 nearest the power connector).

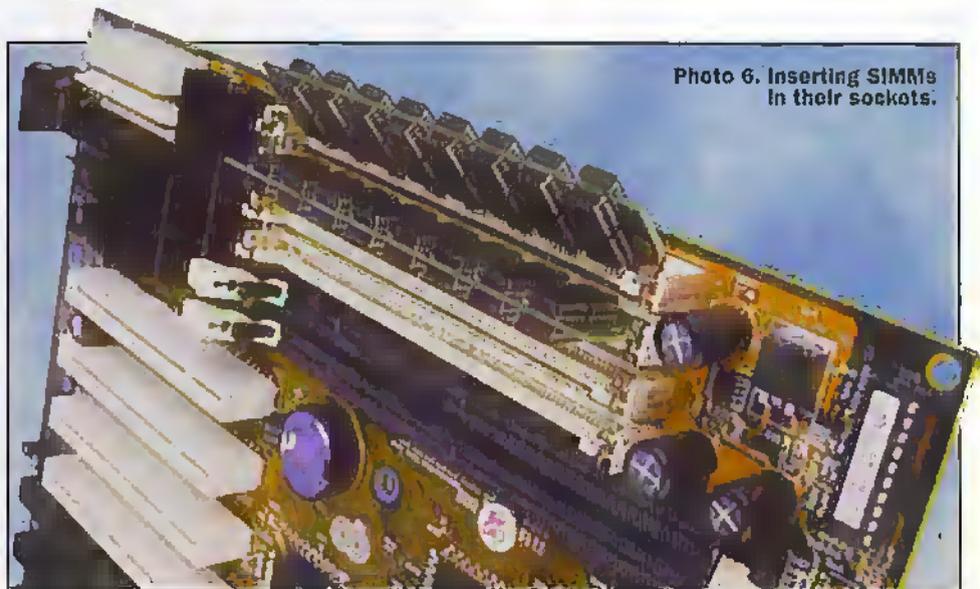
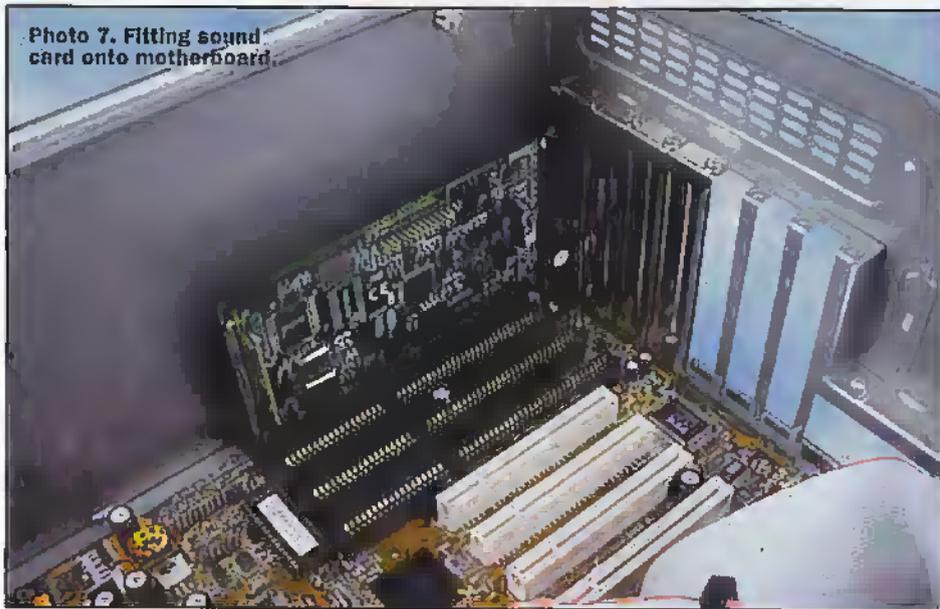


Photo 6. Inserting SIMMs in their sockets.

Photo 7. Fitting sound card onto motherboard.



The hard drive cables supplied with your motherboard and hard drive are both twin drive cables, each allowing up to two IDE drives to be connected. The connector on its own at one end of the cable should now be plugged into one of the IDE connectors on the motherboard (IDE #1 is on J12). As before, note the red stripe/white arrow/pin 1 alignment.

Connect the other end of the cable to the hard drive, with the stripe on the cable nearest the power connector.

Use the second IDE cable to plug into IDE #2 (J11) on your motherboard, noting orientation as before, and plug the other end of the cable into the CDROM drive data connector, stripe nearest to power connector (good lighting helps here). There is no reason why the two drives should not both go on the same cable, other than the fact that the layout chosen here doesn't allow the cable to physically reach both drives. If you were to fit the CDROM drive on the same IDE channel as the hard drive, you would have to alter jumper settings on both drives.

IDE devices will work in pairs, where one device is designated a 'Master' and the other a 'Slave'. The default jumper settings for the drives as supplied will tend to be 'Master, no Slave present'. One drive would need to be set as 'Master, Slave present', the other drive as 'Slave', should you wish to put both drives on the same channel, or add another hard drive to the set up.

Input and output cables

The motherboard suggested, like most modern motherboards, has a built in I/O controller system. The various ports are connected to sockets on the motherboard and these will need to be connected to a pair of adaptor plates that bring the sockets out to the back panel of the case.

Locate the adaptor plates and fit them to the back panel plate positions nearest to the sockets on the motherboard (they could go anywhere that the cable will reach to) in place of the blanking plates already fitted there. The cables on the plate fitted with the small round socket (PS2 mouse connector) and the long male 25 way D connector (COM port 2) should plug into J4 and J9 respectively. Note the red

stripe/pin 1 alignment for J9.

The cables on the other plate are connected as follows. The male 9 way D connector should be plugged into J10 (COM 1) and the female 25 way D connector (LPT1/Printer) to J8, noting red stripe/pin 1 alignment.

All that remains to be connected now to finish the wiring inside your PC are the front panel switch, the LED wires to the motherboard and the CDROM drive audio cable to link the CD audio output to the sound card.

Front panel wiring

The booklet that comes with the recommended motherboard is a very good one and details all of the connection and set up in great detail. Refer to page 16 onwards for the exact details for connecting the various front panel and LED connectors to the block of pins marked 'J15'. I won't go through each of these here, except to say that you shouldn't worry too much at this stage about the polarity of the front panel plugs. If you get the LED's wrong, they simply won't light and will have to be reversed.

CD audio wiring

The CDROM drive has a low level audio output that may be fed to a sound card for amplification and playback via external speakers. The round cable supplied with the CDROM drive should be connected to the socket next to the data cable at the CDROM drive and to the small white socket (J11) on the sound card.

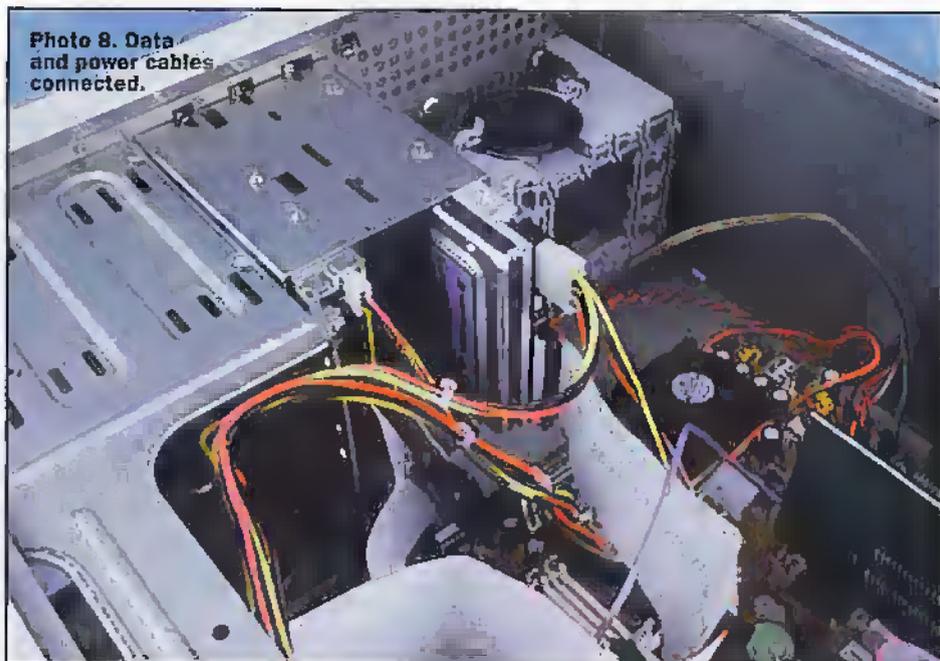
Next month

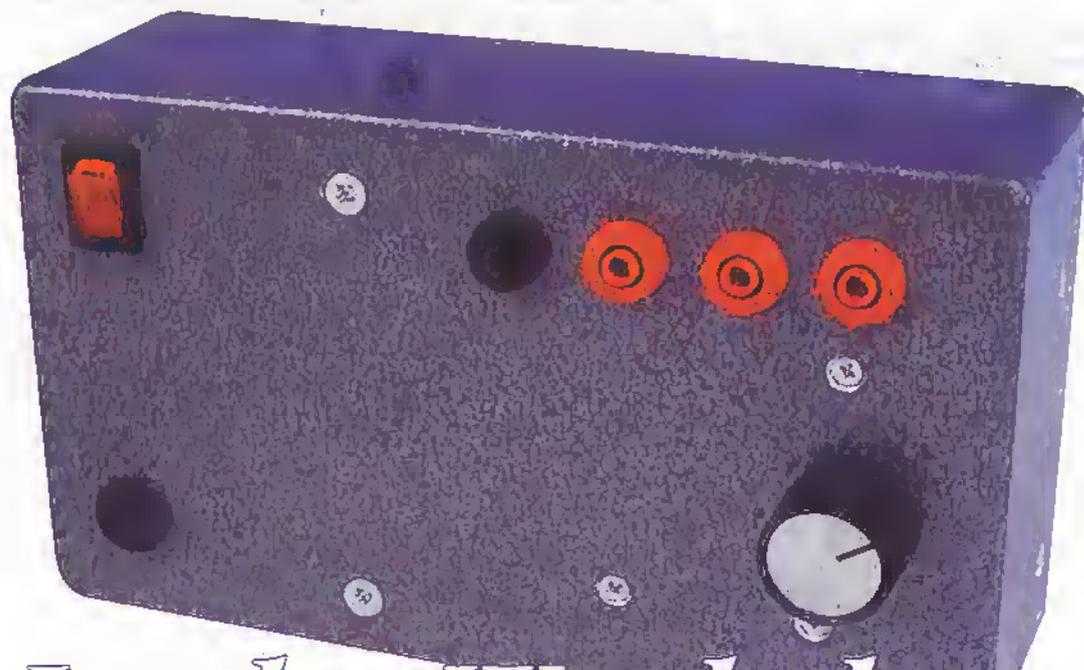
Next month's article will conclude this short series by looking at finishing the PC off, fitting all peripheral devices and setting up the BIOS and a typical operating system. Full operating systems can be surprisingly hard to get hold of! The full version of Windows 95 is only officially available when purchasing a new PC from an approved vendor, leaving only the upgrade version of Windows 95 on the shelf at retail stockists. Those of you who already have access to DOS 6.2 or similar, Windows 3.0, 3.1 or 3.11 and have or can get a Windows 95 upgrade package to install an operating system, may take this rather long route to installing the software. Those of you who are lucky enough to have access to a full version of Windows 95 (preferably release 2) that is not in use on another machine may use this infinitely simpler method to install Windows 95 in one hit.

For those of you who would like to install the full up-to-date version of Windows 95 in one (fairly) simple operation, we are able to offer you this package at the very competitive price of £79.99 including VAT! Windows 95 must be ordered at the same time as computer hardware (order as LS91Y).

You will need a start up floppy disk to load up the first operating software from though, as you can't start your PC (boot up) from the CDROM drive. Some versions of Windows 95 (full version) are not supplied with a floppy disk, so this could be a problem. You will also need to install some special device driver software before your new PC will be able to use the CDROM drive. Get hold of a copy of next month's 'Electronics and Beyond' magazine to find out how!

Photo 8. Data and power cables connected.





In the Workshop

BASIC POWER SUPPLY DESIGN

The power supply is a key element of any electronic circuit. Here Stephen Waddington reviews basic power supply design and shows how to make a low-cost device capable of providing DC outputs of 5V, 12V and 0 to 12V.

A philosophical question: which came first, the chicken or the egg? Here's an alternative question for electronics engineers: which came first, the system or the power supply? The difference between these two questions is that the later is the easiest to answer. It was without a doubt the electronic system that came before the power supply.

After Thought

Power supplies are more often than not bolted onto an electronic circuit as an after thought. However, matching the correct power supply to any electronic system is crucial to its continued operation. An unregulated battery charger would quickly destroy the very batteries it was intended to

recharge. A badly designed audio power supply will result in bass distortion as the volume is increased and the supply voltage falls.

Similarly, there is very little point in wasting money spending a fortune fitting a doorbell with a highly regulated power supply.

The key elements of a basic power supply circuit are shown

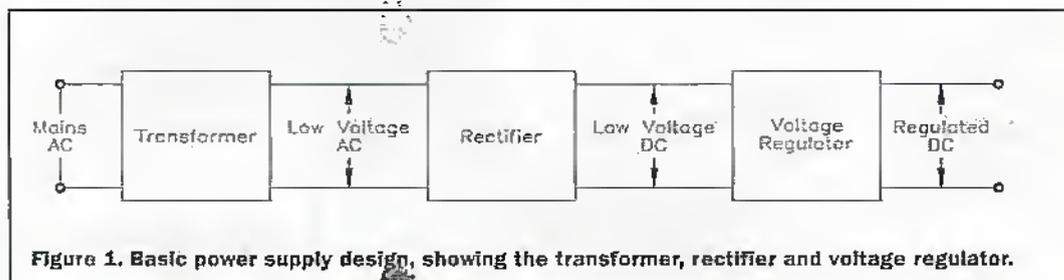


Figure 1. Basic power supply design, showing the transformer, rectifier and voltage regulator.

in Figure 1. A transformer is used to step mains ac voltage down to within the range of the intended application. A rectifier circuit is then used to convert the ac voltage into dc, and finally a voltage regulator clamps the output voltage at its appropriate level.

There are other parameters which could also be considered for more sophisticated power supply circuits. Protection against excessive load variations, and in the extreme, overload, can be incorporated into the design. A back-up battery supply could also be added to safeguard an application such as a burglar or fire alarm in the case of a mains failure. Electronic filters can be added to the rectifier stage to remove mains harmonics.

Design Brief

Here we are going to review the design of a basic power supply system for use in the workshop. We want to generate dc output voltages of 5V, 12V, and 0 to 12V variable. Current handling capability should be of the order of 1A. It is important that the supply is rectified and that the output voltage contains minimal ripple. Cost is also an issue – if possible, the design should come in at under £15.

Let's return to Figure 1: The first consideration is the most expensive component in any power supply circuit, namely the mains transformer. The majority of transformers have a

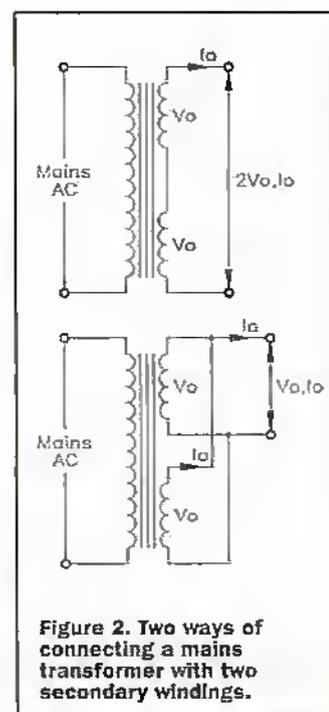


Figure 2. Two ways of connecting a mains transformer with two secondary windings.

Code	Secondary voltage rating [AC Volts]	Secondary current rating [Amp]	Cost
YJ50E	2 x 6V	1	£6.99
YJ51F	2 x 6V	2	£9.49
DH29G	2 x 6V	4	£11.49
DM27E	2 x 12V	0.5	£7.46
WB25C	2 x 12V	1	£9.49
WB26D	2 x 12V	2	£11.99

Table 1. Range of transformers capable of providing 12V AC at 1 A.

single primary winding which carries the mains input voltage and two secondary windings, which carry to the stepped-down voltage. The secondary windings can be connected in series or parallel as shown in Figure 2, to provide a higher voltage or current output.

If it assumed that the secondary windings of a transformer are rated at I_o A and V_s V, then connecting the windings in series provides a current output of I_o and a voltage output of $2V_s$. Meanwhile, the parallel connection gives a current output of $2I_o$ and a voltage output of V_s . Parallel connection should only be considered when the manufacturer's specification states that this mode may be employed. If you try it with a standard transformer you will create a current imbalance, which will more than likely cause it to fail.

Transformer Selection

Let's go back to our design specification. We want a power supply capable of providing 12V at up to 1A. The possible transformer options are shown in Table 1, alongside the configuration that would be required for each device. I opted to use the 2 x 12V 1A secondary coil transformer (WB25V) for no other reason than the fact that I already had one to hand. Otherwise I would

Code	Device	Voltage [Volts]	Cost
QL31J	LM7805	5	£0.99
AW69A	LM7806	6	£1.30
AW70M	LM7808	8	£1.30
AW17T	LM7812	12	£0.86
AW18U	LM7815	15	£0.97

Table 2. The LM78XX family of 1A fixed voltage regulators.

of selected the lowest cost option – in this case YJ50E which has two 6V primary windings rated at 1A.

Returning to Figure 1, the next issue is the rectifier. The bridge rectifier shown in Figure 3 forms the basis of the majority of power supplies. The diode element of this circuit can be constructed using individual components, but more frequently a single encapsulated package is used.

A quick scan at the Maplin catalogue shows that integrated bridge rectifiers are available in almost every conceivable type of voltage and current rating from 35 to 280V and from 1 to 35A. In this instance we are opting for W01, a device with a maximum no-load voltage of 70V and a typical current handling capability of 1.5A. Bridge rectifiers should be rated at the output load current and as a rule of thumb; the no-load voltage rating is 1.4 times the rated secondary output voltage.

The value of the reservoir capacitor shown in Figure 3 is dependent on the load current and the amount of voltage output ripple that can be tolerated. The larger the size of

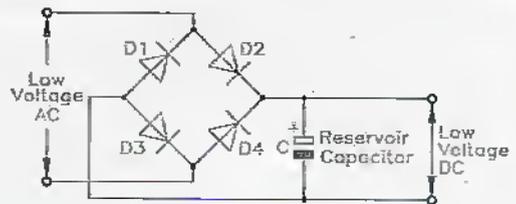


Figure 3. Basic bridge rectifier circuit with reservoir capacitor.

the capacitor, the fewer ripples will occur in the output stage. A 6,800 μ F device should be adequate for the majority of applications, although these can be increased to further reduce the ripple component of the output voltage. Cost is the primary issue here. Like the bridge rectifier, the voltage rating of the reservoir capacitor should be specified in terms of the rated no-load secondary output voltage.

Fixed Voltage Regulation

Next we come to the issue of voltage regulation. We need to produce a voltage output of 5V, 12V and 0 to 12V. If we consider each requirement in turn, this range of voltage outputs can easily be achieved. Zener diodes are often used to shunt fixed voltages but only in low current situations of up to 50mA.

The alternative to a zener diode is a fixed integrated circuit voltage regulator. The LM78XX series of 1A three terminal regulators is available with several fixed output voltages of up to 24V, as shown in Table 2. The devices are manufactured

in aluminium TO 220 packages, which need to be correctly heat-sunk to maximise the current handling capability. Current rating above 1A can be achieved using higher specification devices – check the Maplin catalogue for further details.

Figure 4 shows the pin-out details for the LM78XX family, while Figure 5 shows the LM7805 and LM7812 in circuit to produce voltages of 5V and 12V voltage respectively. In each case an input (C1 and C2) and output (C3 and C4) capacitor are used to trap any spurious ripple voltage generated in-circuit between the reservoir capacitor and the voltage regulator.

Variable Voltage Regulation

Creating a variable 0 to 12V at a current rating of 1A is no more difficult than generating the fixed 5V and 12V outputs. Again an integrated circuit is used. This time it is the LM317, adjustable 3-terminal device capable of supplying up to 1.5 A over a 1.2V to 37V output range. The device is supplied in a standard TO-220 package as shown in Figure 6, while Figure 7 shows a basic circuit configuration.

In operation, the LM317 develops a nominal 1.25V reference voltage, V_{ref} , between the output and adjustment terminal. The reference voltage is converted to a programming current by the resistor R1 and

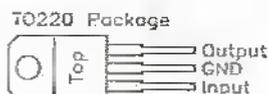


Figure 4. Pin out details for the LM78XX family.

Figure 5. The LM7805 and LM7812 connected in circuit to produce voltages of 5V and 12V.

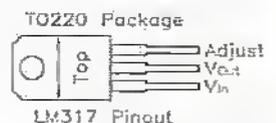
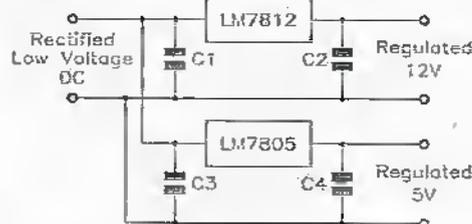


Figure 6. Package and pin out details for the LM317.

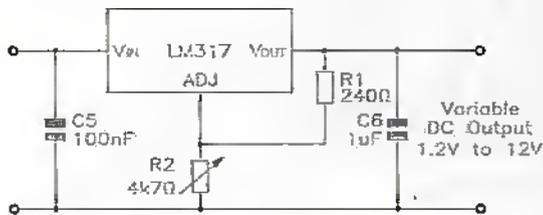


Figure 7. Circuit diagram for LM317, used to create variable 0 to 12V.

this constant current flows through R2 to ground. The regulated output current is given by the equation:

$$V_{out} = V_{ref} (1 + R2/R1) + I_{adj} R2$$

The output voltage is adjusted by varying R2, in this instance a 4.7 kΩ potentiometer. Plugging these figures into the equation above gives a variable output voltage of between 1.2 and 12V.

Since the current from the adjustment terminal represents an error term, the LM317 was designed to minimise I_{adj} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

An input bypass capacitor, C5 is used in case the regulator is more than six inches away from

the reservoir capacitor. A 0.1μF disc or 1μF solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used, but the above values will eliminate the possibility of problems.

Although the LM317 is stable with no output capacitors, like

any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500pF and 5,000pF. A 1μF solid tantalum or 25μF aluminium electrolytic on the output (C6) swamps this effect and ensures stability.

Construction

The key personal consideration when constructing a power supply is protection against mains voltages. The power supply should be fused both on the primary winding side and the secondary winding side of the transformer as shown in Figure 8. While a single fuse on the mains side will provide protection in the event of a component failure in the secondary circuit, it may not protect against all eventualities including overload of the

voltage regulators.

On the mains or primary side, the fuse should be rated at 200% of the maximum current handling output – in this case 2A. On the secondary side a similar approach should be taken and a 2A fuse should be adequate. In power supply circuits where a large reservoir capacitor is used, problems can occur when mains current is initially applied due to a large in-rush of current. To counter this, slow-blow fuses can be used.

The mains supply to the transformer should be switched by a suitable rated double-pole double-throw device (DPDT) as shown in Figure 8. In this instance a neon rocker switch is used to indicate when the power supply is on and off.

Each of the circuits was constructed initially on breadboard and after testing, transferred to Veroboard. Each circuit is relatively straightforward and the construction is further simplified by this modular approach. I used two separate pieces of veroboard one to mount the bridge rectifier, reservoir capacitor and the LM317 variable voltage circuit and a second for the two fixed voltage regulator and their associated capacitors.

Each of the voltage outputs can be used either independently or together providing that the overall current rating of 1A is not exceeded. Ultimately the fuse on the primary side of the transformer prevents this.

Housing

As this power supply is intended to be used as a bench top device, I mounted the transformer, neon rocker switch, fuseholder and two Veroboard circuits in a diecast box with 4mm banana sockets used to terminate each of the dc output voltages. All heat sink integrated circuit devices were secured to the case using a nut and bolt and heat sink mounting compound.

Again another point relating to the mains. As the case is metal each part needed to be earthed. Additionally, all bare live and neutral mains connectors needed to be shrouded. This meant using spade terminals and push on covers on the rocker switch and heat shrink covers on the primary side of the transformer.

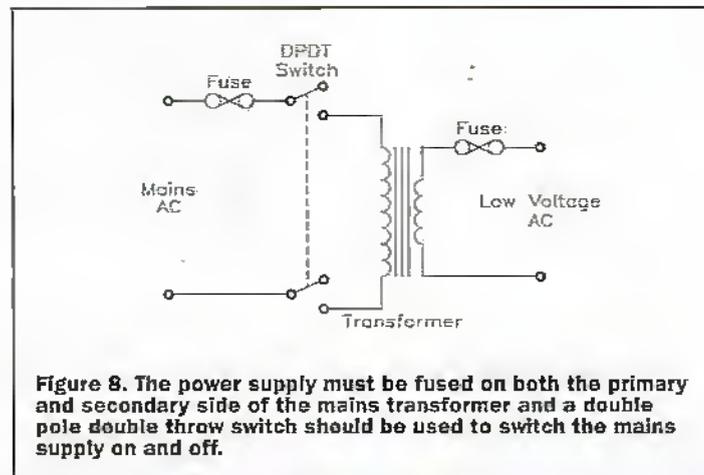
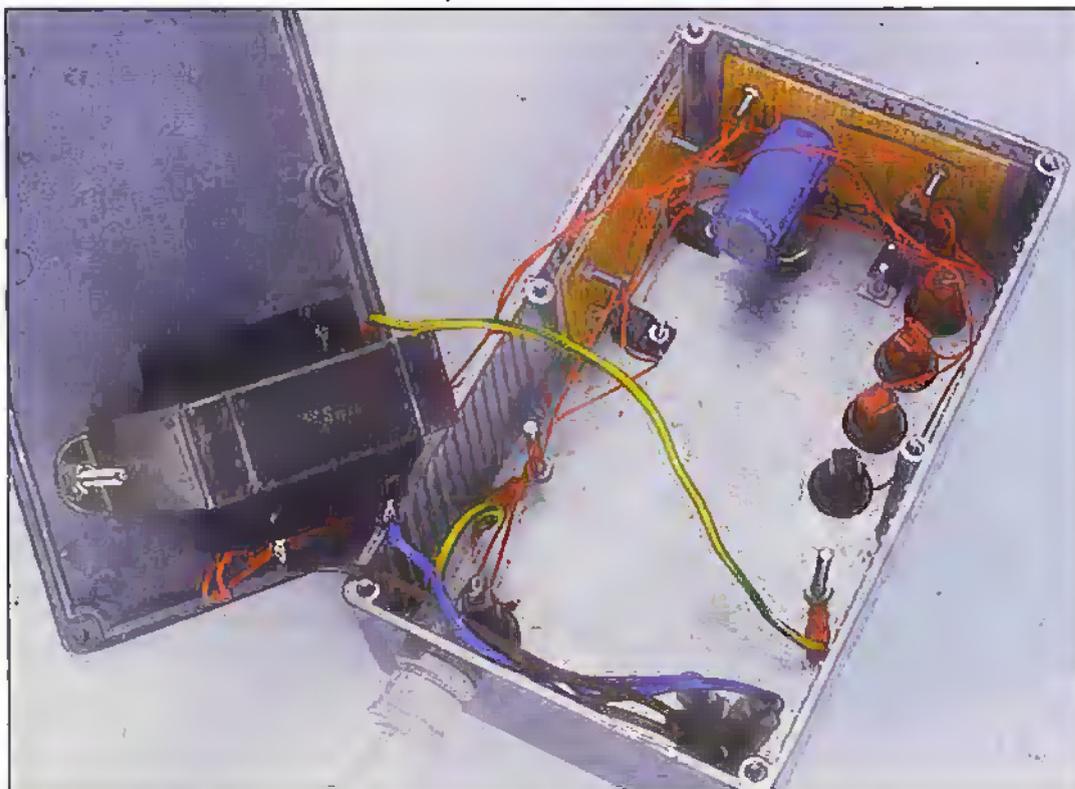


Figure 8. The power supply must be fused on both the primary and secondary side of the mains transformer and a double pole double throw switch should be used to switch the mains supply on and off.



Medical detector which can image breast cancer

Researchers at Philips Research Laboratories in Eindhoven, The Netherlands, have developed a new medical imaging method using red laser light sources. A prototype of an optical mammography device for taking images of women's breasts has been made to test the new method. An array of light sources and detectors, situated in a 'cup' in which one breast is placed, combined with fast image reconstruction techniques is used to obtain full 3-dimensional (3D) images. By taking measurements at three different wavelengths, images can be optimised to show specific characteristics of the breast tissue. Using laser light at 670, 780, and 920nm wavelength it is possible to image blood, water and fat. In principle, it should be possible to discriminate between malignant tumours and cysts filled with water without taking biopsies. If the tests prove the method to be useful, it has a number of attractive characteristics, namely it is harmless, simple, relatively fast and inexpensive. The clinical viability of the method is now being tested in a Dutch hospital in Maastricht. If successful, it holds the promise of being a harmless method that may be used for regular breast-screening programmes. It is also a more comfortable method for women since

RESEARCH NEWS

breasts do not have to be compressed.

The use of light to image breasts has a long history dating back to 1929. The interest in breast imaging is strong because in most of the western world, women over 40 years of age are regularly screened for breast cancer using X-ray radiation. In order to get good contrast, relatively low-energy X-rays are used which cannot penetrate thick tissue. The breast to be imaged is squeezed between two plates in order to reduce its thickness to about 5cm! This squeezing is sometimes painful, and possibly harmful. The use of X-rays for diagnostic purposes may cause unwelcome side effects. Furthermore the breast tissue of younger women is typically much more dense than that of older women and therefore too dense for mammography to image accurately. Light

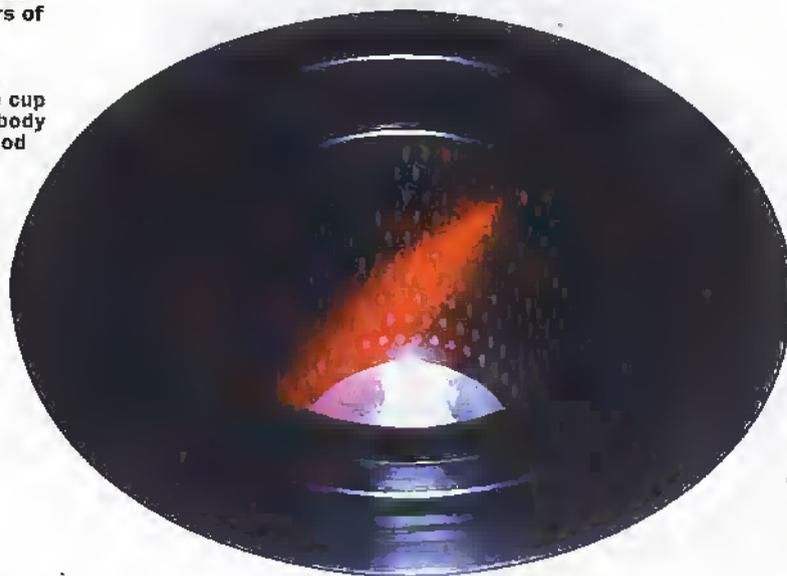
attenuation in breast tissue *in vitro* is well known but there have been few measurements *in vivo*, where the effects of blood or diseased tissue complicates matters. Optical techniques for detecting breast cancer are attractive because they are potentially much safer than conventional X-ray imaging. The difficulty of getting high-resolution images lies in the strong scattering properties of the tissue. Philips tackle this problem using an array of 255 optical fibres together with 255 separate diode detectors positioned in a conical cup 13cm in diameter (figure 1). The cup contains a liquid at 31°C to support the breast. The detectors are sensitive to power levels as low as 25µW, with a wide dynamic range. Laser light is directed to one of the 255 optical-fibre ends, passes through the tissue and is detected simultaneously

by the 255 detectors. A measurement is taken from every combination of optical-fibre end and detectors. These measurements are used for a reconstruction of the 3D image, more or less in the same way as Computer Topography (CAT). 3D scans are reconstructed from slices. The scattering of the tissue is modelled, and corrections to the image are applied. 3D images can be constructed by stacking 2D slices as the low scattering confines the effect of the tissue mainly within one slice. In figure 2 cross-sections through a breast with a tumour about 2cm across is shown. This diagnosis has been confirmed by X-ray.

Professor David Delphy at the Department of Medical Physics and Bioengineering at UCL London, has also been working on an optical imager for breast imaging which started clinical testing in 1997. The cost of current financial support exceeds £500,000, of which over half is for equipment. The technique depends on near infra-red rays which are absorbed by haemoglobin. Because haemoglobin transports oxygen, scientists know that the more infra-red that is absorbed, the more oxygen present in the tissue. Professor Delphy said that his team had decided to apply the method to the breast, head and neonatal research. They reasoned that as a tumour grows its blood supply also grows - which means that there is more oxygen circulating around it. The machine could detect tumours earlier than conventional X-rays which depend on detecting tiny calcium deposits that take time to develop. However, X-ray mammograms now taken by George Town University Medical Centre in Washington DC can now detect 160 to 200 micron micro-calcifications routinely, limited only by the X-ray film. In conjunction with Heriot-Watt University Image Analysis Centre in Edinburgh work is being done to extract information and enhance it from images having up to 9000 × 9000 pixels.

The UCL system illuminates the patient at 32 points sequentially while detecting transmitted light at 32 other locations simultaneously, resulting in 1024 separate

Figure 1. The breast 'cup' has 255 pairs of low-power laser sources and detectors. During measurement the cup contains a warm body milk to ensure good optical contact.



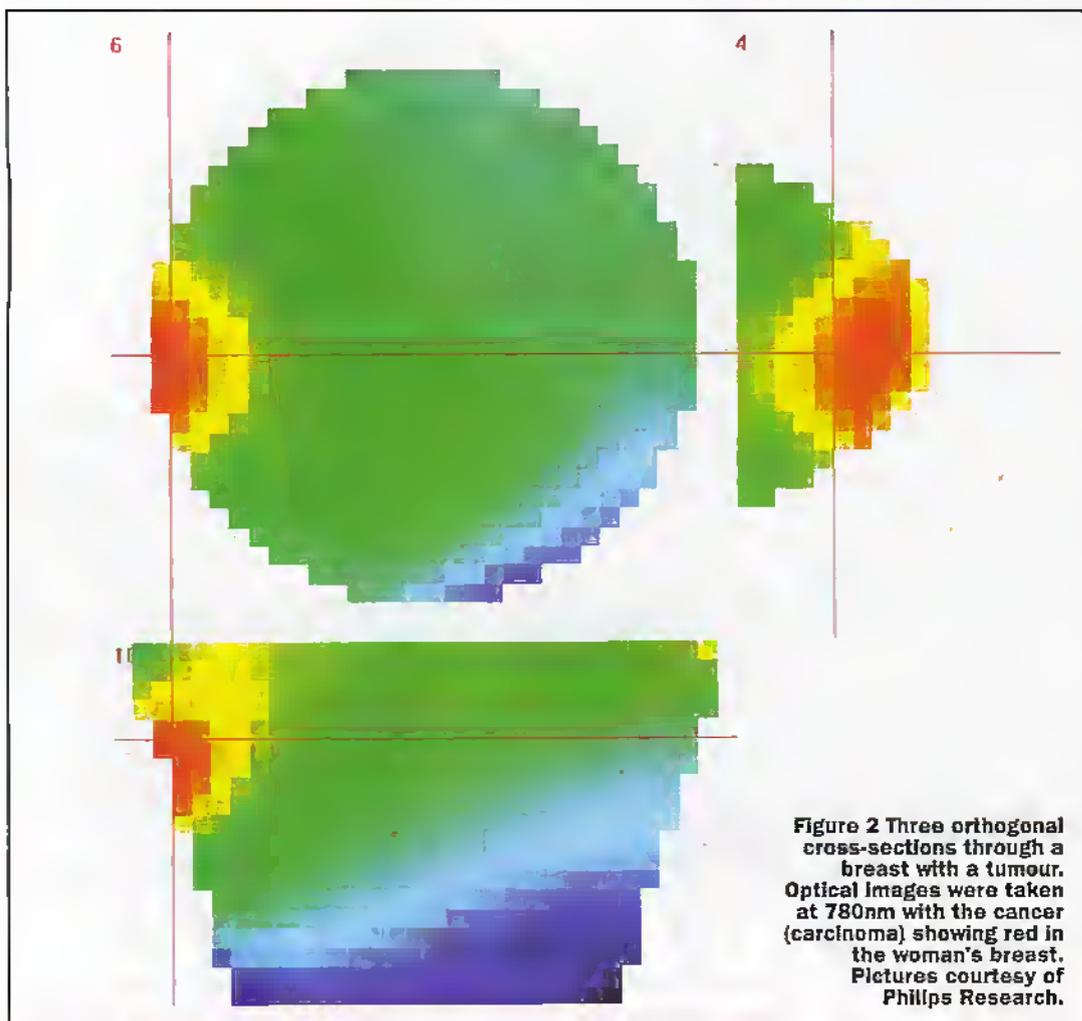


Figure 2 Three orthogonal cross-sections through a breast with a tumour. Optical images were taken at 780nm with the cancer (carcinoma) showing red in the woman's breast. Pictures courtesy of Philips Research.

one breast that do not appear in another indicates a physiological abnormality. Thermography is a test of physiology; it does not look at anatomy or structure, and it only reads the infra-red heat radiating from the surface of the body. Mammography on the other hand is a test of anatomy; it looks at structure. When a tumour has grown to a size that is large enough, and dense enough to block an X-ray beam, it produces an image on the exposed plate. A fine needle biopsy is then performed. Thermography, and indeed any of the visible and near infra-red systems mentioned, should be considered as complimentary techniques and the best results taken from each.

Comparisons of X-ray and magnetic-resonance images with the images obtained from the optical prototype in women with breast tumours are now being conducted, and will give more insight into the optical properties of breasts and tumours, the required detection limits, and hopefully earlier diagnosis and treatment of this terrible disease without the need for extensive and invasive surgery.

histograms of light arrival times. Each histogram represents a time spreading function for a particular line-of-sight path across the head. Near infrared pulses between 750-850nm are provided by a laser operating at about 80MHz with a mean power of up to 1W.

Currently a biopsy is the only 100% effective way of determining if the tissue is malignant or not. Of concern is the fact that radiological techniques yield only a 15-25% detection capability with malignant tumours. X-ray Mammography has come under fire recently in the US from the National Institute of Health and other health advisory boards for being overused with negligible improvement in the rates of breast cancer detection.

Seeing the invisible

Several workers have taken alternative routes to remove the need for surgery including the use of Thermal Imaging. Thermal Medical Imaging Corporation (TMI) and USC/Norris Comprehensive Cancer Centre are participating

in a Thermal Imaging system clinical trial. The results will be taken with another clinical study for FDA approval at Howard University Hospital in Washington DC. The USC study includes 600 women recruited from USC's cancer treatment program, all having breast lumps or suspect tissue and are scheduled to receive biopsies. The study is funded by a \$380,000 grant from TMI.

Thermography is a non-invasive test, in fact there is no direct contact with the body and no radiation is used, and the procedure is painless. Utilising sophisticated infra-red cameras and desk top computers thermal imaging technicians simply capture a photograph of the breast. An infra-red photograph, or heat picture is stored in a computer and may either be printed on high resolution colour printers, or sent electronically to a physician with a similar computer for analysis. The physician, or thermal imaging specialist then compares the heat patterns in the left breast to the right breast. Any difference in heat, or any specific blood vessel patterns in

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Photo 10: John Deere 8300 Tractor, 170Kw, 16 forward gears, electro-hydraulic gear shift.



Electronics

IN AGRICULTURE

PART 5

Intelligent Tractors

George Pickworth continues his look at the changing face of the computerised tractor.

Massive Power

The shift from the traditional spring sowing of cereal crops to autumn sowing and an increase in land brought under cultivation, made possible by large sophisticated tractors, changed the UK from being a net importer of food to a net exporter. It must, however, be appreciated that as tractors run on fossil fuel, land that was hitherto reserved to grow feed for the horses was available to grow other crops. Nonetheless, much of the cereal crop goes into animal feed and indirectly into beef, chicken, eggs and milk.

Obviously, autumn sowing is only possible if the previous crop is harvested at the optimum and this requires large sophisticated combine harvesters. More about these later. In addition to the combine harvester, a whole range of other intelligent machines evolved for planting and harvesting a variety of crops such as potatoes and sugar beet. The days of shovelling sugar beet onto trailers have long since gone.

Dedicated

Unlike some industries where demand on machines is fairly constant over a long period, the demand on farm machinery

comes in peaks. Moreover, most farm implements, for example combine harvesters and sugar beet harvesters, are dedicated machines; they actually work for less than about two months in the year. Whilst tractors are multi-purpose machines, their work periods nonetheless come in peaks, for example, during ploughing, seeding, spraying and during harvesting when tractors are engaged mainly on transporting the crop.

Massive and very expensive implements enable crops to be planted and harvested within the optimum time, and during periods when soil and climatic conditions are favourable. In days gone by, planting and harvesting extended over a much longer period and often when conditions

were far from favourable; a prolonged harvesting period invariably resulted in deterioration of the crop.

So, instead of large tractors and implements reducing the daily time spent working in the fields, endeavours to complete work during ideal, but short periods, in many cases actually increased the time drivers spent daily in the cab. But as we have seen, these long hours in the cab lasted for relatively short periods. On the other hand, with early cabless-noisy-tractors, work lasted for long periods; indeed, ploughing continued all day throughout the winter months. Furthermore, in order to recoup the very high cost of such large sophisticated machines, farmers need to keep them working to limits of driver

endurance during peak periods. Indeed, tractors were fitted with powerful lights for night working

Luxury Cabs

To push back driver fatigue and maximise daily working hours during peak periods, tractors and combine harvesters, and indeed other dedicated machines, were fitted with luxury cabs. The cabs of both tractors and combine harvesters are tightly sealed to insulate against noise. Moreover, electro-hydraulic control of both tractor and implements means that all pipes and their solenoid valves, which can carry sound, are located outside the cab. To give the driver additional comfort, and of course endurance, climate control (air conditioning) is installed.



Photo 11. John Deere Combine Harvester. The large sophisticated machines enabled the cereal crop to be quickly harvested so that ploughing for the following crop can begin.

Intelligence

Unlike earlier tractors with three forward gears and where the driver was able to match the gear and engine revolutions for maximum efficiency, modern tractors have up to thirty two forward and five reverse gears. Obviously, with such a large number of gears, it would be exhausting for the driver to constantly change gear and throttle setting to maintain maximum efficiency. So, in a modern tractor throttle control and gear change are computer controlled.

Massey Ferguson MF 8169 Datatronic

Wheel slip is one of the biggest power wasters and to minimise this wastage, many tractors have four wheel drive plus sophisticated transmission systems. See photo 14. If one wheel begins to slip, power is automatically reduced to that wheel. Moreover, power can be applied to all wheels even when the tractor is turning on the headlands. Touchpads are well suited to tractor cab environment.

Computer management is not confined to the tractor but

extends to the implements. Indeed, the New Holland 'Electro-link' draft control integrates the tractor and implement to give precise control and maximum operating efficiency.

Emulating Horses

The use of computers to maximise traction, goes some way to making the tractor emulate a horse. Indeed, I well remember from way back in the early 1930's how the horses drawing heavily laden wagons looked ahead and without any commands from the wagoner,

adjusted their gait in unison to ensure maximum power and traction when approaching a steep incline.

When approaching deeply rutted sections, the horses increased their walking speed to almost running so as to produce additional momentum which helped to propel the wagon through these bad parts of the lane. Moreover, the horses were 'self-steering' but tractors are not. However, this may be changing.

Combine Harvesters

As with tractors, the operation of the combine harvester is computer controlled by both buttons and touchpads. So, when entering a field, the operator simply tells the computer what kind of crop is to be harvested and the computer automatically sets all the operational parameters for that particular crop.

Instrumentation

Let us look at the instrument panel of a modern tractor, in this case a John Deere 800 series tractor, see photo 13. The six touch pads at the left side of the panel contain tractor performance data and display the following information; percentage wheel slip (determined by radar), calculated ground speed, true ground speed (determined by

Photo 12. New Holland tractor ploughing at night.



Photo 13. Inside the cab, John Deere combine harvester. The right hand console gives fingertip control of the separator, unloading auger, straw chopper and temperature control inside the cab etc.



radar), power-take-off speed (this powers machinery on implements), distance traveled, diagnostic codes, time since last service, engine hours and time since last service.

The touch pad on the right of the panel controls the hydraulic system which sets the depth at which a cultivator or plough penetrates the soil and lifts the implement when turning on the headlands. The driver simply 'keys' in the cultivation program for a particular field and the computer does the rest. By relieving the driver of many repetitive operations, tractor intelligence dramatically reduced the farmer/driver's workload to the level where farmers can attend to management matters via a mobile phone in the cab. Indeed, some John Deere tractors have a compartment within the cab that they call the 'field office' and is designed to hold documents, a mobile phone and lap top computer.

Optical Recognition

Four years ago, the Silsoe Research Institute began development of a virtual automaton intended for precision agricultural operations. Images produced by scanning TV cameras differentiate crop plants from weeds and by detecting crop row structure, provides

guidance to the vehicle; it is therefore self steering. If the Silsoe vehicle is used for weed control in for example, a cauliflower or sugar beet crop, it can either grab a weed and pull it out of the soil, or apply a burst of herbicide specifically to the weed: this latter application results in very efficient use of herbicide and reduces environment pollution.

The Silsoe vehicle is slow moving, but being an automaton this is no problem. Indeed, when soil and climate conditions are favourable,

swarms of such vehicles may work across the fields for twenty four hours a day.

Looking to the Future

Evolution is continuous. Farm tractors will either continue to get bigger, more powerful and smarter, or, smaller and smarter. Indeed, the trend seems to be towards smaller tractors; the massive American articulated tractors are already losing some of their attraction in the UK. However, with some

implements, for example combine harvesters, there is an optimum size, and that is a very large size. For some operations, several smaller tractors (shades of the little grey Ferguson) or collaborative-automatons have the advantage over a single large tractor in providing greater flexibility at work, less ground pressure and less rolling resistance (resistance imposed by wheels sinking into the soil), and this improves efficiency.

Self Steering

Whilst a completely driverless tractor, as opposed to an dedicated automaton such as the Silsoe vehicle, will probably never become a reality, there is no reason why a tractor or combine harvester should not be self steering during actual operations within a field. This would allow the farmer/driver more time to attend to farm management matters from the cab.

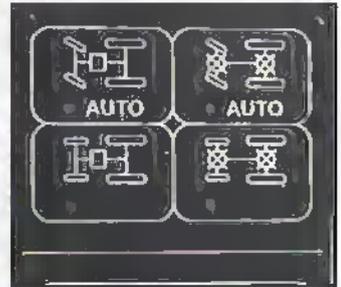
As we have seen, steering with the Silsoe vehicle was facilitated by the computer recognising the crop rows, but with ploughing, or combine harvesting, there are no rows. Moreover, because ploughing and combine harvesting is a one-off operation each season and involves numerous fields of different shapes and sizes, it is impracticable for a computer to learn from operations performed by a human driver. So, the approach to a self steering tractor will probably involve TV cameras scanning ahead of the tractor. The on-board computer would then compare images produced by



Photo 14. Massey Ferguson 8160 Datatronic Tractor. Digital readouts of performance, includes the actual cost of the job as it is being done. 32 forward gears, 24 on-the-move power shifts. Can plough at the rate of about 5.0ha/hour.



Photo 15. Traction control touch pads are self explanatory. The bottom touch pad controls the tractor's lights.



the scanning cameras with computer generated images depicting what the cameras should theoretically see when correctly performing actual operations. Steering would be adjusted so that the two images matched each other. Furthermore, images produced by the scanning cameras may well be complemented with data provided by GPS.

Voice Recognition

Following the introduction of voice recognition computers, there is no reason why the tractor of the future should not respond to voice commands. Whilst it may be stretching the imagination to suggest that the tractor of the future will emulate 'HAL' in the film '2001 - A Space Odyssey,' there is no reason why voice recognition should not complement auto-steering. The driver would take his seat in the cab and speak

commands to the tractor. For example; "Wake up" (shades of my word processor), "Implement working depth 150mm", "Auto steering", "Forward-60m/min". The tractor, or indeed a combine harvester, would then work as an automaton allowing the farmer/driver to attend to other matters via his mobile phone and on-board lap top computer.

When work is completed in a field, the commands may well include, "Stop", "Raise implement", "Return to Manual Steering". The farmers would then drive the tractor manually to the next field or to base at the end of the day for re-fueling.

Remote Control

The driver need not necessarily be in the tractor cab; he/she could be in the farm office, or a caravan in the field, and monitor operations by television. Indeed, depending

upon the degree of automation, one operator may be able to control several machines each doing different jobs. So instead of being constantly mobile in the tractor cab, the farmers of the future may be able to supervise the operation of their tractors from the comfort and convenience of the farm office.

Tractors of the future will almost certainly respond to voice commands, so by the end of the millennium, evolution may well have gone full circle by creating a tireless machine that thinks and behaves like a horse.

Viable Rural Economy

It is very significant that since the introduction of large tractors, the number of agricultural workers has declined in number to just about the minimum necessary to sustain a viable agricultural

system. So, I believe that intelligent machines will be designed to improve the welfare of farm workers rather than cause any further reductions in the number in their numbers.

Energy Input

To complete this study, let us look at energy sources for horses and tractors. Horses acquired energy indirectly from the sun by means of photosynthesis. At risk of over simplification, plant leaves absorb CO₂ present in the air and in the presence of sunlight convert this into carbohydrates which provides the energy for the horses. There is a direct relationship between CO₂ levels in the air and crop yields. Some would say that present day high crop yields are only possible because of the higher concentration of CO₂ in the air resulting from burning fossil fuel. Indeed, it had long been a practice to burn paraffin lamps/heaters in glass houses to increase the level of CO₂ in the air and thereby increase yields.

Fossil Fuel

With modern brute force farming systems, the energy required to cultivate a crops is many times greater than that required by traditional horse based farming systems; if the energy used by tractors was derived from plants, the area required would greatly exceed that of marketable crops. On the other hand, the area of land required to feed horses was only a fraction of the land used to grow saleable crops.

So with tractors, the energy expended in the cultivation of a crop is invariably fossil fuel;



Photo 16. Instrument panel, John Deere Tractor, gives a clear view of all gauges and displays.

Photo 17. The Silsoe experimental Autonomous Vehicle - no driver.



this input is not simply in tractor fuel but in fertilizers and agrochemicals applied to that crop.

Nonetheless, straw contains large amounts of energy and in recent years was burnt in the fields, but is now used more intelligently for cattle

fodder, bedding and industrial purposes: it is also used for heating purposes on the farm. Remarkably, straw was burnt as fuel with many early steam engine cultivators and could possibly be used with modern equipment and thereby reduce dependence on fossil fuel.

Less Land Needed

Paradoxically, high crop yields made possible by modern farming methods and possibly by enhanced CO₂ levels, have brought about a significant reduction in the area of land

required for food crops. Unwanted land is known as 'set-aside' land.

Rape oil is good fuel for diesel tractors and theoretically there is no reason why fuel crops should not be grown on set-aside land; it is analogous to traditional farming systems whereby land was reserved to grow feed for the horses.

In the future, brute force farming systems and their dependence on fossil fuel may well be tempered with a return to more elegant traditional farming systems where nature did much of the work - for example, with the limited power of horses, farmers relied on frosts to break down soil lumps to produce a fine seedbed. No doubt farming systems requiring less energy input will be complemented by highly efficient computer controlled, intelligent tractors and probably automotons which may well further reduce the energy input required to cultivate crops in the future.

Appreciation

Appreciation for photographs and help in preparing this study go to:-

Brian Letts, Vintage Tractor Restorer, Finetun, Northants

John Deere Ltd

Massey Ferguson Ltd, Coventry

PA Turney Ltd (New Holland) Wellingborough, Northants.

Roland Woods, Farmer, Clopton, Northants.

Silsoe Research Institute, Bedfordshire

1124

Photo 18. John Deere combine harvester discharging grain into a trailer. Operations are controlled by touch pads.



Burglar ALARM CONTROL

Alex Hunt of Masushita describes how to use and program an 'FPO series' PLC as a burglar alarm central controller with the help of the advanced Windows-based programming software FP-SOFT.

Programmable Logic Controllers, better known as PLC's, can be used for varying degrees of control and monitoring. Specifically, the FPO hardware and software (FP-SOFT) contains easy to follow programming steps that allows flexibility within a control environment.

In this project an FP0-C16P (order code NC47B) is used to control keypad entry codes, timers, alarms and the alarm sensors. The programming may be constructed in stages to allow verification by the software, although this may also be carried out at a later stage, but it is easier to debug shorter programs that may have been inputted poorly.

For this application the program has been written in FPSOFT (order code NC52G) using 'Ladder Logic' programming language. This software allows the creation of a program by using a mouse or keyboard. The ladder diagram is programmed using BASIC and high level instructions written on to 'ladder rungs'. Specific rungs have been grouped in such a way as to assist the operator, so making it easier to view live inputs on one screen. Each group of instructions is identified to give the programmer knowledge of

how the system will work.

The programming kit includes all the cables and converters/connectors required to connect the PLC to a PC. The programming software allows ease-of-use of programming between the user and the PLC. The advanced Windows based software allows the user to create ladder diagrams very quickly using symbol palettes and tool bars, and allows the remote switching between 'program' and 'run' mode.

The Alarm Requirements

The alarm may be switched on using a keypad entry code (password) thus allowing the user to turn the system on, or alarm off, before or after it is sounding.

A timer is then required to let the occupants exit the building without setting the alarm off.

The system will then monitor the inputs for signs of a break in without the keypad entry. If any sensor is activated other than the front door switch the alarm will sound. If the front door is opened then a second timer will activate allowing the system to be switched off before the alarm is sounded.

PLC 16 I/O Controller
ORDER CODE: NC47B
£202.13



FP0 Programming Pack
ORDER CODE: NC52G
£63.26

Help Button
ORDER CODE: FP12N
£1.49



Window Contact
ORDER CODE: MM11M
£1.99



Glass Break Detector
ORDER CODE: FP11M
£2.99

Door Loop
ORDER CODE: YW48C
£3.99

Pressure Mat
ORDER CODE: YB91Y
£5.99

Stair Pressure Mat
ORDER CODE: FK79L
£4.99

Numeric Keypad
ORDER CODE: JM09K
£2.99

Additional features that maybe added include a panic button (order code FP12N), a timer-on alarm that times out after 20 minutes and then resets the system, an entry/exit courtesy light, an entry/exit courtesy buzzer, window contacts (order code MM11M) and pressure mats (order code YB91Y or FK79L).

Programming

Programming is carried out using the RS232C port on the FPO and a PC using the programming cable supplied with the FPO programming pack. The software is Windows based using symbol palettes and tool bars to create what is commonly called a graphic

operating environment, or a graphic user interface (GUI). Operating with a Windows based software package from Matsushita simplifies the keyboard operations that were previously typed in using a DOS based system.

FPSOFT also provides various kinds of features that enable effective programming. You can customise FPSOFT to make it easier to create a program. While creating a program, it is possible to copy, delete, move, or search for a part of the program.

Monitoring

To support programming capability, FPSOFT can monitor a program and perform a 'Test Run' for verification. The status of relays and registers and the operating status of the programmable controller may also be monitored in ONLINE mode. Therefore debugging can easily be performed.

Input/Output requirements

1. The FPO controller selected for this project has 16 I/O, eight input and eight output.
2. The keypad requires seven multiplexed I/O (three for

inputs and four for outputs). See Figures 1 and 2.

3. The alarm requires a single output.
4. The front door alarm requires one input (closed circuit).
5. The alarm sensors require an additional one input (closed circuit), and two inputs if a pressure pad is used (open circuit) so allowing any number of sensors to be used in series and parallel.
6. The panic switch requires a single input.
7. The keypad entry light and the entry buzzer require a single output each.

Programming

The project requires that the alarm may be switched on using a keypad entry code (password). The keypad requires 7-I/O, this can be achieved by multiplexing the keypad using 3-inputs and 4-relay outputs. To achieve this the outputs must be pulsed to give a specific relay output when the keypad is pressed.

Each key is represented by a horizontal and vertically positioned I/O. When a button is pressed a contact is closed between the touch sensitive circuit. The first horizontal line

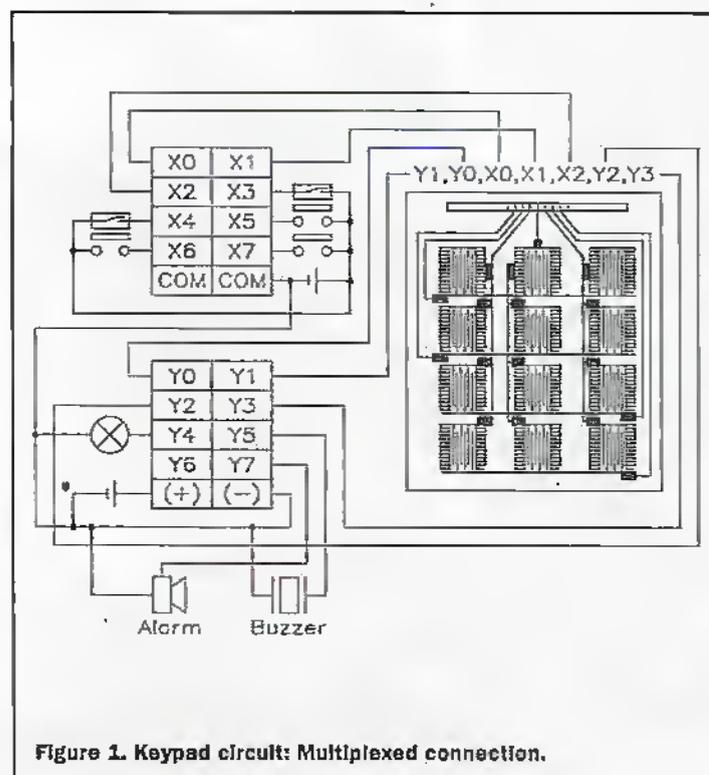


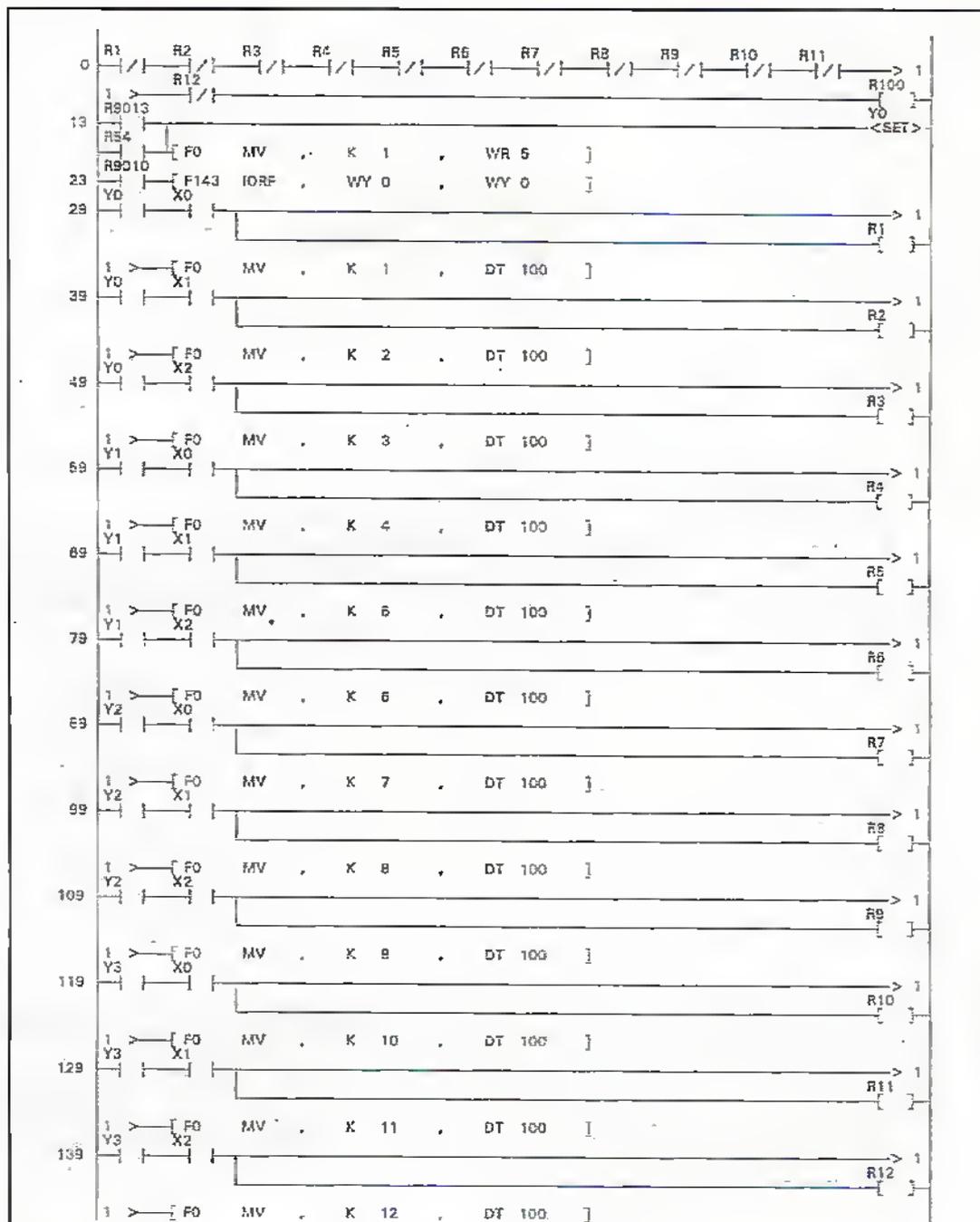
Figure 1. Keypad circuit: Multiplexed connection.

(buttons 1,2,3) is represented by Y0. The first vertical line (buttons 1,4,7,*) is represented by X0. If button 1 is pressed then a positive pulse for both Y0 AND X0 closes a logic circuit sending a constant to a data register. The constant to be sent is 1 and the data register is DT100.

A timer is then required to let the occupants exit the building without setting the alarm off. The exit timer is activated by entering a specific password into the FP0. This in turn triggers the timers register. The register triggered from the correct password is used as an input to start the timer.

The keypad is used to enter a password which can be set by the operator to any four symbols on the keypad. The first time the password is entered the alarm will become active after 'n' seconds allowing the operator time to get out of the building. If any of the sensors are activated the alarm will sound. To deactivate the sensors (or the alarm if it is sounding) the operator re-enters the building and has 'n' seconds to enter the same password. If the operator fails to type in the correct password the alarm will sound.

To aid in entering the password, an extra output has been programmed to turn a courtesy light on for 15 seconds from when the keypad is pressed. A further output has also been programmed to activate a buzzer for each press of the keypad. For convenience, it is possible to alter the operator's entry and exit timer for shorter or longer periods of time.



Ladder Logic Programming Diagram (continued over).

RELAY LIST

X 0	*Multiplexed input 1st vertical line	R 4	*Relay 4 activates R100 when broke	R 99	*Relay 1 to 9, 10, 11, 12 activates relay 99
X 1	*Multiplexed input 2nd vertical line	R 5	*Relay 5 activates R100 when broke	R 100	*When open relay 100 sets Y4
X 2	*Multiplexed input 3rd vertical line	R 6	*Relay 6 activates R100 when broke	R 9010	*Special always on relay
X 4	*Front door reed switch - normally closed	R 7	*Relay 7 activates R100 when broke	R 9013	*Special initial on relay
X 5	*Pressure mat normally open	R 8	*Relay 8 activates R100 when broke	R 9018	*Special relay 0.01s clock pulse
X 6	*Panic button 1	R 9	*Relay 9 activates R100 when broke	T 0	*Turns the alarm off after 20 minutes
X 7	*Panic button 2	R 10	*Relay 10 activates R100 when broke	T 1	*Turns sensor (R30) live after 4 seconds
Y 0	*Multiplexed Input 1st horizontal line	R 11	*Relay 11 activates R100 when broke	T 2	*Resets R30 & R90 after 6 seconds
Y 1	*Multiplexed Input 2nd horizontal line	R 12	*Relay 12 activates R100 when broke	T 3	*Moves K0 to data register DT1 after 5s
Y 2	*Multiplexed Input 3rd horizontal line	R 30	*Turns sensors X4, X5, X6, X7 live	T 4	*Sets Y7 after 15 seconds
Y 3	*Multiplexed input 4th horizontal line	R 30	*Activates output Y0	T 5	*Resets Y4 after 16 seconds
Y 4	*Keypad entry light	R 51	*Activates output Y1	C 100	*Triggers R71, Resets R30, Y7, Y4 sets R90
Y 5	*Entry buzzer	R 52	*Activates output Y2	DT 1	*Data register used to shift 1 hex digit
Y 7	*Alarm	R 53	*Activates output Y3	DT 2	*Data register used to shift 1 hex digit
R 1	*Relay 1 activates R100 when broke	R 54	*Resets pulse at R54	DT 100	*Stores keypad constants
R 2	*Relay 2 activates R100 when broke	R 70	*Decrements counter	WY 0	*Starting word address
R 3	*Relay 3 activates R100 when broke	R 71	*Resets counter	WR 5	*Used to pulse relay group R50 to R5F
		R 90	*Relay that sets timer 2		

specified. This is a special internal relay that activates a clock pulse of 0.01 second and repeats in 0.01 second cycles. It is used to pulse the multiplexed outputs, which in turn are used as inputs from the keypad to the PLC.

Line Starting 157

A series of parallel inputs labelled R1 to R12 will activate internal relay R99 when high. Each time the keypad is pressed, internal relay R99 is used to advance the password.

Line Starting 170

From line starting 157, when the keypad is pressed R99 is activated which in turn activates F113 the left shift of one hex digit. This is used to move the individual keypad entry and exit codes, allowing a four number password.

Line Starting 177

From line starting 29 to 139, when the keypad is pressed a constant is moved to data register DT100. When the keypad is pressed (triggering R99) F6 moves the Hex digit stored at DT100 (the source) to DT1 (the destination) by 'n' number of digits.

Line Starting 186

Compares the set password in hex to the decimal constant, sending R70 high if equal to K. For this example the password has been set as 1234 hex which is equivalent to 4660 in decimal.

Line Starting 192

From line starting 186, R70 goes high when the correct password is entered decrementing the counter by 1. The counter is reset by R71. This counter is used to differentiate between the entry and exit code as only one password is used.

Line Starting 197

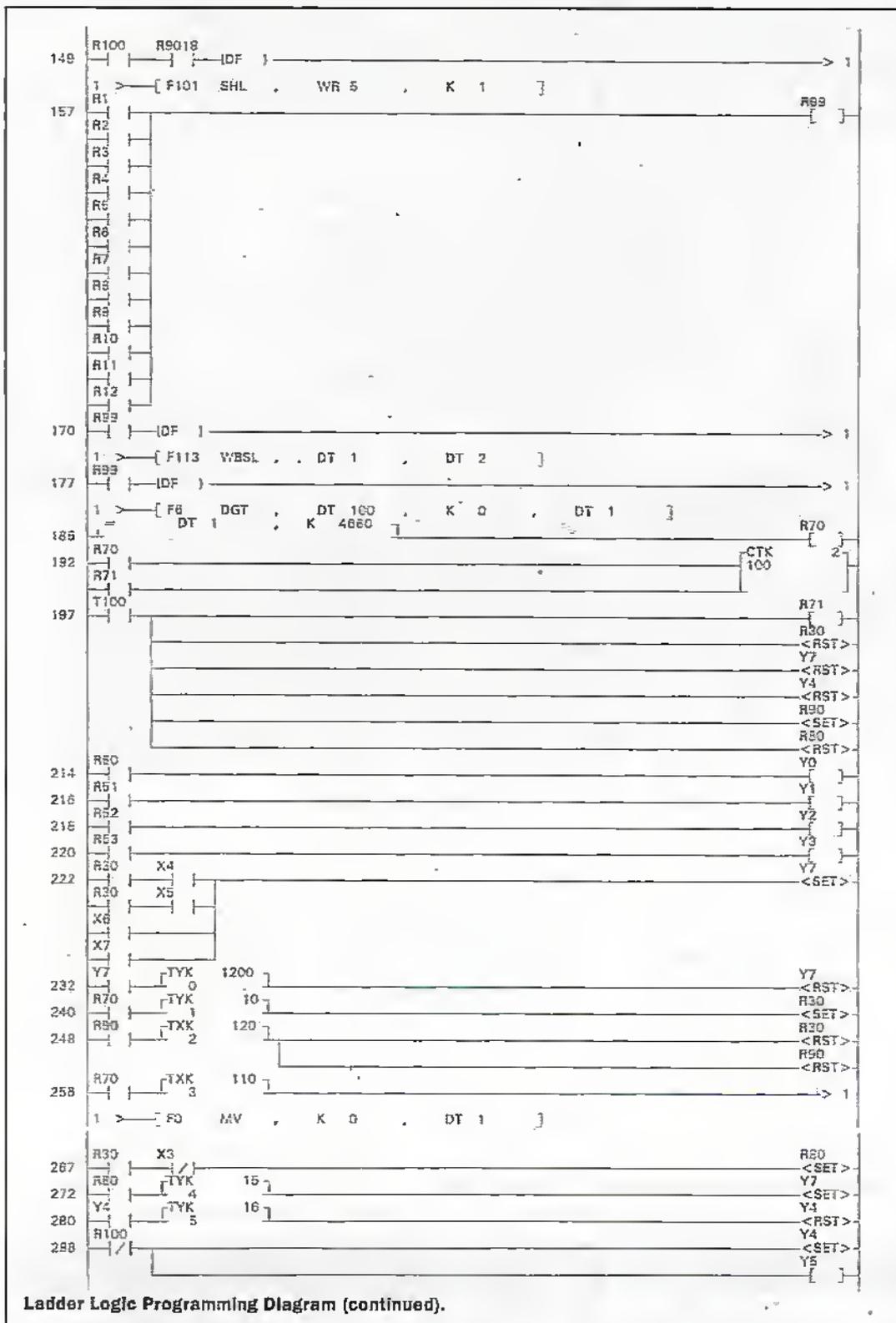
From line starting 192. When the counter has reached zero, C100 goes high, this triggers R71 (counter reset), sets R90 and resets R30, Y7, Y4. This makes sure the second password entry turns the sensors off.

Line Starting 214 to 220

Relay group WR5 pulses outputs Y0-Y3 to the multiplexed keypad.

Line Starting 222

R30 is used to arm the sensors after you have exited the building. X4 is a constantly closed circuit



Ladder Logic Programming Diagram (continued).

THE PROGRAM

Line Starting 0

A series of inputs labelled R1 to R12 will activate internal relay R100 when they go low (logic Not input). Pressing the keypad will pause the multiplexer.

Line Starting 13

The 9013 is a special Initial ON relay that turns ON only for the first scan of the program and turns OFF from the second scan and maintains the OFF state. F0 is a 16-bit data move that copies a constant to the

area specified when a trigger (R54) turns on. This set of instructions is used to reset the multiplexer at R54 as R53 is the last multiplexed relay.

Line Starting 23

The 9010 is a special internal flag that is an always ON relay that makes sure F143 is on. F143 is a partial I/O update.

Lines Starting 29/39/49/59/69/79/89/99/109/119/129/139

When '1' is pressed on the keypad (line 29), Y0 and X0 will

both go high forcing R1 to close. This then moves constant K1 into data register DT100. When 2 is pressed (line 39), Y0 and X1 will both go high forcing R2 to close. This then moves constant K2 into data register DT100. This function is repeated for all input/outputs taken from the multiplexed keypad and is used to allocate constants for processing the password.

Line Starting 149

From line starting 0, when R100 and R9018 turns on, the R9018 internal relay pulses the outputs

such as a reed sensor and will set Y7 if a broken circuit is detected. X5 is a constantly open circuit such as pressure pads and will set Y7 if a closed circuit is detected. X6 and X7 can be set up as either a closed or open circuit depending on the panic button being used. The panic buttons can trigger the alarm (Y7) at any time but X4 and X5 can only be triggered once the alarm system is set.

Line Starting 232

Once the alarm (Y7) has been set, timer 0 starts counting down from 1200 seconds or 20 minutes. When 0 is reached the alarm is reset. If the alarm is required to stay on until the keypad entry is made, then this line maybe removed.

Line Starting 240

When R70 goes high, timer 1 starts counting down from 10 seconds. This is the exit time to close the door. After 10 seconds R30 turns the sensors into live mode and the alarm starts monitoring for break-ins.

Line Starting 248

When R90 goes high, timer 2 starts counting down from 12 seconds. This is used to reset

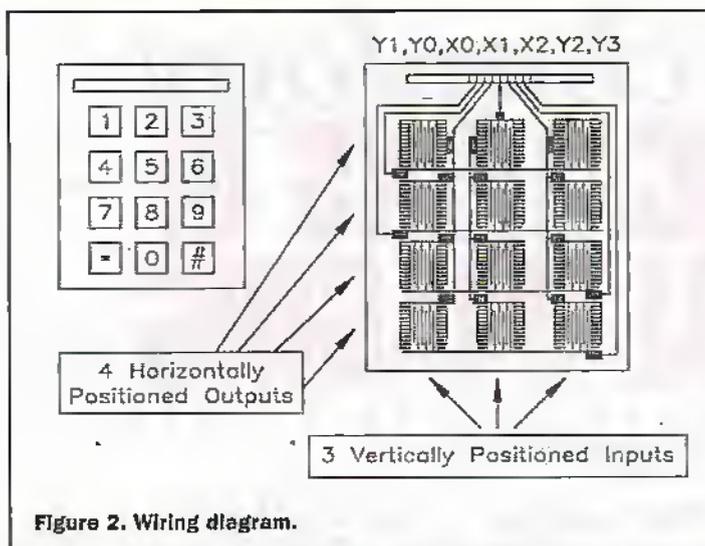


Figure 2. Wiring diagram.

SPECIFICATION FOR 'FPO SERIES' PLC TYPE FPO-C16P

Supply voltage:	24V dc
Current consumption:	25mA
Max. current:	40mA @ 24V dc
Processing speed:	0.9ms per BASIC instruction
O/P type:	open collector (PNP)
Inputs/outputs:	8/8

The PLC type FPO-C16P, order code NC47B, costs £172.02 plus VAT. The FPO programming pack, order code NC52G, costs £53.83 plus VAT. Note that the PLC will require a suitable power supply, order code NC51F, and costs £53.83 plus VAT.

R30 turning the sensors from live to dormant. The timer also resets R90, therefore resetting itself.

Line Starting 258

When R70 goes high, timer 3 starts counting down from 11 seconds. This then moves a constant 'K0' into data register DT1-resetting R70.

Line Starting 272 & 267

R30 is used to arm the sensors after you have exited the building. X3 is a constantly closed circuit such as a reed sensor and will set Y7 if a broken circuit is detected. When the circuit is broken timer 4 will count down from 15 seconds until it reaches 0 and sets the alarm.

Line Starting 280

From line starting 288, when the entry/exit light is set, timer 5 starts counting down from 16. When the timer reaches 0 the entry/exit light (Y4) and buzzer (Y5) is reset.

Line Starting 288

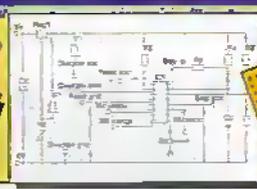
From line starting 0, when the keypad is pressed R100 is logic notted to set the entry/exit light Y4. At the same time sounding a buzzer (Y5).

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The Technology & APPLICATIONS OF THERMAL IMAGING

by Dr. C R Lavers

Until recently only the military, using very high-performance equipment, possessed the ability to see in complete darkness or through the heavy dust and smoke of battlefield conditions. Now new affordable thermal imaging technology is bringing the advantages of vision enhancement to a broad spectrum of commercial applications.

Originally developed for military purposes, infra red (IR) technology is now a valuable tool in diverse fields such as power maintenance, medical research, archaeology, search and rescue and law enforcement. Systems are available in many configurations across a range of prices. Recent advances have improved image quality, reducing both cost and weight, with built-in camera processing ability. Most IR imaging systems now use 'staring' imaging arrays that are sensitive to radiation from approximately 2 to 5 microns (μm) 'short-wave' or 8 to 12 microns 'longwave'. The IR region ranges from 0.75 microns to over 1000 microns and is sandwiched below visible light and above radio waves in the electromagnetic frequency spectrum.

In thermal imaging heat radiation emitted by all objects above absolute zero is detected. Very hot temperature objects, such as the sun, emit radiation across a range of spectral bands, having a peak emission wavelength in the visible. The cooler the object the longer the peak emission wavelength and the broader the spread of radiated power over wavelength. This power distribution is more commonly referred to as the Stefan-Boltzmann law and the prediction of peak wavelength is given by Wien's displacement law (figure 1). Room temperature objects emit strongly in the Far Infra Red (FIR) between 6-15 microns; the Middle Infra Red (MIR) corresponds to 3-6 microns radiation and the near Infra Red or NIR 0.75-3 microns.

The ratio of emitted to reflected radiation for a heat source is known simply as the emissivity. An emissivity value of 1.0 represents a perfect emitter, or blackbody. Perfect emitters exist only in theory; practical applications involve sources that are not perfect emitters (grey bodies) or in fact consist of different substances with only specific wavelengths of emission (selective or coloured body). In the heart of the IR system is the thermal detector. Essentially,

photoelectric devices either measure a voltage change (photovoltaic) or a resistance change (photoconductive) as IR radiation strikes the detector array surface. Common materials used with high quantum efficiency (light to electrical conversion) include: mercury cadmium telluride MCT, indium antimonide InSb, and platinum silicide PtSi. In contrast to visible-light charge-coupled-devices (CCD's), most IR imaging systems require cooling to cryogenic temperatures (usually liquid nitrogen) to achieve acceptable performance. Since the detector will be sensitive to heat from *any* source, steps must be taken to carefully cool the detector and the surrounding sensor housing to ensure that the detector response is attributed to radiation from the viewed scene alone. The IR energy measured by a detector is a

combination of radiation emitted by the source of heat under inspection, and radiation reflected from other sources in the scene. Until recently only scanned systems incorporating a single detector or, a small line of detectors, were available where a mirror would be used to rapidly scan the scene in either a serial or parallel format.

Over the last few years staring systems have been developed in which the detector is a monolithic integrated circuit with the entire scene focused upon it. The technology is similar to that of an ordinary camera. A germanium thermal lens (transparent in the IR bands) focuses the image directly onto the detector. Such systems remove the need for mechanical scanning, reducing weight and increasing reliability. Military staring systems have an additional advantage that the absence of moving components makes them very quiet to operate. IR imagers provide sensitive indication of the relative temperature distribution across the scene. Systems specified as *radiometric* also provide calibrated temperature measurements at individual points or across the entire display. The system is calibrated in the manufacturing plant by aiming it at a precision blackbody, the calibration source is set to a number of different temperatures and the detector optics response is measured at every temperature, and the information written into an internal software calibration table. In addition, data from other sensors allows compensation for changes in background ambient temperature and the temperature of the system optics; variations in atmospheric propagation are also considered.

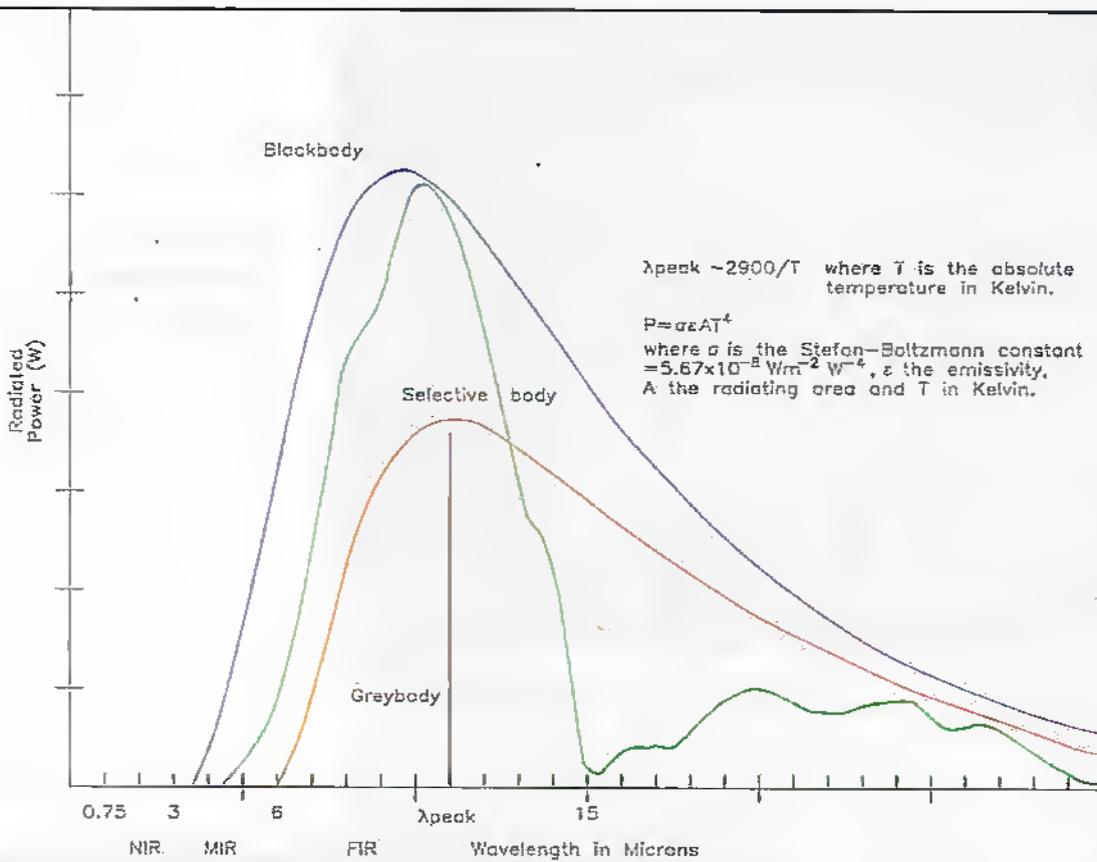
Applications

Thermal IR imaging or thermography is rapidly emerging as one of the most valuable resources available for a wide variety of applications such as: predictive plant maintenance, aircraft analysis and process monitoring.



Figure 2. Overheated on top changers. Courtesy of Inframetrics.

Figure 1.



Predictive maintenance

Thermal imaging is able to discover building flaws and structural defects at very early stages. Power failures and major power outages can be unnecessarily avoided, resulting in significant cost savings and in some cases, potentially lives. Portable maintenance IR imaging systems have been available for some time. Hand held systems may be used to scan structures and equipment, rapidly converting the radiated thermal energy into visible pictures which are displayed for quantitative temperature analysis. ThermaCAM, the most recent product from Inframetrics of Massachusetts USA, (a world leader in the design and manufacture of thermal imaging systems since 1974), offers a major advance in predictive maintenance. ThermaCAM is both lightweight and has a high performance, and includes a full-screen temperature measurement with 12-bit digital data storage. Images may be stored in the camera via solid-state memory cards and output as TV, VCR-compatible video or digital signals. Images may also be stored as either 8-bit or 12-bit TIFF files which can be viewed outside the camera and uses image processing software for a PC Windows™ environment, enabling extensive data analysis of both static and real-time images.

At the centre of ThermaCAM is a field-tested microcooler which keeps its Focal Plane Array (FPA) detector at a constant operating temperature. Combined with advanced electronics ThermaCAM's rapid data handling ability and low power requirements, only 12W, means it is able to run on a conventional camcorder battery, a design feature which reduces the overall system weight and increases portability. The battery attaches directly to the camera, avoiding the need for cables and will

operate continuously for over 2 hours with a single battery charge. ThermaCAM incorporates accurate radiometric calibration with an optical camera, resulting in an extremely stable, full-screen radiometric system able to measure temperatures from -20°C to over 1000°C and up to 1500°C using optional high temperature filters. High-resolution black and white or colour images with 256 colours may be viewed through a colour Liquid Crystal Display (LCD) showing images free of ambient light or reflections. ThermaCAM is rated to withstand a 70G shock, equivalent to dropping the camera from 3 metres onto a concrete floor!

An Inframetrics ThermaCAM camera has been used by the Maintenance division of London Electricity plc as part of routine servicing throughout the power distributor's region. London Electricity provides commercial and domestic power to Central and Greater London with responsibility for sub-stations and grid sites,

throughout the region. Highly detailed images of vital equipment such as transformers and connectors helps save costs on unnecessary equipment strip-downs. Damaged transformers and generators easily show up as hot spots much higher in temperature than expected during temperature analysis. As London Electricity Engineer John Parker explains, 'there can be little doubt that the thermal imager will pay for itself in terms of cost

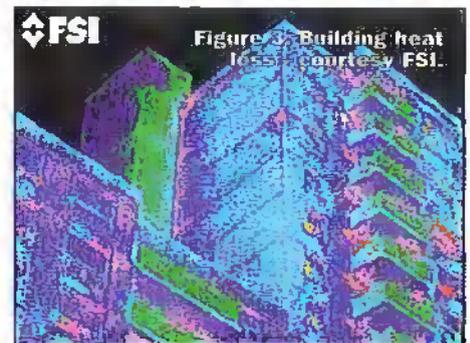


Figure 4. Left: Checking faulty fuses. Right: Heat rise on air compressor cylinder heads. Courtesy of Inframetrics.



Figure 5. Breakdown of refractory lining in furnace walls. Courtesy of Inframetrics.

saving and it has proved a source of very accurate data as part of our ongoing maintenance activity' The camera is used for identifying hotspots in connectors and isolators but has also proved useful in identifying oil flow problems in transformers-giving early warning of problems which could cause major supply network disruptions. See Figure 2. The camera's portability has proved popular with engineers in cramped site conditions or working up ladders and on scaffolding. Applications include electrical and mechanical IR inspection, condition monitoring of refractory linings, insulation effectiveness, roofing studies, etc. See Figures 3 and 4.

Thermal imagers are now an integral feature of preventative maintenance programmes at Blue Circle Industries cement plant in Staffordshire. Blue Circle purchased an Inframetrics ThermoCAM system to develop highly accurate records of machine conditions within the plant, which in the past were largely made by visual inspection. In addition, the identification of hot spots in the refractories and kiln bricking enables local action to be taken on potential problems. Figure 5 shows a breakdown of refractory lining in furnace walls.

Law enforcement or Military Technology applied to the Criminal Battlefield

With the end of the Cold War, many military technologies have increasingly found their way into the civilian sector. Thermal imaging technology, extremely useful to the military, is providing its benefits to law enforcement agencies through North America and the world. Raytheon TI systems (RTIS) has been leading in the provision of law enforcement with their high technology tools to fight the war on crime. 'Nightsight' Thermal Imaging Solutions products provide several useful law enforcement features. 'Nightsight' allows police officers to pursue suspects into building, dark alleyways, and the smallest, Raytheon PalmIR 250 camera weighs only 1.2kg and has a range of over 700m.

Finding Missing Persons

Detecting hiding or missing persons has become commonplace through the use of thermal imaging technology. Law enforcement agencies have documented

numerous cases of spotting suspect criminals hiding in bushes, or children lost in open areas and heavily wooded areas at night. One North Carolina law enforcement agency, used a RTIS thermal imager to find an arsonist hiding in a ravine, preparing to set a house on fire!

Uncovering the Concealed and Heightened Surveillance

The RTIS P200 vehicle-mounted camera is highly effective in scanning for recently driven cars (the engine appears hot), searching for drug making equipment and the early detection of fires in closed buildings. Thermal imagers can even detect concealed weapons, an option all police officers would like to have to protect their own officers in high risk environments.

On patrol, or when called into specific situations, policemen can now use night vision technology in a wide variety of ways: seeing through smoke and dust, pinpointing snipers, and securing public buildings and spaces. These are all surveillance benefits reaped through the use of thermal imaging technology. Monitoring people and objects in the dark, see Figure 6, or even in the



Figure 6. Policeman using 'Nightsight'. Courtesy of Raytheon TI Systems (RTIS).

shadow cast within well-lit areas, is difficult. Thermal imaging can highlight people, vehicles and certain objects in the dark, or even intruders hiding in foliage or beside buildings. By detecting IR energy, these cameras can translate heat into high-contrast video pictures, making warmer objects show out as red against a cooler background in blue using so called *false colour representation*, where hot objects may be shown in red against a cold blue background. In total darkness or daylight it is easy for US officers to detect illegal immigrants trying to cross borders or avoid perimeter patrols.

Search and rescue teams in co-operation with fire-fighters and police officers may also move safely inside buildings to find people trapped in rubble, determining potential hazards such as gas or oil leaks, and even detecting weak spots in dams holding back floodwater. Thermal imaging has also proven useful in helping secure the disaster scene of a recent crashed TWA Flight 800. Fire-fighters are also able to see through smoke and detect hot spots to determine the source of a fire.

Safety at Sea

When the sun sets at dusk it doesn't mean that mariners head for the nearest port. Public vessel transport, the Coast Guard, military, pleasure boats and even commercial oil rigs need to manoeuvre at night. Crowded and dimly lit dock areas may be hazardous, especially when operating a large vessel. With thermal imaging obstacles and buoys, small boats and floating debris may be spotted easily in the water. Passenger vessels such as the Washington State Ferries of Seattle, have adopted a Raytheon *Nightsight* system to complement their existing radar in order to avoid floating navigational hazards that could lead to a collision.

Navy Coastguard and military personnel often need to mount search-and-rescue operations in the middle of the night or in foul weather conditions. By detecting heat differences between objects in a 'scene' thermography has become a crucial ally in poorly lit dock areas and in boating accidents. The US Coast Guard has found thermal imaging beneficial in a number of ways, from spotting a swimmer's heat trail in the water to detecting warm boat engines. The technology is now used during routine patrol as well as in emergency situations. The SAFIRE (FLIR) family of thermal imager is available in a shipboard version for maritime patrol, navigation assistance, and search and rescue.

Oil platforms are notorious for their high levels of maintenance and hostile operating environments. Preventable maintenance and non-destructive examinations (NDE) of internal pipework surfaces has been reduced significantly by introducing portable ThermoCAM IR image analysis cameras at BP's 40's oil field platforms. The camera system is able to identify 'hot spots' in bearings and components susceptible to wear within motors and pumps, and can confirm data supplied by diagnostics equipment. Thermal imaging has proven useful in thermal surveys of pipework and pressurised vessels which are susceptible to

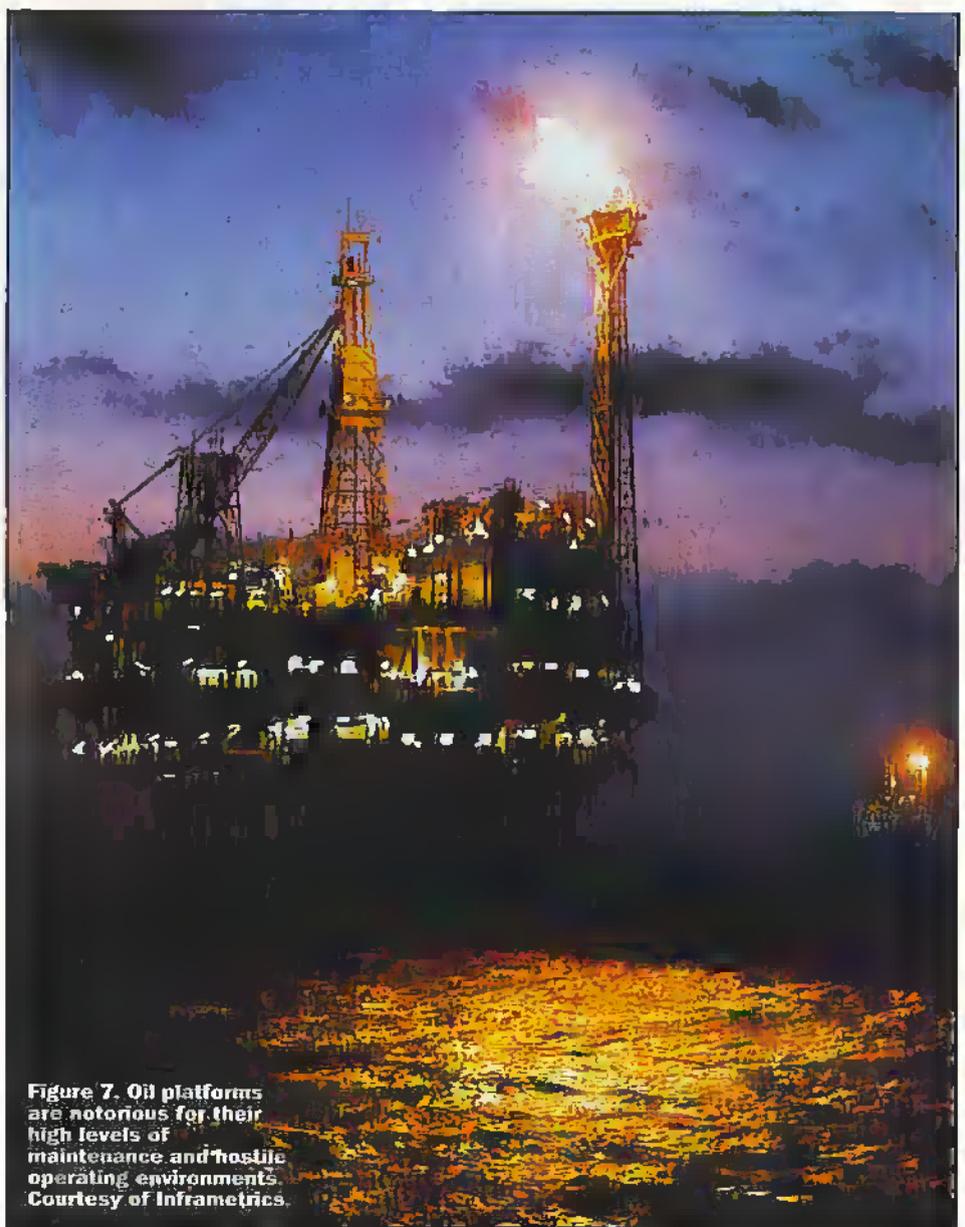


Figure 7. Oil platforms are notorious for their high levels of maintenance and hostile operating environments. Courtesy of Inframetrics.

the build up of salt water 'scale', which appears as cooler areas with the imaging camera. BP is now able to assess build-up levels and respond before blockages occur. As David Cathpole of BP Offshore Exploration explains "having assessed the thermographic image technologies and now purchased our own camera it will play an increasingly important role in BP's production platform maintenance."

Improved Night Driving Safety

55% of all driving fatalities occur at night, yet only 28% of all driving takes place after sunset. NightDriver, a Raytheon thermal imaging system is now available as an integrated option for automobiles; it permits drivers to see 4-5 times further than conventional headlights, giving drivers precious time to react to unseen traffic, pedestrians, obstacles or animals. The camera may also be adapted for track applications. The system uses a heads-up-display (HUD) to project real-time thermal images onto the lower part of the driver's windshield. The image created by a thermal array translates the IR heat into high contrast video pictures, and because it is unaffected by headlights helps reduce the

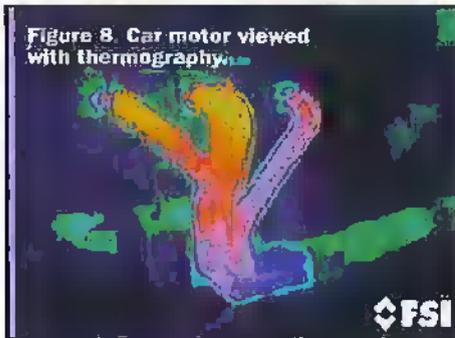
distraction caused by oncoming traffic glare. Recently an RTIS NightDriver was driven to victory in the US Score Baja 1000 Stock Car race with a 13 minutes victory margin. Similar night vision technology is being developed by automobile manufacturers as a consumer safety feature.

Aircraft fatigue

A new NDE technique relying upon the reflection of heat pulses from sub-surface defects, analogous to radar detection, is currently achieving good results in aircraft maintenance. Thermal Aid for Defects and Ranging (THADAR), has become more commonly known as pulse-echo thermal wave imaging, a concept first suggested by Alexander Graham Bell, the inventor of the telephone. A high power photographic flashlamp pulse-heats the object surface under inspection. A plane thermal wave propagates into the material. As the pulse encounters a defect below the surface the defect scatters back a fraction of the pulse energy towards the surface. When these reflected pulses (or thermal wave echoes) arrive back at the surface, the defect depth is given by the simple time of flight ($\text{speed} = 2 \times \text{Range}/\text{time of flight}$).

Through the use of fast image processing

Figure 8. Car motor viewed with thermography.



hardware and software the computer memory stores a sequence of gated images corresponding to the various arrival times of the echoes at the surface. The result is a series of echo images located at various depths beneath the surface. The return times for aluminium aircraft alloy skin is typically milliseconds, whilst those of graphite-reinforced carbon fibre composites are from 100ms to seconds, depending upon the image depth. In practice operational range covers from a few microns of paint to 2-3cm of concrete. This NDE technique is crucial in aircraft analysis for monitoring fatigue and crack propagation, particularly in wingtips.

Thermal imaging has several advantages over other traditional NDE imaging technologies such as x-rays and ultrasound in that it is: non-invasive, non-contact and may be used over large image areas (square metres). Spatial resolution from deep defects tends to blur, or 'wash-out', but software is available to partially correct for these aberrations. High energy flashlamps are used in the 8-12 μ m band. In the automotive industry IR is used to monitor the adhesion of ceramic coatings onto diesel engine pistons, processing defects and in injection moulded polymer parts for braking systems. Aerospace and engineering applications allow rapid and contactless corrosion and bonding failure detection in metal aircraft skins, and process defects in carbon composites. Effects that have been demonstrated in both Boeing B-727's and ageing military aircraft. It can detect the presence of voids, which show up with a 1-2 $^{\circ}$ temperature difference. Car and vehicle engine performance may be easily monitored with IR thermography.

Radomes, the conical glass fibre enclosures on aircraft noses which house the radar must provide an 'electromagnetically' clear window through which the radar signal is transmitted and echoes are received. Trapped moisture and glass fibre delamination will block or deflect radar signals. Moisture is also responsible for radome cracking. California Radomes of San Jose uses a Thermvision 450 IR camera from AGEMA. Radomes are heated to 50 $^{\circ}$ C and then observed as they cool down. Industrial Quality Inc (Gaithersburg Massachusetts) in co-operation with the US Coast Guard are searching for ways to use thermography in assessing boat hull damage. The thickest fibre glass laminates are 100mm to 125mm thick, such as minesweeper hull material; but yacht structures may have foam cores 50mm thick. "Kevlar and graphite composites may be evaluated in this way; but as a general rule you cannot detect flaws smaller than the thickness of the material", says Thomas S Jones, Vice President of California Radomes. Jones uses a variety of heat sources, but prefers to use a 0.6-1kW



Figure 9. Horse stress thermogram.

quartz lamp UV heater, and 'strokes' between 4-5kJ. "Using strobes makes the heat pulse an instantaneous event, and you can do time sensitive processing."

Health Imaging and Stress Analysis

Breast cancer has become a big issue in women's health today, particularly in advanced industrialised nations, however, nearly 1,000 men develop breast cancer every year. One procedure which has gone largely unnoticed is Breast Thermography, which offers the possibility of earlier detection of the disease before breast self-examination or mammography. Utilising sophisticated IR cameras and desk-top computers, thermal imaging technicians may capture a thermal breast portrait. The data may be either printed out or sent electronically to a physician for analysis, who can then compare the heat patterns in both breasts. Any difference in heat, or any specific blood vessel patterns in one breast that does not appear in the other, indicates a physiological abnormality, which may be pathological (a disease) or indicate an anatomical change, possibly cancer related. An IR thermogram may be sensitive to as little as 0.2 $^{\circ}$ C temperature variation. Thermograms have emerged as a valuable diagnostic tool in sports medicine for musculoskeletal disorders, not only helping confirm diagnoses, but clinically assessing progress and treatment. Since IR thermography is non-invasive, portable and risk-free it is a very practical tool in the clinical environment. It is useful for the diagnosis of: ankle injuries, shin splints, stress fractures, shoulder injuries, vasculodisorders etc. The versatility of IR thermography for humans has led to the technique being increasingly applied in veterinary studies of fitness performance, particularly the physiology of racing horses. Additional data on the level of physiological stress is given by a simple IR thermogram. See Figure 9.

Good System Design

Critical features of a good IR system should include:

- ◆ Power Focusing- which gives sharper viewing,
 - ◆ Low picture distortion,
 - ◆ High quality software packages,
 - ◆ A large number of detector elements or 'pixels', A high degree of element uniformity and accuracy,
 - ◆ Low power consumption & lightweight.
- Several systems exhibit these characteristics, including Tracer (FLIR Systems), which has

Figure 10. Bulb testing.



high quality real-time IR imaging, combining high-resolution, radiometric accuracy and robust PC based analysis in a Windows environment. Tracer may be configured for a variety of R&D applications, including microelectronics failure analysis and electrical component testing. See Figures 10 and 11. The high resolution provided by 78,080 elements in the FPA of a typical FLIR Prism DS sensor with digital storage, makes it easy to capture and analyse thermal activity. State-of-the-art FPA cameras work with frame rates between 60Hz-200Hz, frame sizes of 165 kbytes, with pixel sizes of 24 μ m². The Prism DS includes a microprocessor which all decent IR thermal imaging systems should have, managing the power and imager performance. Software upgrades are simply achieved by inserting a removable PC card which may also hold over 2000 images.

Future Systems

Amber was the first company to develop a fully integrated camera system. The portable Radiance 1 camera has frame rates up to 200Hz, a 256 \times 256 FPA with digital output, computer processing, a 12V power supply, comparable with the Electrophysics ThermoTracer. Series 3,4,5,6000 are generally fixed and make use of InSb gallium-doped silicon.

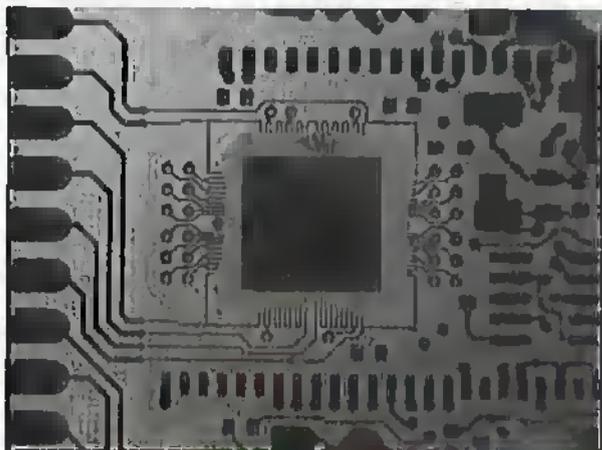
Current projections are that by the year 2000 sensors will have 7000 \times 7000 elements. Philips now have an optical FPA with 7000 \times 9000 visible elements on an integrated CCD wafer with an incredible 66 million pixels per sensor. Transferring this to platinum silicide in the IR is underway, an advanced prototype eyeball size sensor has 2000 \times 2000 pixels. Analysts anticipate micro-optics and multi-hyperspectral systems (the ability to image a scene and simultaneously determine the spectral content). The basic principle of hyper-spectral systems relies on the diffraction grating. Radiation is separated into different bands according to its wavelength, see Figure 12, and this method is used in chemical analysis.

The use of microlithography or reactive ion etching readily produces diffractive elements or microlens for monitoring the IR spectrum. They allow a significant weight reduction as only the lens curvature is necessary to focus the IR and not the complete lens itself, however, resolution is worse. The minimum feature sizes are 1 μ m \pm 0.1 μ m using standard NIR materials.

Advanced Cooled IR FPA

PtSi has a cut-off wavelength of 5.7 μ m, a maximum response at 4.3 μ m and took \$10,000,000 to develop a 256 \times 256 array with 30-40 sensors per wafer, typically throwing 99% of available light away. PtSi

Figure 11.
Microchip
testing.



uses a simple Schottky-Barrier diode with each pixel $30\mu\text{m}^2$.

InSb operates in the $3\text{-}5\mu\text{m}$ band with a peak response at $4.7\text{-}4.8\mu\text{m}$. The quantum efficiency of InSb is 90%, more sensitive than PtSi. In 1997 Amber developed a 512×484 rectangular TV format, and was the first to develop fully integrated camera systems incorporating the new arrays.

Mercury Cadmium Telluride (MCT), is known this side of the Atlantic as Cadmium Mercury Telluride. By varying x in the formula, $\text{Hg}_x\text{-Cd}_x\text{Te}$, changes the cut-off wavelength between $3\text{-}5\mu\text{m}$. Loral IR Imaging Systems have developed a MCT system with pixels $45\mu\text{m}^2$.

Quantum Well Infra-red Photodetectors (QWIP) have quantum efficiencies of only 50% but based upon GaAs semiconductor processing technology which has several advantages. A typical GaAs/AlGaAs system is engineered for a peak spectral response between $3\text{-}19\mu\text{m}$ with $0.4\text{-}0.5\mu\text{m}$ bandwidths. Currently a 128×128 prototype is under development. The JET Propulsion laboratory, and Amber announced recently the design of a cooled Long Wavelength Infra Red (LWIR) camera, combining JET's success with QWIP's and Amber's 256×256 FPA.

Infra red photodetectors made from materials already used in laser fabrication promise a superior new generation of IR cameras and night-vision devices. These quantum well devices are made from alternate layers of semiconductor materials

arranged atom by atom. Quantum wells are already widely used in lasers to generate light from current but in IR cameras this process is reversed. In conventional quantum well devices electrons only exist in one of two energy bands, either a low energy 'valence' band or a high energy 'conduction' band. A photon striking a conventional detector surface liberates an electron into the conduction band generating an electrical signal if a voltage is applied across the detector. The most recent QWIP's are so sensitive that incident photons may be detected even if they only have enough energy to shift electrons within the bands.

GaAs/InGaAs materials may be fabricated into large 2-dimensional arrays sensitive to both the $3\text{-}5\mu\text{m}$ and $8\text{-}13\mu\text{m}$ atmospheric transmission 'windows'. Since the earth's atmosphere is relatively transparent across these two regions an IR QWIP array camera mounted on a plane or preferably a low earth orbit satellite will record high resolution IR images, obviating the risk of conflict caused by U2 spy planes overflying Iraqi airspace. QWIP detectors also offer several additional advantages over other LWIR detector materials such as MCT, including: higher detector to detector uniformity, simple semiconductor fabrication, higher yield and therefore lower unit cost.

Future developments will include multicolour (dual band) sensors offering better performance with moderately good

MIR and FIR sensors linked together relatively cheaply. They will make use of *image fusion* technology which combines different types of image to create a single 'hybrid' display that is clearer and more informative than the individual pictures. Scientists have for some time merged radar and optical satellite data, e.g. ERS1 used to study European agriculture. At Cranfield University Dr Chris Thompson's group is investigating fused images from the NIR ($0.75\text{-}1.1\mu\text{m}$) with good contrast and spatial resolution, but limited range and FIR images ($8\text{-}12\mu\text{m}$). Merging images and tracking key features 'edge tracking' and using neural networks help significantly to improve vision.

Emerging Uncooled FPA (UFPA) Technologies.

A small group of devices, ferroelectrics, microbolometers and pyroelectrics, have one characteristic in common, no cooler is required although they are temperature stabilised. This will mean lower cost devices. Texas Instruments has just introduced a ferroelectric UFPA onto the market. There is also a significant interest in microbolometers because cost may be reduced further from \$12,000 for a ferroelectric UFPA to \$6,000. LWIR uncooled devices will operate for room temperature applications ($8\text{-}12\mu\text{m}$), with silicon compatible processing, high video contrast and also possessing high frame rates. UFPAs were originally developed by Honeywell, purchased by Lockheed Martin and licensed to Loral, Hughes and Rockwell. Uncooled microbolometers and pyroelectric sensors rely on a pixel absorbing the IR radiation causing a temperature rise. A transistor switch beneath each pixel in a 2-D array enables active addressing by the integrating circuit. UFPAs are ideal candidates for medical Thermography due to their potential for both low cost and longwave response. Clearly a promising future awaits thermal imaging in many scientific disciplines still to be explored fully, such as medical temperature sensing, predictive maintenance and satellite based systems for remote earth observations.

Further information on IR thermography may be found at <http://www.flir.com>.

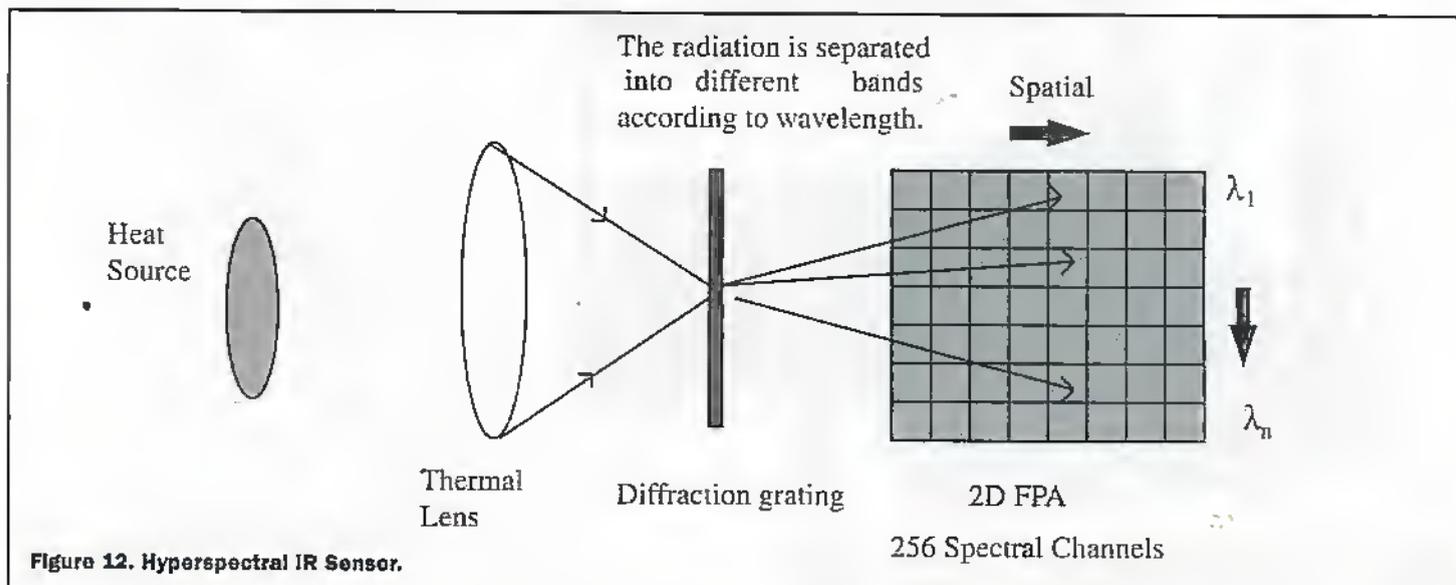


Figure 12. Hyperspectral IR Sensor.

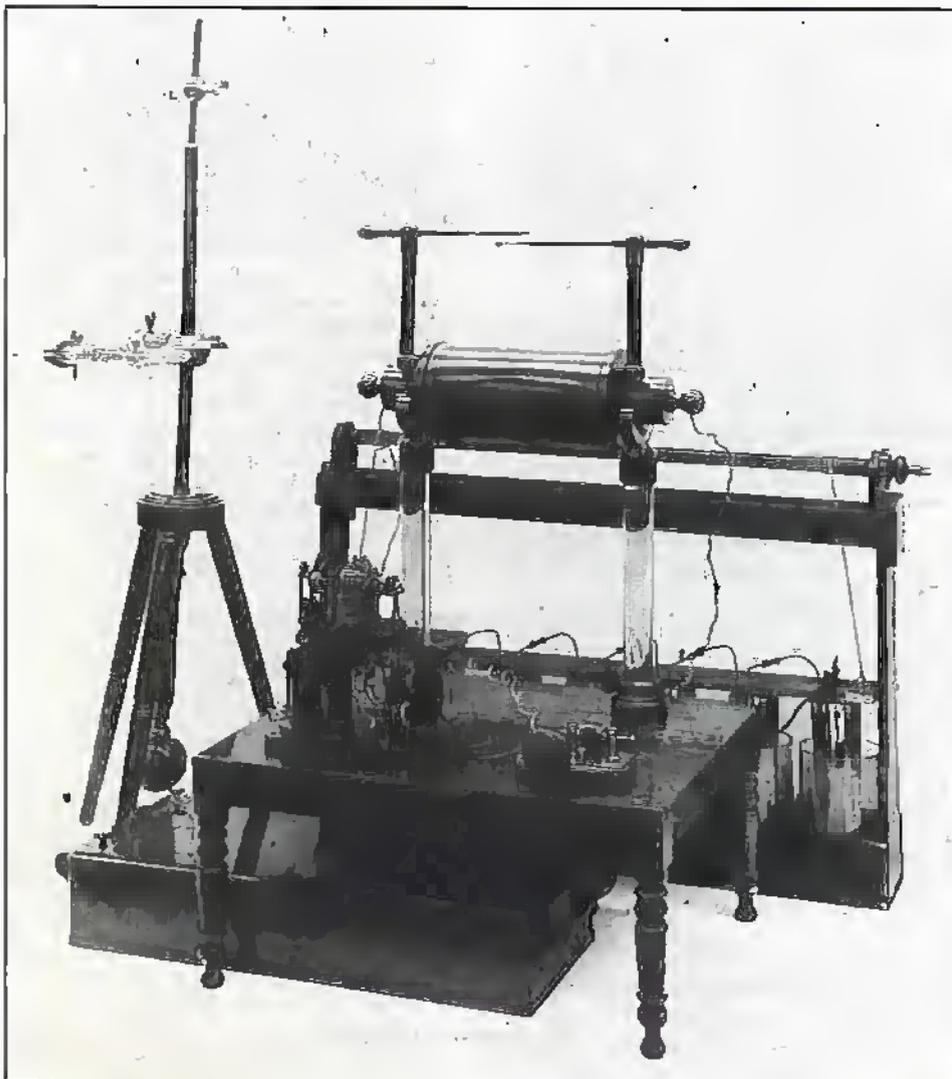
Radioactivity

A CENTURY OF CONTROVERSY

PART 1

How it all began

There are emotive subjects, emotive scientific or technical subjects and then there is radioactivity. This phenomenon is everywhere and has been since time began, infinitely longer than that great pariah of the young, the nuclear industry. In this, its centenary year, it's time to look objectively at both the benefits and the well-trumpeted pitfalls of this almost taboo topic.



Röntgen Rays

Wilhelm Konrad Röntgen had an unusual background for a scientist. The colour-blind son of a German father and Dutch mother, he spent his childhood in Holland and his student years in Switzerland. He was further unusual in that, although Rector of Würzburg University, he had no high school diploma. The reason for this lack of formal qualifications was simple – he had been expelled for what was, apparently, some minor misdemeanour.

Young Röntgen did not let this hamper his academic career and, given his background, perhaps it's not surprising that he should choose, as a research topic, a subject equally as unusual – Cathode Rays.

For a year, Röntgen had investigated materials which fluoresced when exposed to cathode rays. In the course of an experiment, he had wrapped a Crookes Tube in black paper and was on his way to examine his fluorescent material, a small barium platinocyanide screen, located in a darkened room. To his astonishment the screen continued to fluoresce when the Crookes Tube was switched on.

The radiation – whatever it was – could obviously penetrate glass and paper. Having no idea as to what was causing the fluorescence, Röntgen termed his discovery X-Strahlen, or X-rays. In the weeks that followed, Röntgen established the majority of the characteristics of X-rays, which he published in a paper entitled 'On a New Kind of Rays, A Preliminary Communication.' Having had the paper published in Würzburg University's medical journal, Röntgen then sent reprint copies and some X-Ray photographs to scientists around the world. The date was January, 1896.

So what exactly are X-rays? Röntgen discovered that they were akin to ultra-violet, or U-V, rays but smaller and more energetic. More to the point, how were they produced? X-rays were the result of cathode rays striking a piece of metal. To begin with, electrons have considerable energy of motion but when they collide with a metal they decelerate swiftly, losing this motive energy.

Energy, of course, is indestructible and so if it is lost or absorbed in a process, or area of activity, it must appear in some end product of the process, or in another related area of activity. In this case, the electron energy re-appears as radiation.

Since it was a German who discovered this phenomenon, and other German physicists who studied it further – at least initially – they termed it *Bresstrahlung*, or 'Deceleration' radiation.

Röntgen's paper astonished and excited scientists everywhere, the majority of whom got hold of Crookes Tubes plus induction coils and repeated the experiments. Since the inventor did not patent his discovery, commercial apparatus quickly became available and in short order, but the newly discovered radiation was being extensively used in medicine.

In 1911, the British physicist Charles Barkla had found that the energy content of the rays was dependent on the nature of the metal used to stop the electron stream. By 1923, the American physicist Arthur H. Compton had discovered the Effect called after him, in which the wavelength of X-rays increase when these photons collide with electrons. His discovery demonstrated that

X-rays had a particulate nature also.

It has now long been confirmed that X-rays are indeed the electromagnetic radiation transmitted when matter is bombarded with high speed electrons. Their wavelength is shorter than Ultra Violet radiation - i.e. less than 1×10^{-8} m - and they extend to indefinitely short wavelengths. However, below about 1×10^{-10} m they are frequently termed Gamma Rays.

Becquerel's Contribution

One scientist who was fascinated by Röntgen's discovery was the French physicist Antoine-Henri Becquerel. Like his father before him, Becquerel had been working with fluorescent substances. After Röntgen's paper and photographs had been published Becquerel wondered if, in fact, the radiation given off by such substances could include X-rays.

One such substance was potassium uranyl sulphate, which both he and his father had worked with. In February 1896, Becquerel wrapped some photographic film in black paper and, with a potassium uranyl sulphate crystal on top of the small package, placed it in direct sunlight. He reasoned that the sunlight would make the crystal fluoresce, and the X-rays produced would penetrate the paper and darken the photographic film.

On examination, the film was most decidedly darkened and so Becquerel concluded that fluorescence did indeed produce X-rays. It was at this juncture, however, that nature entered the picture. An extended spell of cloudy weather meant that Becquerel could not continue with his work, despite having a fresh film all neatly wrapped and with an identical crystal sitting

on top of it, lying in a drawer.

But, Becquerel was an impatient man, and chafing at this enforced inactivity he decided to develop the film anyway, simply to check that his reasoning was on the right lines. To his astonishment the film was deeply fogged. Quite clearly, the radiation passing through the black paper depended on neither fluorescence nor sunlight. It was a natural, continuous phenomenon, spontaneously emitted. Radioactivity in short was a fact of life and Becquerel, through his discovery of this photographic action of uranium salts, instigated the study of this new area in science.

In 1899, Becquerel noticed that some of the radiation emanating from uranium compound could be bent by a magnet. There were now two different types of rays and the New Zealand physicist Ernest Rutherford decided to name them Alpha and Beta rays, after the first two letters of the Greek alphabet.

A Woman Takes a hand

One of the experimenters who followed up Becquerel's discovery was the Polish-born French chemist Marie Skłodowska Curie. In 1897 she used her husband Pierre's discovery, piezoelectricity, to measure the intensity of the radiation emitted by a number of uranium compounds with which she had been working.

Marie Curie subsequently showed that radiation intensity was proportional to the amount of uranium present in the compound. In short, the radiation was given off specifically by the uranium atom, and so was atomic in nature as opposed to molecular.

In the following year, Marie Curie proved

that the heavy metal Thorium - discovered as long ago as 1828, by the great Swedish chemist Jons Berzelius - also produced radiation and she then coined the expression Radioactivity for this natural phenomenon. Another of her discoveries was that, although pure uranium compounds were radioactive only in so far as uranium was present, a few uranium ores produced far more radiation than could be accounted for simply by uranium's presence alone.

There were, she thought, small quantities of other far more intensely radioactive ores present in the compound. By July 1898, the Curies discovered exactly such an element and called it Polonium, after Marie's homeland. By December, this husband and wife team had isolated yet another, which they termed Radium because of its intense radioactivity.

The radiation given off by the uranium compound consisted of alpha, beta and gamma rays, also probably having been named as such by Rutherford. Becquerel was the first investigator to show that beta rays were the same as cathode rays, in other words streams of electrons. By 1900, Rutherford had demonstrated that gamma rays were basically the same as X-rays but with even shorter wavelengths.

A few years later Rutherford and his German student Hans Geiger discovered that alpha rays were helium atoms which had been stripped of their electrons. Therefore, Becquerel and the Curies' radioactivity was not a new type of radiation, rather a radiation spontaneously emitted by atoms.

However, the year 1900 would usher in far more than simply the final century of the second millennium AD. It would also give us the concept of universal radiation.

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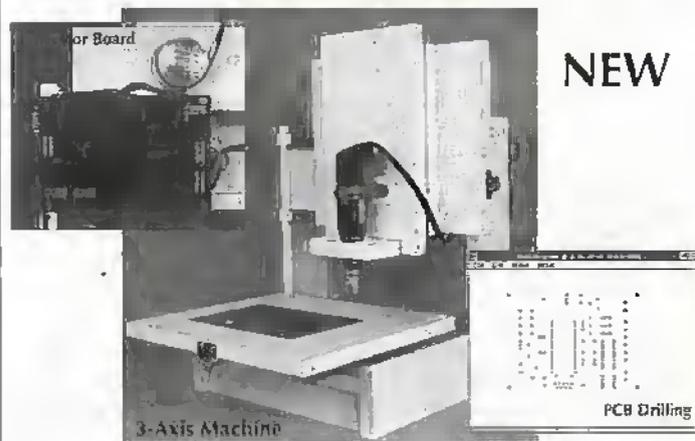
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Sound Card TECHNOLOGY

PART 1

Mike Bedford guides you through the sound card jungle and helps you understand the various facts and figures you'll find in the specification sheets.

If all you need of a sound card is something to play the jingle as Windows 95 starts up and perhaps allow you to listen to the occasional audio CD while you're working, just about anything will fit the bill. However, if you're serious about multi-media titles, about games playing or about music composition, then you'll be rather more critical about the sound card in your PC. This is when things start to get complicated. With a hard disk drive, about all you need to know is how large it is, the speed is all that differentiates one CD-ROM drive from another, and the clock speed and family fully defines a processor. But when it comes to sound cards, there seems to be just too many variables to take into account. Should it use FM or wavetable synthesis? How many voices, notes polyphony, parts multi-timbral or midi channels do you need – and what about the wavetable ROM

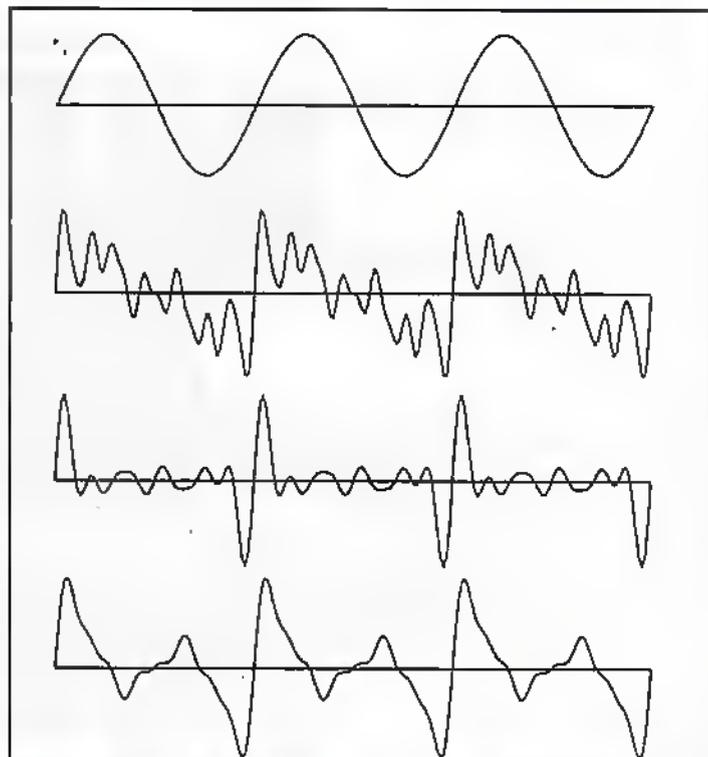


Figure 1. From top to bottom:- sine wave, cello, trumpet and flute, all at middle C.

size? With all these buzz words, the specification sheets seem designed more to confuse than to clarify. It's not as if these details are largely irrelevant. A listening test will prove that there's a vast difference in sound quality between one card and another.

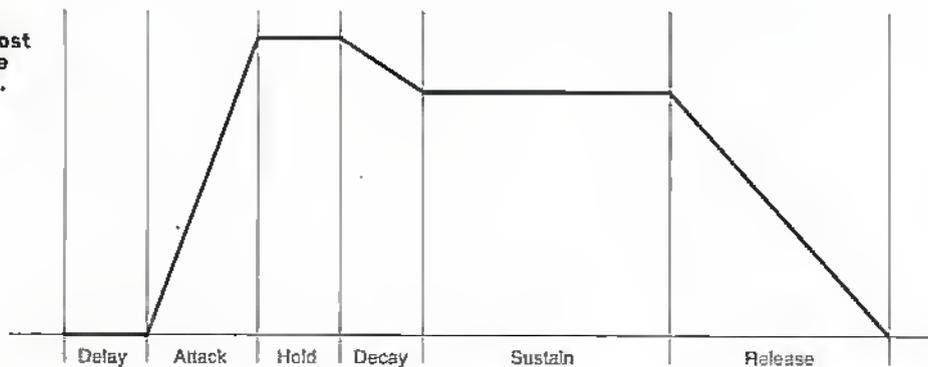
In this series of two articles, we will guide you through the sound card jungle. So we will look at all the various facts and figures you'll find in the specification sheets, to help you understand what they all mean. We will also look at the pros and cons of the different approaches to music synthesis in order to help you decide which is appropriate for your needs. But unlike other articles on sound cards found in PC magazines, we'll also take an in-depth look at how sound cards work, indeed, this will be the main emphasis of this first article. Finally, we will look briefly at associated equipment, specifically multi-media speakers and surround sound systems.

Instrument Characteristics

Next month, we will present a high level view of the soundcard to illustrate the various tasks it performs, and although we'll see that the synthesis of musical instruments isn't the only job a sound card performs, this is almost certainly the most important. It's also the most technically challenging. So in this article, we will take an in-depth look at the various techniques of synthesising instruments. To set the scene, though, let's take a quick look at the various ways in which our ears differentiate one instrument from another.

The first property which characterises an instrument is its timbre. In musical terms, this is defined as the tonal quality of a sound and has also been referred to as the tonal colour. In electronic terms, the timbre is defined by the waveform of the sound. We are all familiar with the sine wave and this is the most basic waveform – it can be thought of as a pure sound since it contains just a single frequency. With the possible exception of early electronic keyboards, no real musical instrument produces a sine wave. Instead, they all produce more complicated waveforms which our ears

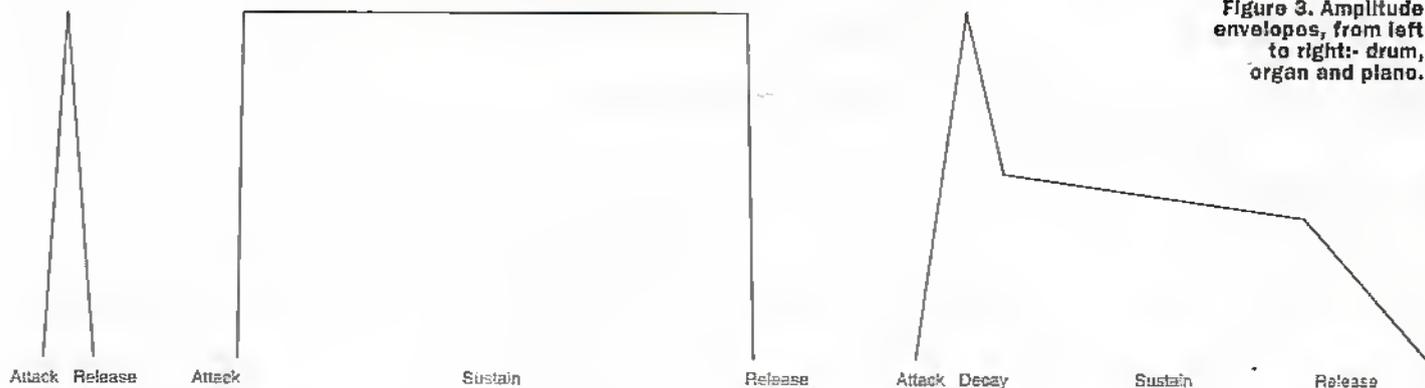
Figure 2.
The six post
amplitude
envelope.



amplitude remains constant. Next, in the decay section, the amplitude decreases. In the following section – the sustain – the duration of the note is extended by, for example, holding down a key. And finally, in the release sections, the amplitude falls away to zero when, for example, the key is released. Very few, if any, instruments exhibit all the sections of the envelope we have just seen.

A few examples of envelopes are shown Figure 3. The first, the snare drum, is typical of

Figure 3. Amplitude envelopes, from left to right: drum, organ and piano.



perceive as more interesting sounds. A sine wave is contrasted with the waveform of a few real musical instruments in the illustration – see Figure 1.

The second property which differs between one instrument from another is its amplitude envelope. With many musical instruments, notes don't start and end abruptly. Instead, when a key is pressed or a string plucked, the volume builds up over a period of time, and similarly, the note decays away over a period of time. The waveform which defines the variation of a note's amplitude over time is called the 'amplitude envelope' and, in general, it's split up into 6-segments as shown in Figure 2. The first section is the delay between the note being initiated on the instrument and the amplitude starting to build up. For most instruments, this delay is zero, although on a bagpipe, for example, air has to be blown into the bag before any noise is generated. The second section is the attack – the period during which the note builds up to maximum amplitude. Now there is a hold section during which the

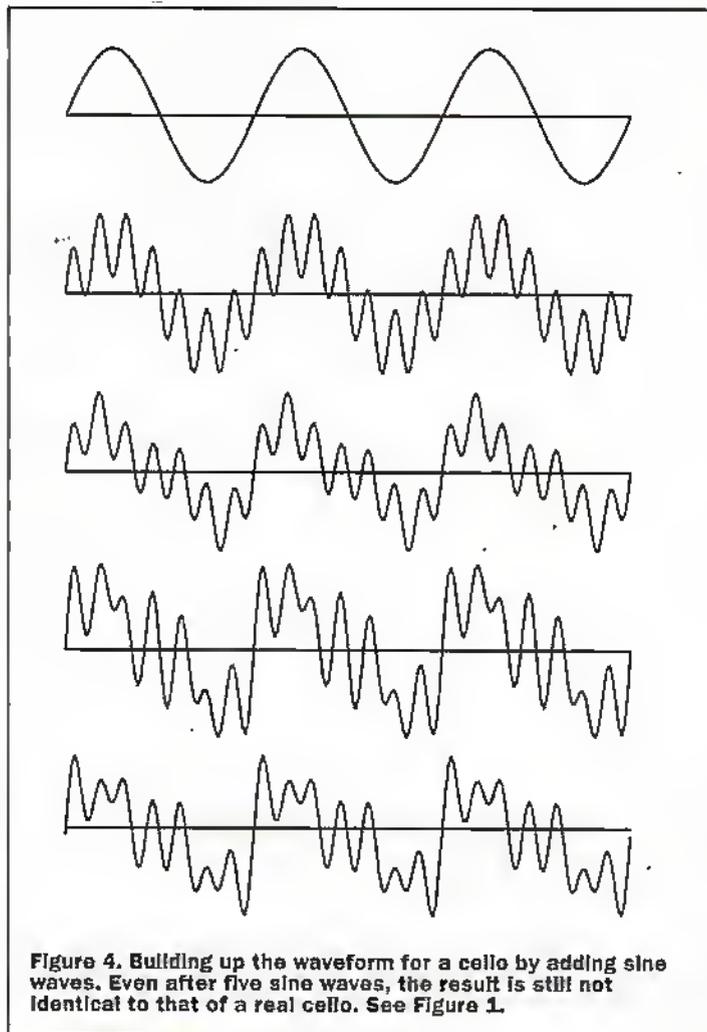


Figure 4. Building up the waveform for a cello by adding sine waves. Even after five sine waves, the result is still not identical to that of a real cello. See Figure 1.

percussion instruments. The attack is almost instantaneous and is followed immediately by the release which is also very rapid. The pipe organ also has a rapid attack and release but it has a sustain period, the length of which can be of any length, depending on how long the key is kept depressed. However, the piano shows the most complicated envelope. Although still quite rapid, the attack now takes place over a longer period. A decay section follows almost immediately, reducing the note to about 60% of its maximum amplitude. Unlike the organ, the sustain cannot continue forever, in fact you'll notice the amplitude continuing to decay during this period. And finally, when the key is released, the amplitude drops to zero.

Having seen what we need to synthesise, let us now turn our attention to the techniques which are employed in sound cards. Although we'll make passing reference to the amplitude envelope, we'll concentrate mainly on the methods of synthesising the timbre which is, after all, the more challenging.

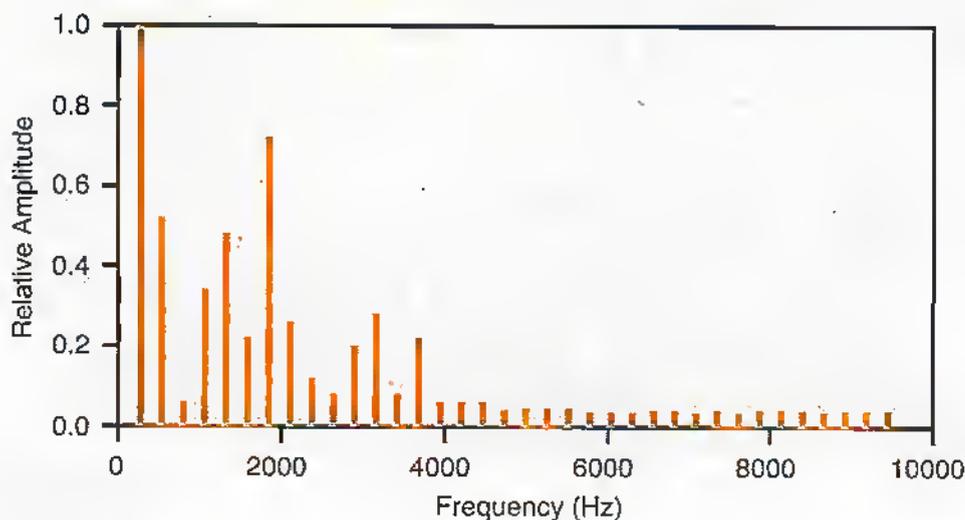


Figure 5. As an alternative to a waveform graph, the timbre of an instrument can be summed up by a spectral plot. Here, the spectral plot of a cello is shown.

FM Synthesis

As you are probably aware, according to the Fourier Theorem, any waveform can be described as the sum of a number of sine waves of differing frequencies and differing amplitudes. We won't go into the maths in all its gory detail, but a graph should help clarify this. In the series of traces of Figure 4, we are attempting to create the waveform which we have previously presented as that of the cello. Specifically, we want the waveform for the cello playing middle C so we start off with a sine wave at 265Hz – the frequency of middle C. In the second trace we've added another sine wave at 1855Hz and with an amplitude 70% of

that of the original sine wave. 1855Hz is, in fact, seven times the frequency of our first sine wave – this is called the seventh harmonic and is the second most important frequency in the cello's waveform. In the remaining traces, we have added the second, fifth and fourth harmonics, these being the ones with the next-most significant amplitudes. As you will notice, we are starting to get something close to the waveform previously shown as that of a real cello. However, in order to get sufficiently close that the two could not be differentiated by ear, it would be necessary to add many more of the less significant harmonics. In passing, you will notice that we have been talking about harmonics. More generally, an

instrument's waveform is made up by adding so-called partials to the fundamental frequency. With many instruments, these partials are multiples of the fundamental frequency in which case the word harmonic is, indeed, appropriate. In percussion instruments, on the other hand, inharmonic partials – frequencies which are not exact multiples of the fundamental – are also important.

Clearly, the information presented so far provides a means of synthesising any musical instrument. All that is needed is multiple audio oscillators, the frequency and amplitude of which can be controlled by the software. In practice, this form of additive synthesis is not used in sound cards since it would be

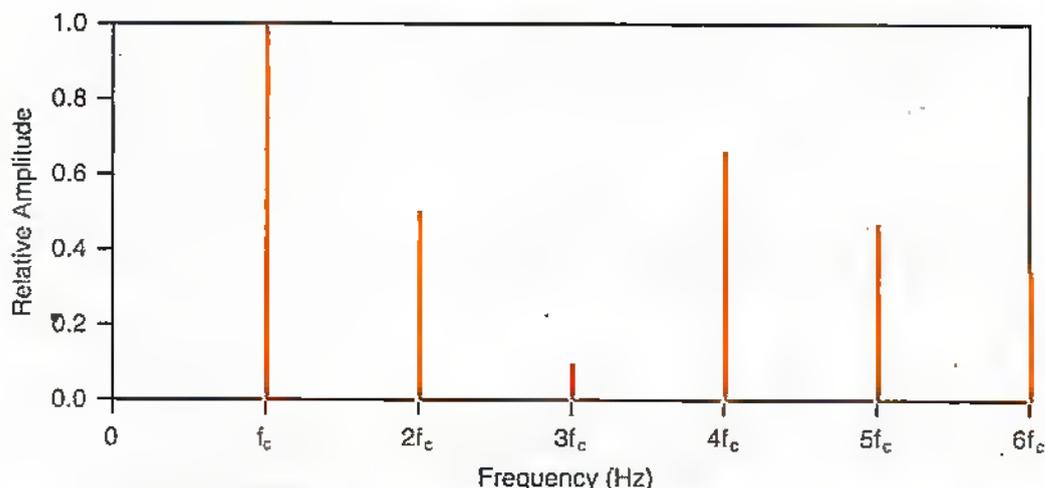
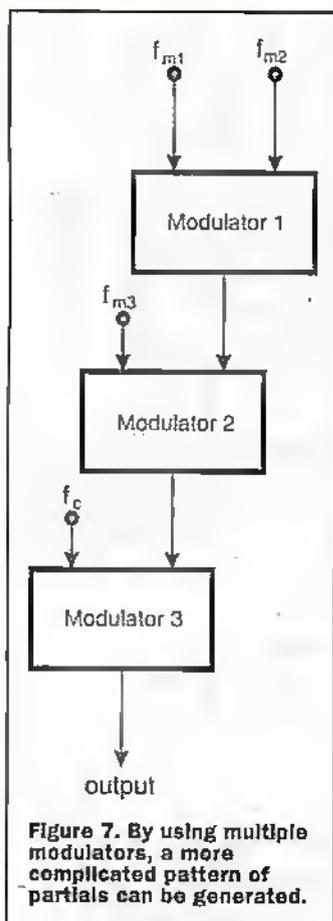


Figure 6. By frequency modulating one audio signal with another, a range of harmonics is generated. Here we see the fundamental and first five partials generated when the carrier frequency and the modulation frequency are the same. Amplitudes are affected by the amount of modulation.

expensive in terms of the number of oscillators required. However, FM synthesis performs a similar task, albeit in a rather different way.

As an alternative to a waveform plot, the timbre of an instrument can be depicted as a spectral plot, that is, as a graph showing the amplitude of the fundamental frequency and each of the partials. So, for example, the spectral plot for a cello is shown in Figure 5. Since we've already looked at how the cello's waveform can be built up, this should be reasonably self-explanatory. As we start to look at FM synthesis, this will be the most appropriate way to think of an instrument's timbre. The phrase FM – or frequency modulation – is, perhaps, more familiar in the sphere of radio broadcasting. Here, a high radio frequency carrier has its frequency modulated by the audio signal being broadcast. As applied to synthesising musical instruments, the technique is the same except that the two signals are much closer in frequency. Now let's take a look at what happens when one signal is frequency modulated by another. If a signal at f_c Hz is frequency modulated by a signal at f_m Hz, the resultant signal will contain frequency components at $f_c \pm n f_m$ where n can be any integer. The amplitude of the components depends on the amount of modulation, but decreases with increasing n . You will notice that this will result in some negative frequencies, but these can be considered as out-of-phase signals and will simply subtract from the amplitude of any positive frequencies of the same value. The end result is a rather complicated spectral plot like the one shown in Figure 6, which is for $f_c = f_m$. So, with just a pair of oscillators, we've managed to generate a signal containing many partials (there are far more than the six shown in the diagram) – an improvement over additive synthesis. If we add further modulators of different frequencies, each one modulating the output from the previous stage as shown in Figure 7, we can end up with a very complicated waveform. Exactly how the frequencies are selected to achieve any given mix of partials is quite a complicated question, but suffice it to say, a reasonably convincing approximation to any instrument's waveform can be generated this way.



Wavetable Synthesis

Wavetable synthesis is much simpler than FM synthesis, at least from a conceptual point of view. You record a fraction of a second of each note on each instrument to be synthesised, store the waveform in a ROM, and when that note is required, you play back that sample, suitably modified by the amplitude envelope, and repeated, as necessary, to achieve the required duration. Actually, what I've just described is the way it would happen in a perfect world. In the real world, to save on ROM space, not every note is sampled for each instrument. Instead, only occasional notes are stored in the ROM and the missing notes are created by stretching or compressing the sampled waveform – in other words, by playing it back faster or slower. For example, if you play back a sample at double the speed, you end up generating a note an octave higher. At this stage, it's worthwhile asking why manufacturers don't just store a single note for each instrument, and scale that note as necessary to generate every other note. We will answer that question by resorting to a couple of illustrations. In the pair of traces in Figure 8, we have taken the

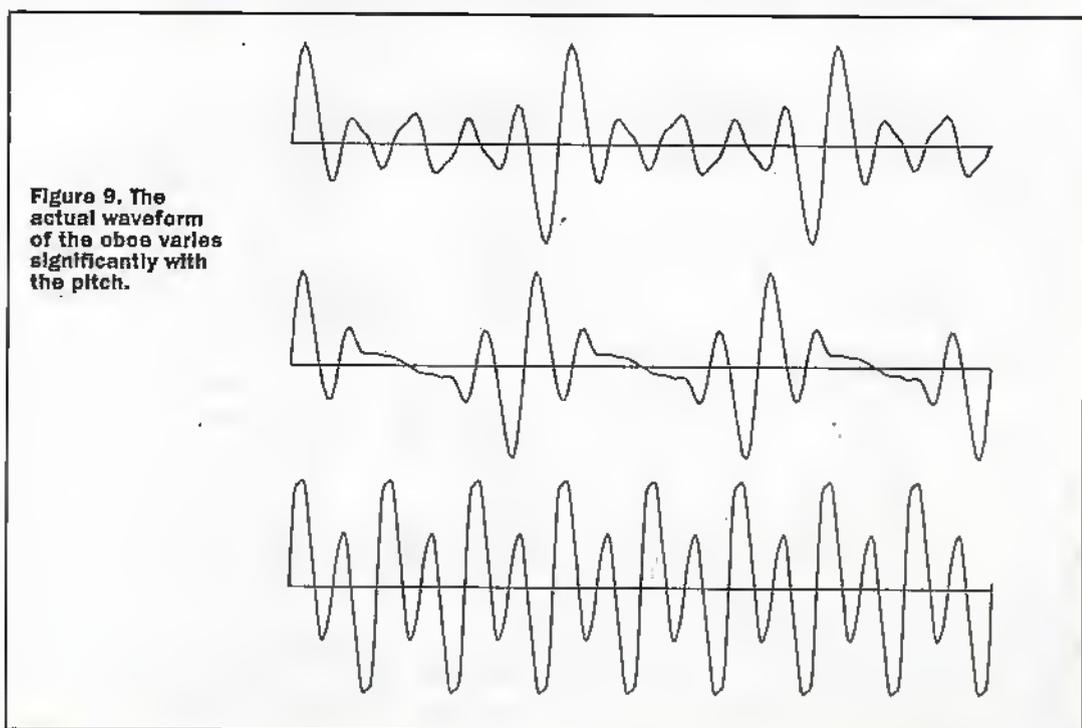
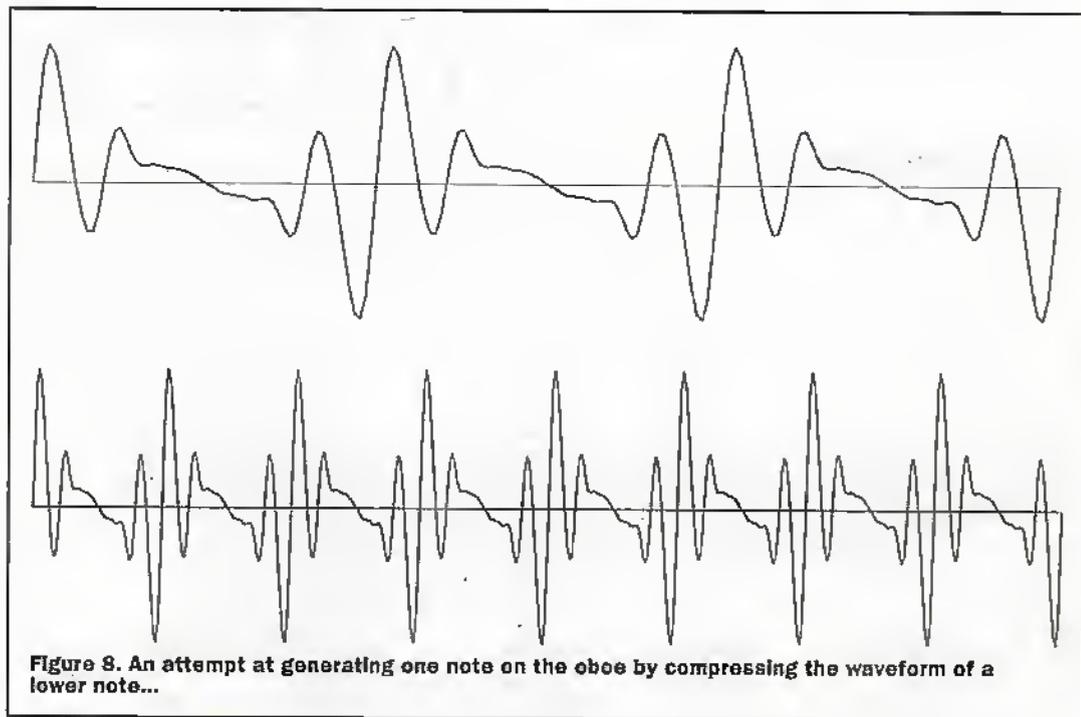
waveform for middle C (we will call this C4, i.e. the C in the 4th octave) on an oboe, and played it back at a higher speed to generate the F an octave and a half above middle C (F5). Clearly, the frequency has increased but the waveform is the same shape. However, now take a look at the two waveforms of Figure 9. Here we see the actual waveform for the F5 played on the oboe and – for reference – A#3 too. You will notice that the three traces differ in much more than just their frequency – the shape of the waveforms differ significantly and the actual F5 waveform is quite different from that we obtained by

scaling the C4 sample. In general, the timbre of an instrument does vary throughout its frequency range. Clearly a compromise has to be reached and, in practice, wavetable cards tend to store quite a few notes per octave.

In fact, the waveform of an instrument also varies with many other factors such as the loudness of the note, whether a string is plucked or bowed, and many other subtleties concerned with exactly how the instrument is played. Additionally, with many instruments, the timbre will be different during the different stages of the amplitude envelope. So, despite the

possible perception that, by definition, wavetable synthesis will produce a perfect representation of any instrument, this clearly is not possible with a modest amount of wavetable ROM.

On most sound cards, the wavetable samples are stored in ROM on the card and these samples are manipulated by an on-board DSP chip. However, there are a couple of variations on this theme. The first variation concerns downloadable samples. Here, the sound card has an area of wavetable RAM in addition to the more common ROM. Samples can be written to the RAM by the host PC, thereby

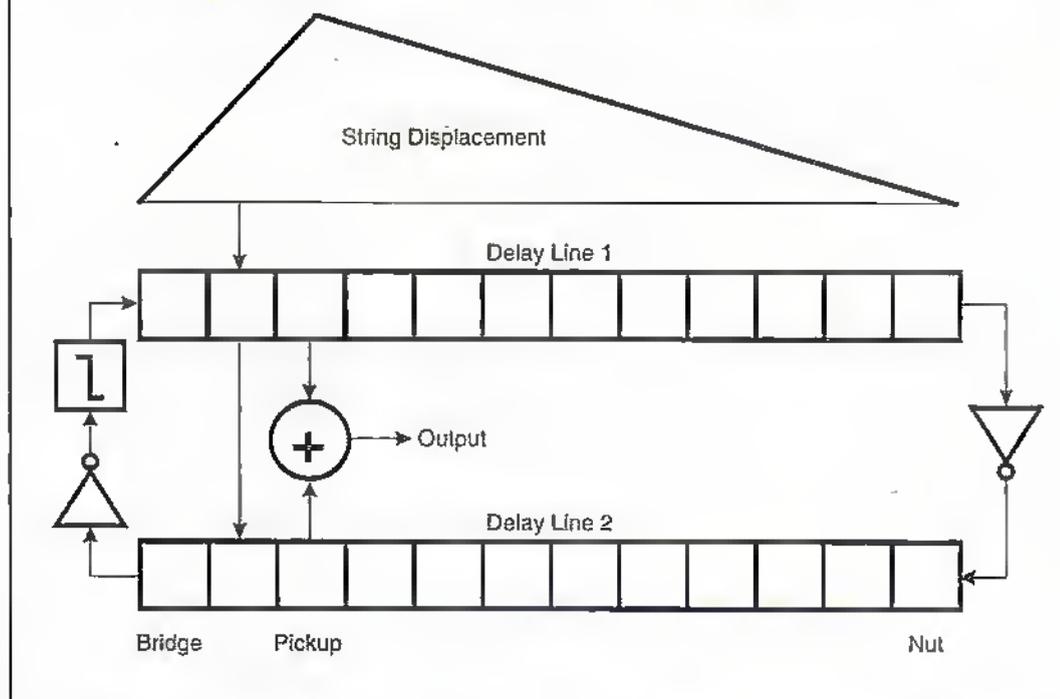


allowing additional instruments to be added. This is obviously a close parallel to the way soft fonts are downloaded to printers, indeed the phrase 'sound font' is often used to describe the data which is downloaded. The second variation is the software approach to wavetable synthesis. Now, instead of using the dedicated processing facilities on a sound card, all the manipulation of the samples is carried out by the main processor in the PC. Therefore, all that is required of the sound card is a DAC. Clearly this reduces the hardware cost of the sound card, as well as providing a more flexible approach in that updates can be effected simply and quickly, but it does place significantly more load on the main processor.

Physical Modelling Synthesis

The third method of synthesis we will look at is called 'physical modelling'. We won't cover this in as much detail as FM and wavetable synthesis since it's still quite a new technique and only found in a few of today's sound cards. However, this method of synthesis is used extensively in top-end stand-alone synthesisers and, in all probability, it is something which will be much more significant in sound cards in the near future. Unlike the other methods of synthesis, in physical modelling no information about waveforms is stored. Instead, a mathematical model of each instrument is created. By a mathematical model, we are referring to a set of equations which relate variables such as the size of the instrument, the air pressure, the amount of vibration of a string, or whatever is relevant to the instrument in question. Now a simulation can be performed using as its input the positions of fingers on strings, keys or levers, the pressure on the key or the bow and so forth. The exact waveform which would be generated by the actual instrument is then calculated from the laws of physics. A flight simulator is a good analogy to this approach. Microsoft Flight Simulator doesn't contain a screen image for every possible circumstance - this would be akin to the wavetable approach of

Figure 10. Block diagram of the waveguide approach to physical modelling. Here we see a simple model of an electric guitar.



synthesis and would be quite impossible. Instead the software contains a set of rules which allow the software to calculate what you should see on the instrument panel and out of the cockpit window for different pilot actions. So it is with the physical modelling approach to musical synthesis - the input consists of information such as the position of the bow on the violin strings, the pressure applied and the speed of the bow and the software calculates exactly what sort of sound would be produced. Clearly, the accuracy of this approach is dependant on the accuracy of the equations which constitute the model and this, in turn, depends on how well the physics of each instrument is understood.

The block diagram, Figure 10, is that of a very simple physical model based on a waveguide. This is for a plucked string and relates to an electric guitar. But before we look at this diagram, it is appropriate to address the question 'what is a waveguide?'. Stringed and wind instruments produce travelling waves. These are waves which travel up and down the bore of a wind instrument or the string of a stringed instrument. In the case of a stringed instrument, the wave will be of string displacement whereas in a wind instrument it will be air pressure. The waves travel in both directions and will be

reflected when they reach the end of the bore or string. The physical structure which carries these waves is called a waveguide. In our example, the waveguide is simulated using a digital delay line which is basically an area of memory in which values are written from one location to the next at regular intervals. The number of locations in the delay line depends on the length of the string. At the end of each delay line, the signal is inverted to represent a reflection and injected into the start of the other delay line. At one end, a low-pass filter simulates the decay of a note. So that's the model - to produce a sound, you simply inject a triangle wave to represent the displacement of the string, and take the output from a position on both delay lines corresponding to the position of the pickup.

Even with this simple model, we start to see something of the power and flexibility of the physical modelling approach. To simulate the placing of a finger on a fret, the length of the delay lines is adjusted; to simulate the positioning of the pickup, the point at which the output is taken can be adjusted, and to simulate the position at which the string is plucked, the point at which the displacement is injected into the delay lines can be adjusted. Furthermore, different ways of plucking the string can be simulated by altering the shape

and amplitude of the input waveform. All these have an affect on the sound produced, just like on a real electric guitar. Similarly, it is possible to simulate pitch bending, or even the feedback which would result if the guitarist was to face one of the speakers. By fine tuning the parameters of a more sophisticated model it should be possible to alter the model to produce sounds representative of a Fender 'Stratocaster' or a Gibson 'Les Paul'. Going one stage on from here, it's also possible to produce the sound which corresponds to a non-existent instrument. So if you fancy playing a granite piano or a rubber saxophone, physical modelling is the way to do it.

Next Month

That completes our look at what goes on behind the scenes in synthesising musical instruments. Next month, we will investigate the pros and cons of the various approaches to synthesis. Then, we'll wind up our investigation of sound cards by looking at what all the figures on the specification sheet mean. This should help you to pick a card which is suited to your application. We'll also take a quick look at associated multi-media and music-related equipment such as speakers and surround-sound decoders.

Weighing TECHNOLOGY

PART 1

Past and Present

In this first part, Douglas Clarkson looks at the history of weighing.

Weighing Through the Ages

One of the key factors contributing towards a global society is the adoption of common standards. One of the more important of these is that of weighing – a function that continues to remain very much at the core of trade and industry. The dependence of commerce on relevant systems of weighing systems is just as significant today as in the days of Babylon and Ancient Egypt some 6000 years ago, when the first traces of the art of weighing can be discerned. For in unravelling the analysis of this history the changing face of social and commercial need is also revealed.

In fact, with possibly an interlude for Islamic culture, the degree of precision of the scales developed in Ancient Egypt was not improved upon until the late Middle Ages, with the interim phases of Greek and Roman civilisation associated with a general decline in the accuracy of systems of weighing. However, the medical texts of ancient Egypt give no indication of the use of weighing for measuring the proportion of ingredients, though more precious materials such as gold, copper and lapis lazuli were weighed. While weights of the Old Kingdom of Egypt were chiefly rectangular blocks – typically of diorite – later in the New Kingdom, truncated cones became more popular – with weights in the shape of ‘cupcakes’. It is difficult to gauge the relative accuracy of such excessively old weights due to the fact that they would have undergone some degree of deterioration. Photo 1 illustrates a collection of weights of Ancient Egypt from around 2500 BC, mainly made of syenite, a grey form of granite.

The best weights of history were almost certainly related to Islamic weights as researched by Sir Flinders Petrie who reported that Islamic coin weights made out of glass in the year 780AD differed from each other by no more than a third of a milligram (0.0003g). In Roman times, the smallest identified unit of weight was the siliqua, which weighed 0.189g, so the resolution of weighing accuracy would then have been of the order of 0.1g. This smallest unit of Roman weight was also identified with the carob seed of the Carob plant (*Ceratonia Siliqua*).

When in 1870, some ‘exact’ weights which had been created in 1707 as copies of the Cologne Mark were weighed, they were found to weigh 467.548g, 467.737g and 468.125g – with the greatest difference between them of 0.577g. The accuracy with which weights would have been weighed has varied with different cultures. Scientists in the 18th and 19th century were acutely aware of the intrinsic importance of the material used to create standard weights. This was especially the case with the adoption of the kilogramme mass. The

denser the material, the less correction there would be required for estimating the effective vacuum weight. (see Static Buoyancy). There is a requirement for chemical inertness and also low coefficient of thermal expansion so that any variation of displaced air/buoyancy correction is also minimised. At one time there was interest in the use of quartz as the standard and while some specimens kilogramme samples were made, it failed to be adopted as the standard. While gold is not liable to oxidation or corrosion, it is considered too soft – and would be prone to handling effects. It was decided that the best material would be platinum-iridium on account of its superior hardness coupled with high density.

The system of organisation of weights appeared to have been widespread throughout various historical periods – with a great wealth of information in particular being available from Roman history. The excavation of Pompeii in particular has furnished a great wealth of detail of weighing systems – particularly steelyards.

While we take for granted today the use of a single system of weights for measuring almost all commodities – as indeed was the practice put in place by the Romans – after the fall of the Roman Empire it became commonplace to arrange to use different weighing standards for different commodities. This probably had more to do with preserving the vital interests of groups of merchants than the lack of scientific clear headedness.



Photo 1. Collection of New Kingdom weights of Ancient Egypt. (Courtesy Avary Barlow)

Weights and Art

It was also the fashion to create weights in the form of animals – witness the lion and duck of Babylon, the cow of Ancient Egypt and the goat of Roman Pompeii. The counterpoises of the steelyards of Pompeii in the form of cast heads were typically of the female deities Juno and Artemis – with Juno identified with the female attributes of the state – including money – and Artemis the goddess of the hunt. The sculptural interdicts of Islam and Jewish culture restricted the representation of animal forms and shapes into such objects – so weights from these cultures are generally unadorned.

Weighing and Coinage

Particular attention has been paid throughout history to the correct weight of metal used for coinage. Thus in Roman times, so called 'exoglia', or coin weights, were officially checked and distributed throughout the empire in order to regulate coinage. In ancient Greece and Rome, standard weights were kept within the sanctuary of temples. In AD307 the Emperor Constantine the Great defined the weight of the gold solidus as 1/72 of a Roman pound or 4.54 grammes. It was a continual feature of the Roman civilisation, however, to continue to devalue the value of metal in the coinage.

At various times throughout history, the authorities have been keen to prevent the weighing of coins which would have allowed individuals to identify overweight coins in circulation with a view to removing the excess metal. The milling round the edges of higher value coins in circulation today is evidence of previous attempts to discourage their 'clipping'. We see the Emperor Julian in AD363 seeking to restrict the use of accurate scales, and again restrictions put on their use in the Germany of the middle ages.

Today's high technology banking system is a far cry from the more chaotic scene of the marketplace of the middle ages. While we are always shown in films of the period people testing the softness of the coin by biting it, the astute merchant would weigh coinage using special balances. In Europe they were once in widespread use where a whole range of high value gold coins were in circulation – issued by countries, principalities and city states. It must have been the case that there would always have been a brisk trade for the money changers – exchanging Venetian ducats for marks of Cologne.

Pre-Metric British Weights

Three principal pre-metric weighing systems had a wide utilisation prior to metrication – a process which is still to see the final demise of the pound in the United Kingdom. The Troy weight system used the system of units as outlined in table 1.

24 Troy grains	=	1 pennyweight
20 pennyweights	=	1 Troy ounce (480 grains)
12 Troy ounces	=	1 Troy pound (5760 grains)

Table 1. Relationships of the Troy weight system.



Photo 2. A range of Wedgwood pottery weights. (courtesy Avery Berkel)

There is some conjecture about the origin of the name Troy. The most widely accepted origin is probably that it originated in the town of Troyes in France, which in the twelfth century was a major European centre for trade and commerce.

20 grains (Troy)	=	1 scruple
3 scruples	=	1 drachm
8 drachms	=	1 ounce
12 ounces	=	1 lb (5760 grains)

Table 2. Relationships of Apothecaries' weight.

This system of weights was used for the weighing of precious metals such as gold. The Apothecaries' Weight, outlined in table 2, utilises the same number of total fine divisions (5760) but with a different set of intermediate units.

The use of Apothecaries weights was legal in Britain until 1st January 1971. The Troy pound is identified as being equal to 373.242 grammes, and the Troy ounce 31.104 g in the metric system. The grain is identified with the typical weight of a grain of barley.

The Avoirdupois weight system is

16 drams	=	1 ounce (437.5 grains)
16 ounces	=	1 lb (7000 Troy grains)
14 lb	=	1 stone
2 stones	=	1 quarter
4 quarters	=	1 hundredweight (112 lb)
20 cwt	=	1 ton (2240 lb)

Table 3. Relationships of Imperial (Avoirdupois) weight.

summarised in table 3 and reflects the pre-metrication definitions in use in the UK.

This system is thought to have come into being around the rule of Edward I, circa 1300, in order to harmonise trade in wool into Europe, and in which the Avoirdupois lb is almost identical to the weight of 16 Florentine ounces. There are, however, a number of theories as to the origin of this weighing system. There is also great similarity to local British varieties of the Roman pound of 12 ounces, where the value of the Roman ounce is very close to that of the Avoirdupois ounce. There matters are expertly described, however, in Conner's scholarly work 'The weights and measures of England'. The use of 16 ounces seems to have been chosen as some more easily handled system for determining weights. The Avoirdupois pound weighs 453.59g and the corresponding ounce 28.3494g.

One of the great problems of the Elizabethan age was to appreciate that the Troy ounce (480 grains) was not the same as the Avoirdupois ounce (437.5 grains).

Photo 2 shows a range of pottery weights made by Wedgwood for W & T Avery. However, these weights were banned in 1907 on account of the practice of steeping them in water to make them heavier, or heating them in an oven to make them lighter. They were also prone to chipping through everyday use. The weighing of commodities had to cope with a large range of items. The use of stone weights was quite common for weighing commodities such as grain. A selection of such stone weights is shown in photo 3.



The Legacy of Rome

The definition of the weighing system of Rome is outlined in table 4.

1 libra	=	12 unclae (ounces)
12 unclae	=	48 scilicci
48 scilicci	=	96 drachmae
96 drachmae	=	288 scrupula
288 scrupula	=	576 oboli
576 oboli	=	1728 siliquae

Table 4. Relationship of Roman weights.

Before the process of metrication in Europe, numerous local weighing systems made use of various units of subdivision – in particular the value of 1728. Present estimations are that the Roman pound weighed 327.6g and with the Roman ounce weighing 27.3 ounces. Table 5 summarises the units of Roman, Troy and Avoirdupois (Imperial) systems with reference to the metric system. The Roman ounce is approximately some 4% lighter than the Avoirdupois ounce of the Imperial British system.

The Mark of Cologne

At a time of consideration of a common currency for Europe, it is perhaps prudent to glean something of the history of the Mark of Cologne, which was from at least the 12th century until the middle of the 19th century the standard unit of weight of Germany and a wide range of other European countries. There was also a directly held relationship between the weight of the Mark of Cologne and various issues of gold coin in circulation within Europe.

The dominance of the German mark at present in the European currency scene is perhaps explained by the long historical period of mutual interaction associated with this unit of weight and dependent coinage. Various cities within Germany continued to issue their own standard of weights during this period – as if to try and control their own trading status. Estimates indicate that two Marks of Cologne equalled one pfund (pound) of 467.62g which is some 3% heavier than the British Imperial pound.

The Legacy of Egypt

The vast amount of archeological interest in the culture of Ancient Egypt has led to various theories of the origin of systems of weights. One theory would indicate that the Egyptian talent weight is considered to have been defined as the weight of water in a volume of side of one Royal Egyptian foot or 13.76 inches. This is itself divided into 3000 shekels where each shekel weighs around 4.23g or very close to half of an Avoirdupois ounce. Could it have been the case that there was a great deal of scholarly activity to show that the British Imperial system of weights could be traced directly back to the systems of measurement of Ancient Egypt, and in doing so slow the pace for change towards metrication?

Also, the more common unit of Egyptian measurement the cubit equal to 8.24 inches could have been derived as 1/4000 of the distance of one minute of arc along the earth's circumference – the meridian mile. It is noteworthy that R. D. Connor in his reference work does not get involved in these questions.

The Kilogramme Standard

The kilogramme standard is essentially derived from the definition of the metre which was originally defined as one part in 10,000,000 of the quarter circumference of the earth. Between 1792 and 1798 the angular arc between Dunkirk and Barcelona of 9 degrees 40 minutes 45 arc seconds was measured as 551,584.72 toise – the pre-metrication unit of France. The total distance corresponding to 90 degrees of arc was computed and this in turn was used to define the metre. The first metre made to this definition was deposited in the National Archives on 22nd June 1799. The die as it were had been cast and the standard existed. Although the accuracy of the initial survey had been undertaken with utmost skill, the actual metre was about 0.2 mm short of its true initial definition.

The definition of the kilogramme was then taken as the mass of 1000 cubic centimetres of water at its highest density at 4°C. Careful measurements were made of changes in weight of displaced water using Archimedes principle and a value of the kilogramme was made with reference to previous French standards – 18827.15 grains of the old system. The first kilogramme weights were made from platinum in 1796 and became legal in 1799 in France. The interlude of the aftermath of the French revolution and the onset of the Napoleonic wars distracted Europe from taking up the new standard for some time. In the 1870's, when it came to producing a wide range of standards of metre and kilogramme in platinum-iridium, the British firm of

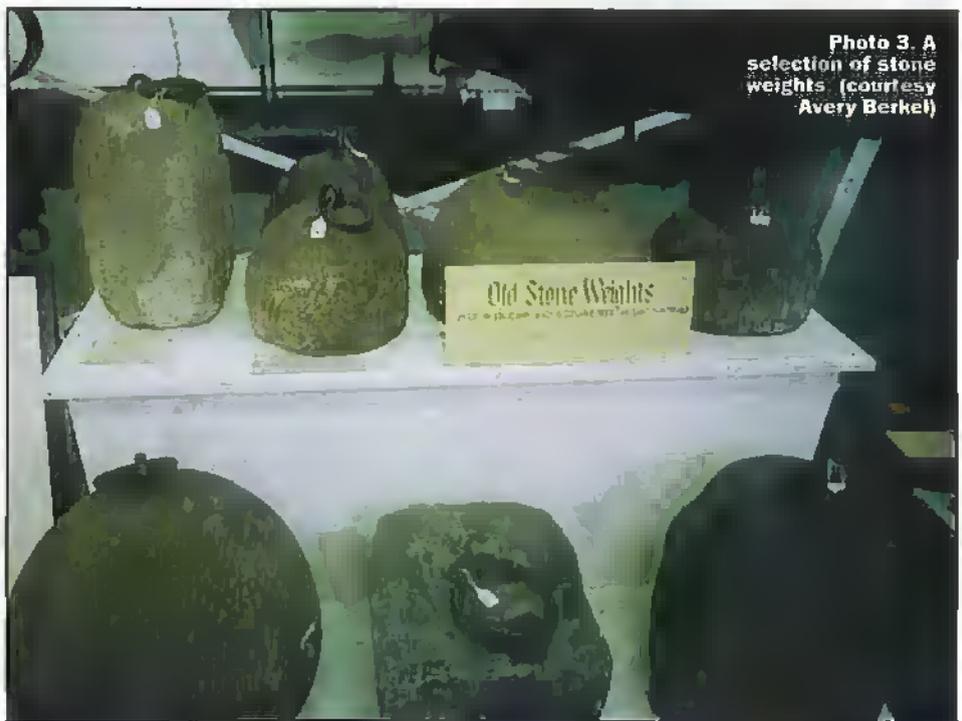


Photo 3. A selection of stone weights (courtesy Avery Berkel)

	Pound Unit	Ounces/lb	Ounce (metric)	Grain (metric)
Roman	327.6 g	12	27.3 g	-
Troy	373.242 g	12	31.104 g	64.8 mg
Avoirdupois	453.59 g	16	28.3494 g	-

Table 5: Comparison of Roman and pre-metric UK weight measures expressed in metric units.

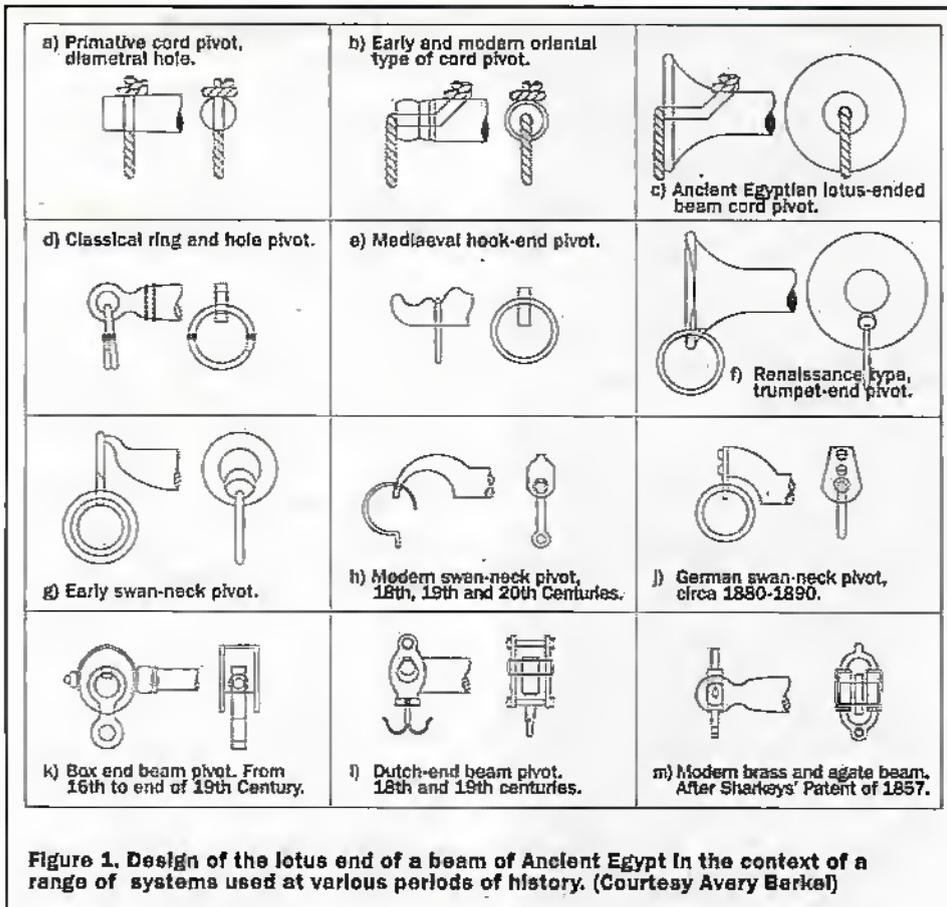


Figure 1. Design of the lotus end of a beam of Ancient Egypt in the context of a range of systems used at various periods of history. (Courtesy Avery Berkel)

Johnson Matthey & Co, was commissioned to fabricate the standards after a previous attempt in France had failed to produce ingots of the required quality.

The Balances of Egypt

It is assumed that one of the most direct means of appreciating the weight of objects would have been via the yoke with equal masses suspended over the shoulders. Around 4000BC the balances used in Egypt were straight pieces of wood or stone with a suspension cord passing through a hole midway between the two ends. Separate load bearing cords were then fitted through holes at the appropriate ends of the yoke. A

significant improvement in accuracy was achieved by bringing the cords out of the ends of the beam. The advanced development in Egypt of this design was achieved with the use of the 'lotus end beam' as indicated in figure 1, which shows also a range of pivot systems used for balances.

Photo 4 indicates a set of such reconstructed scales on show in the Avery Historical museum in Birmingham. The vertical support column of the balance does not directly support the balancing arm whose cord support is offset slightly from this central support. The earlier method of simply attaching cords to support the pans through vertical cords would have resulted

in inaccuracies as the cord holes became enlarged through use.

Figure 2, an extract from the papyrus of Hunefer of 1350 BC, shows a figurative use of scales used in weighing the heart of an individual against the weight of a feather. The process of weighing is being overseen by Anubis with Thoth the scribe of the gods making note of the proceedings. If the weight is found wanting, the soul of the individual will be thrown to the beast Amemit.

The Steelyard

The steelyard is considered to have been invented by the Romans around 200 BC. Although not as accurate as the balance for weighing precious items such as gold, spices and precious gems, the steelyard's chief advantage was that relatively large objects could be weighed without the need for balancing weights of equal value.

The principle of the steelyard is shown in figure 3. With a mass suspended at B, the unit is held at A and mass C moved along the scale arm until a point of balance is attained. For a ratio at balance of x:y of 1:20, a 0.5Kg moving weight could be used to weigh up to 10Kg. Thus a merchant travelling to market would not be required to carry up to 10Kg of balance weights to be used with a balance system.

Photo 5 indicates a Thomas Beech steelyard of around 1785. It was also common for such steelyards to be able to be used with at least two ranges, by having two suspension points. The one with the shorter distance x would be used for weighing heavier objects.

The steelyard can be considered as a device favoured in commerce, while the balance remains in favour for more exact weighing applications. The steelyard, however, is more prone to false readings due to interference with either the scale or the balance weight. A more primitive version of this device is the so called bismar in which a position of simple balance is determined between an unknown mass and a fixed position weight by varying the relative point of suspension. This unit is considered to date from around 400 BC.

Figure 2. Typical figurative use of scales of Ancient Egypt used in weighing the heart of an individual against the weight of a feather. (Courtesy Avery Berkel)

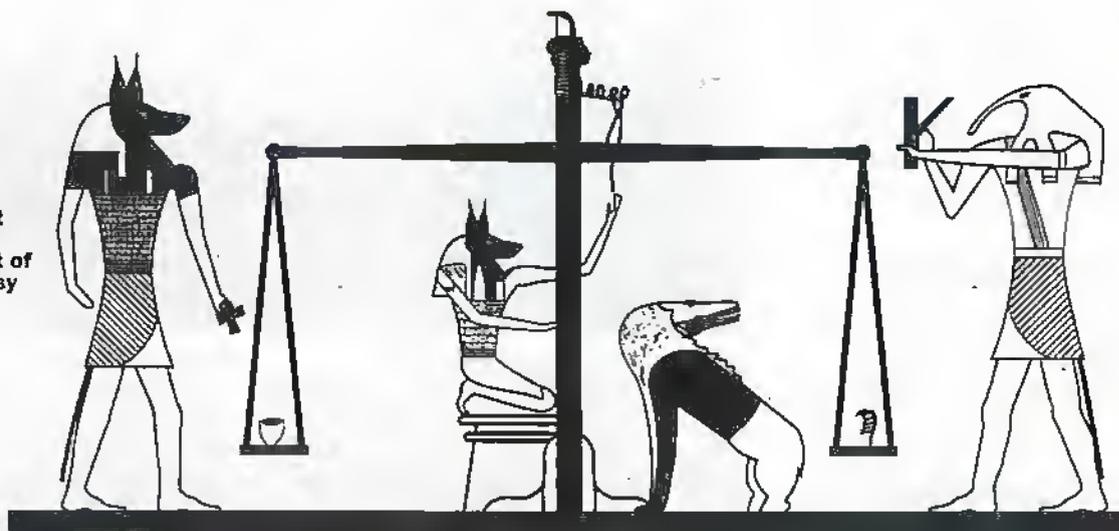
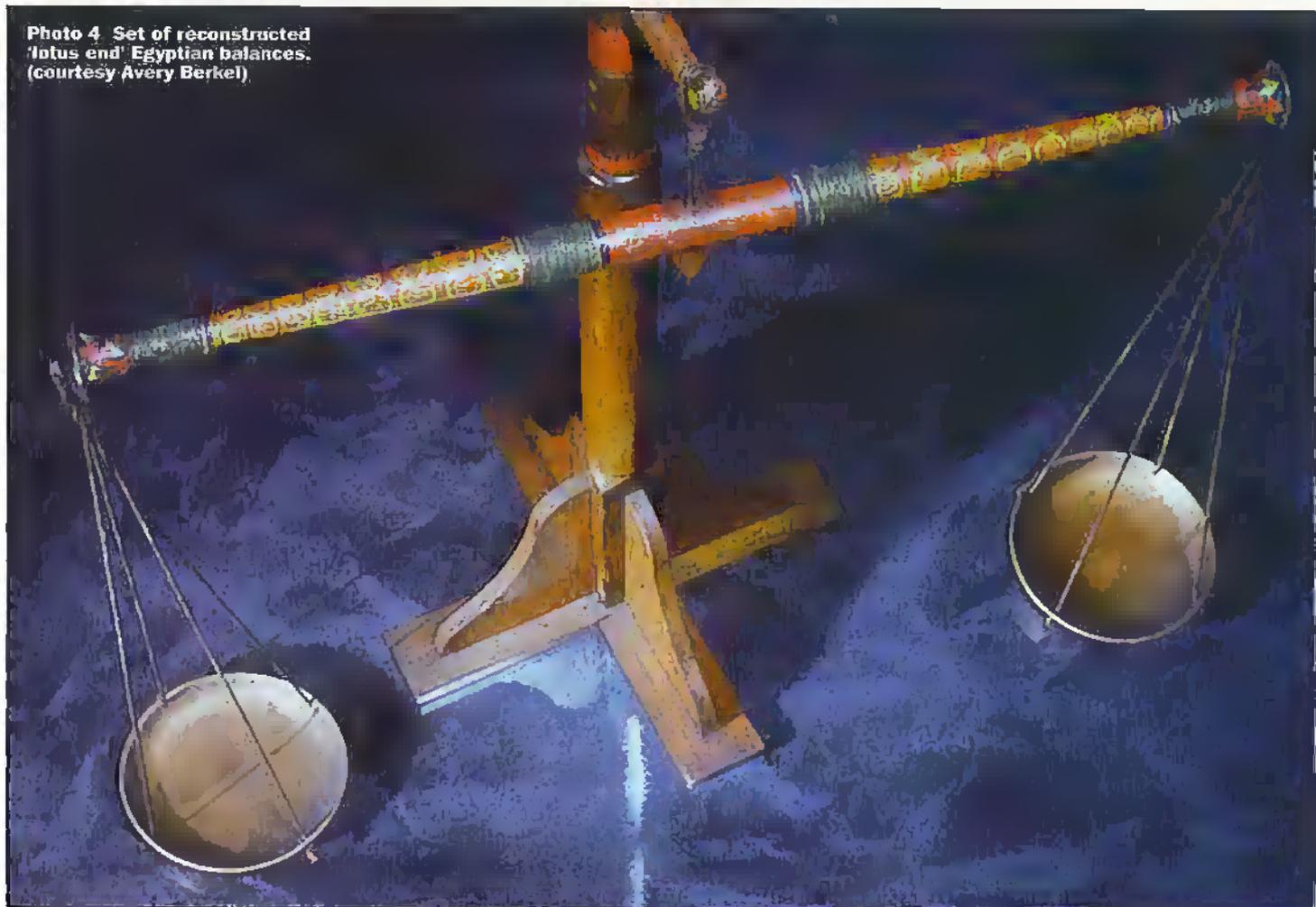


Photo 4 Set of reconstructed 'lotus end' Egyptian balances. (courtesy Avery Berkel)



Self Indicating Scales

Around 1519, Leonardo Da Vinci is credited with designing the first self indicating scale. However, its potential as a weighing device was not developed until some 300 years later. Photo 6 shows a working model from the Avery historical museum. When a mass is placed on the measuring pan this is balanced with the moment of the lifting of the centre of mass of the flat surface of the indicating dial. The pendulum is used to indicate the position on the scale appropriate to the mass being weighed. At small angles the scale of angular deflection as a function of mass is reasonably linear, with the tan of the angle of deflection being proportional to the ratio of the mass being weighed to that of the moving dial unit.

The Roberval 'Static Enigma'

In 1669 Gills Personne de Roberval produced in the form of his 'static enigma' a puzzle which was to keep the best minds of Europe guessing for 100 years. The experts say that it can be appreciated today by any student of basic science conversant with the interaction of forces. The suspension point under the top centre is a balancing edge and other points are free pivots.

If the structure is maintained as a parallelogram with strictly vertical sides then no matter where the equal masses are positioned on the arms, the balance of the structure will be maintained. While the 'Static Enigma' was widely known within scientific circles, it was in fact an ideal

means of creating a top level balance instead of balancing two masses about a central pivot point. From about 1800 this principle of top loading was to become widely used, especially in the market for shop scales.

Photo 7 shows a working model of this device from the Avery historical museum.

Improving Traditional Balances

Inventors in the 16th and 17th century utilised knife edges to achieve greater levels

of accuracy in balances as indicated in figure 4. A central pivot pointing downwards is balanced by pans suspended on knife edges pointing upwards. Agate became adopted as a hard wearing material from which to construct the knife edges.

Mechanisms were introduced which would lift the beam clear of the knife edges when the balance was not in use and thus prevent the knife edges from broadening. In this way, balances were made to perform better and were now more sensitive. This was especially important for a wide range of developments that were taking place in science, especially within the field of chemistry.

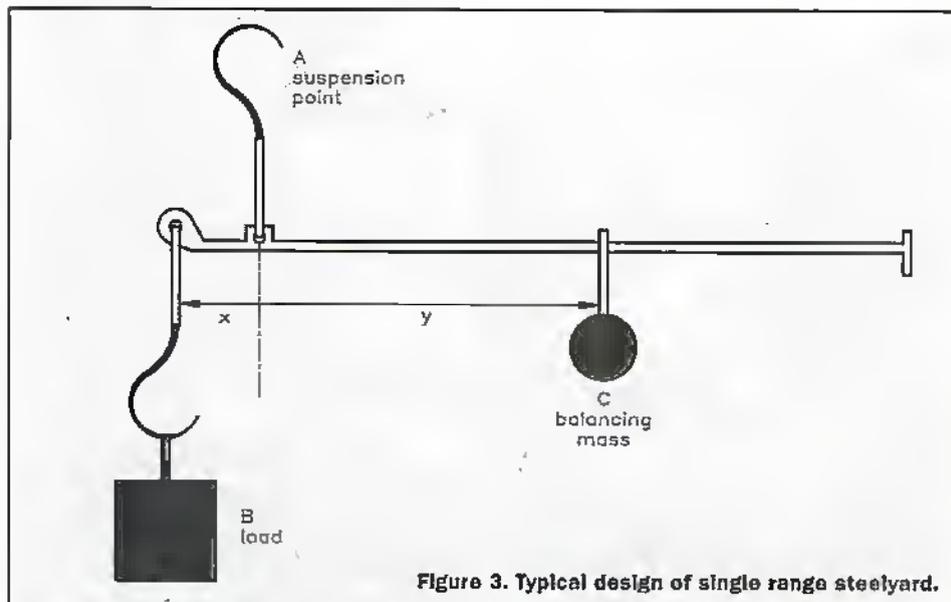


Figure 3. Typical design of single range steelyard.

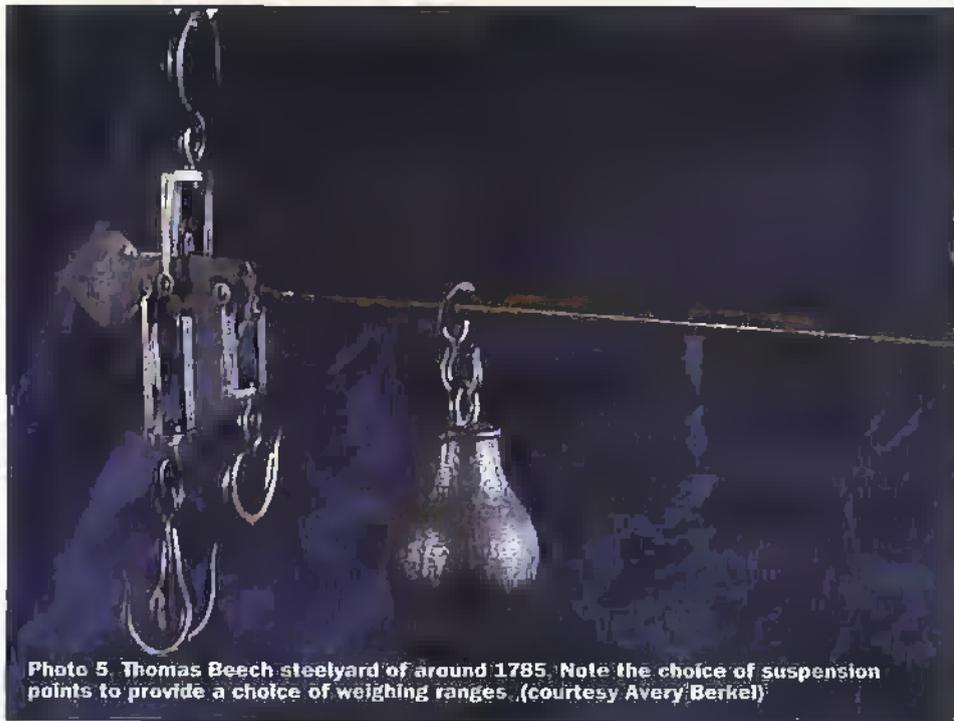


Photo 5. Thomas Beech steelyard of around 1785. Note the choice of suspension points to provide a choice of weighing ranges. (courtesy Avery Berkel)

Weighing Necessity

In many ways, within historic times, the development of a certain feature of weighing technology has centred around an event in social and economic structures. The Turnpike Act of 1741, with its establishment of tolls on roads rated according to the weight of the vehicle and load, created an immediate need for systems for weighing vehicles at the roadside. The initial response was to construct massive steelyards whereby the vehicle was required to be lifted off the road to determine its weight – no doubt a time consuming procedure!

Considerable effort was subsequently directed towards developing platform scales or weigh bridges, which would operate by merely placing the object to be weighed on the weighing platform. A so called compound lever system was developed by John Wyatt, a Birmingham mechanic, in which the load was suspended on a level system. This allowed proportional weights of significantly smaller value to be used to determine the condition of balance. The

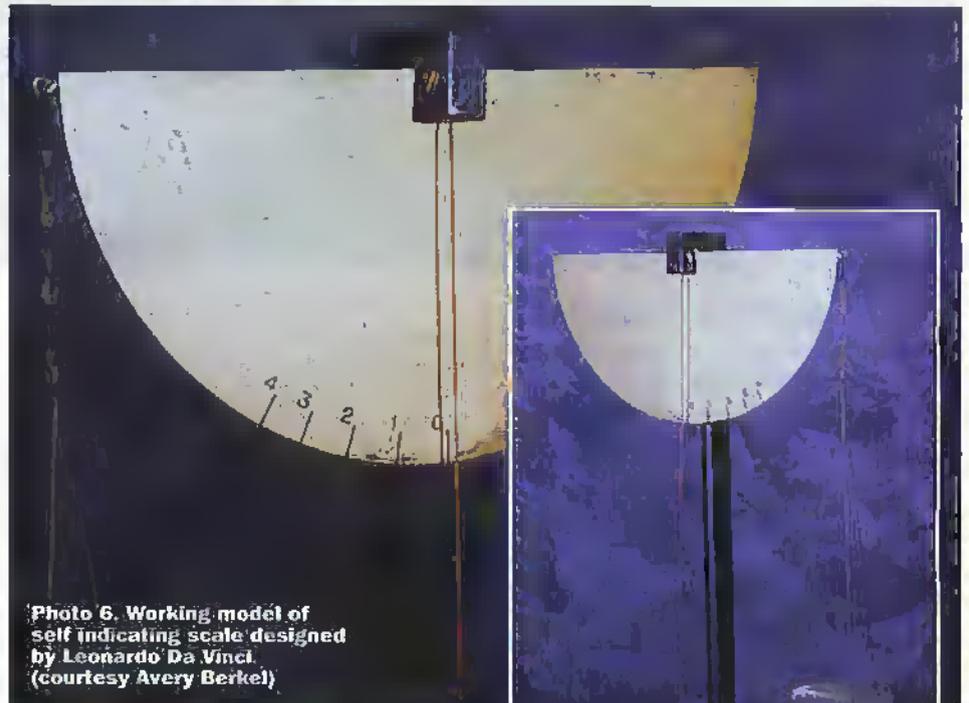


Photo 6. Working model of self indicating scale designed by Leonardo Da Vinci. (courtesy Avery Berkel)



Photo 7. Model of Roberval's 'stallo enigma'. (courtesy Avery Berkel)

accuracy allowed by this method, of around one pound per ton, remained until well into the 20th century.

The introduction, for example, of the Unified Postal Act of 1840 created almost overnight a demand for scales to weigh letters. In the period before 1915, a four ounce letter could be mailed for one old penny and scales were variously marked in penny intervals. As rates of charge varied – ever upwards – the design of scales was modified accordingly. Photo 8 indicates a range of postal scales.

In effect, it was largely the Industrial Revolution that gave rise to the great demand for a broad range of weighing systems as all manner of commodities were transported around the country and exported.

Spring Balance

The technique of the simple spring balance dates back to around 1770, with initial designs relating to a simple vertical extension of a spring arm with gradation on the central bar which slides in and out of the housing.

A variation of this technique was used in the elliptical spring balance where the load was made to deform a retaining spring in a housing – in some way like drawing back the string of a bow under tension. Photo 9 shows the inner workings of this type of device. The vertical motion was in turn translated through a rack and pinion drive to the rotational motion of a pointer with an indicating face. Such a method found widespread application as a means of weighing goods and luggage at railway stations.

The weighing with any degree of accuracy continued to require the use of the conventional balance with agate pivots. The development of the substitution balance around the 1950's and 1960's led to the speed up of weighing procedures. In this



Photo 8. Range of postal scales. (courtesy Avery Berkel)

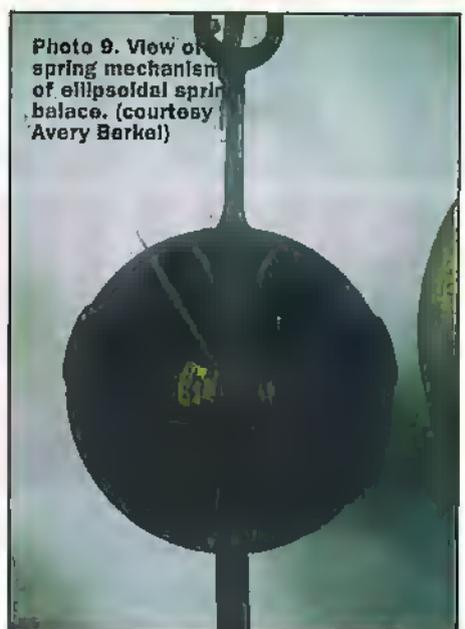
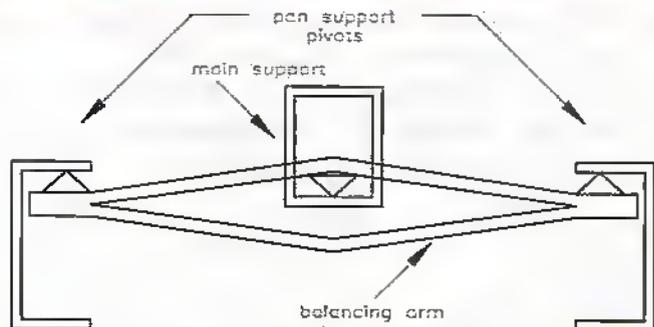


Photo 9. View of spring mechanism of ellipsoidal spring balance. (courtesy Avery Berkel)

method, only one pan – that with the sample – was visible to the operator. Balancing weights were automatically added or removed from the 'hidden' pan in response to the operator turning a rotational knob which showed the added counterweight. This method allowed measurements to be made more rapidly, and took conventional weighing technology – involving direct comparison of masses – effectively to its most highly developed form. From this point electronic technology has successively taken over, but more about this next month.

Figure 4. Principle of knife edge balances. The main pivot which supports the arms is pointing downwards while the pivots supporting the pans are pointing upwards.



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IBUS

ANALOGUE OUTPUT MODULE

PART 6

Design & development by Neil Johnson,
Cambridge Consultants Ltd

This IBUS expansion module equips your computer with an 8-bit resolution voltage source, for use in a wide range of instruments, experiments and projects.

It is the last module in the IBUS series, complementing last month's analogue input module. The list of modules includes a general-purpose digital I/O module (issue 122), an opto-isolated input module (issue 123), a relay output module (issue 124) and last month's analogue input module (issue 125). Completing the set is the IBUS-to-PC Parallel Port Adaptor (issue 119), all to be found in back issues of *Electronics and Beyond* – The Maplin Magazine.

Circuit Description

The circuit for this module, Figure 1, consists of three main blocks: address decoder, digital-to-analogue converter (DAC), and power supply. All three blocks work together to produce an output voltage proportional to the digital value sent to the module.

Starting with the address decoder, top left, the connection to the IBUS is made through connector JP1, a 34-way IDC connector. The eight address lines, A0 to A7, are fed into one half of magnitude comparator IC1. Switch SW1 and pull-up resistor pack RP1 set the specific board address, which is connected to the second half of IC1. When the IBUS address matches the board address the output pin, pin 19, goes low turning on the DAC, IC4.

The remaining IBUS signals –

eight data bits, D0 to D7, and the write strobe WR – feed directly into the DAC, the second main block shown in the centre of Figure 1. This project uses a modern 8-bit multiplying DAC, the AD7524. It accepts an 8-bit digital value and produces an output current proportional to the product of the digital value and the reference voltage V_{ref} (pin 15). For this circuit, the output voltage is given by the following

relationship:

$$V_{out} = (N \times V_{ref}) / 256$$

where N is the digital value written into the DAC, in the range 0 to 255.

The output current is converted to a voltage by a current-controlled voltage source based on IC3, a low-noise FET-input op-amp. The feedback resistor is provided as part of the DAC silicon circuit, ensuring excellent matching between the DAC's internal resistor network and the external op-amp circuit. Capacitor C8 provides a measure of loop gain stability. For accurate operation, trimmer VR1 is used to adjust any offsets in IC3 (more on this later in Testing). The output voltage is then presented to the outside world through connection point TP3.

The reference voltage for the DAC is generated by precision reference D3 and resistor R2. The reference diode is actually a complete shunt-regulated voltage reference circuit in a two-pin package. The resistor provides a load for the regulator, which maintains a temperature-stable 2.50V between its two terminals. Due to the inverting characteristic of IC3 a negative reference voltage is required for a positive output range. With one end of R2 tied to -12V the V_{ref} input to the DAC is held at -2.50V.

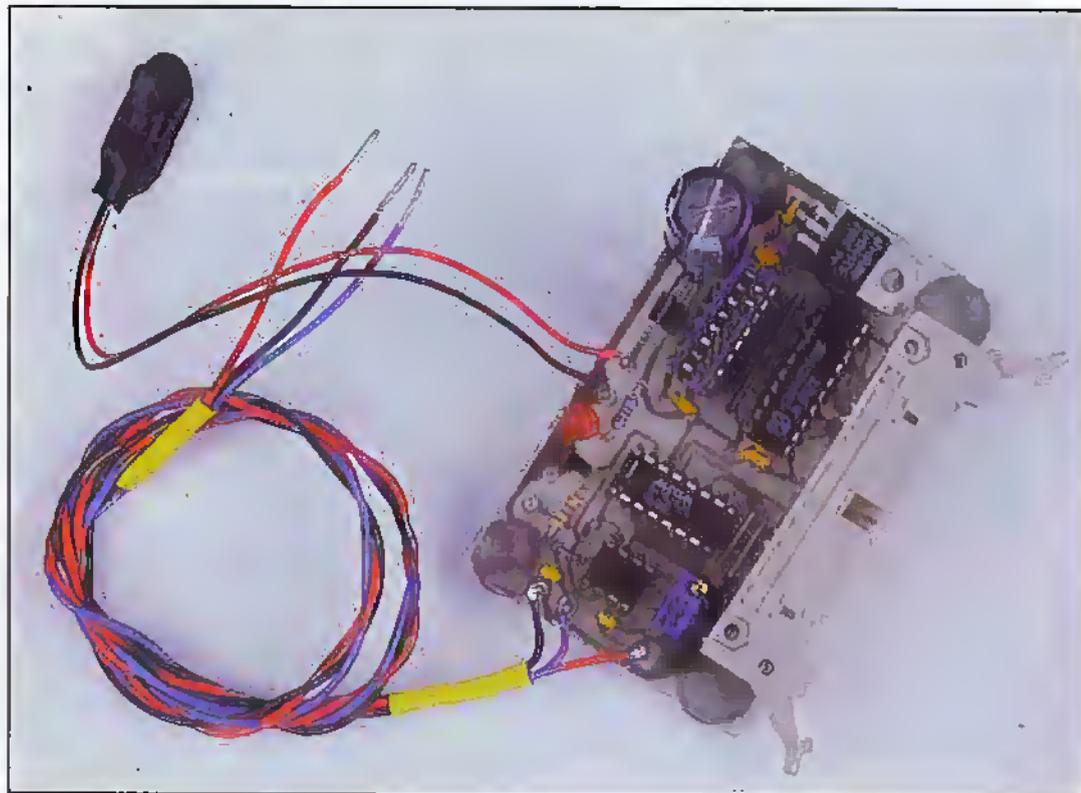
The third and final section of this circuit is the power supply. This is based on a three-

terminal voltage regulator, IC2. It takes an input voltage in the range 7V to 35V and regulates this down to a stable 5V suitable for the digital parts of this project. The supply input is protected against reverse voltages by diode D1, and smoothed by capacitors C3 and C7. The second diode, D2, protects IC2 from its output voltage exceeding its input voltage (this is possible if more than one expansion modules are connected to the IBUS). Power indication is provided by LED1 and R1, while the remaining capacitors are for local supply rail decoupling.

Two separate supply systems are used in this project. The digital circuitry has its own on-board regulator, as already discussed. The second supply is for the analogue circuitry, and needs to be a smooth $\pm 2V$. For a low-cost system the digital supply can be connected to the positive analogue supply rail.

Construction

The PCB overlay is shown in Figure 2. As always, all components are mounted on the PCB, with all connections brought out to the edges of the board. Start with the PCB pins for the power and output connections. A slight tap with a small hammer should be sufficient to push them firmly into place. Continue with the three wire links, resistors, small capacitors and the diodes D1 and D2.



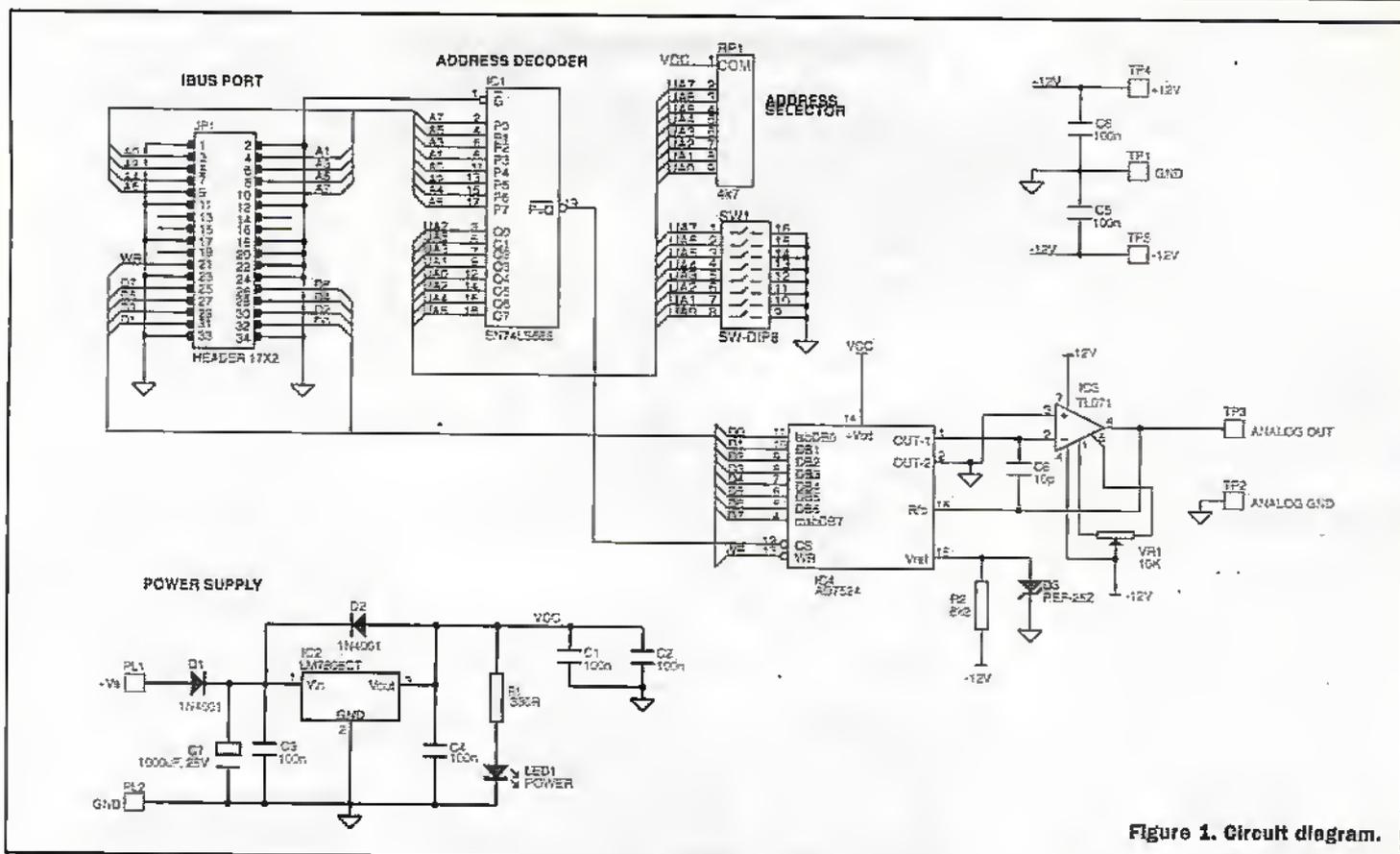


Figure 1. Circuit diagram.

The reference diode, D3, is supplied in a three-legged E-line package. This circuit needs connection to only two of these legs, and the third leg can be removed (see Figure 3). Continue with the remaining components, except for IC1, IC3 and IC4.

At this stage apply power to the board and check the voltage levels using a multimeter. Pin 3 of IC2 should be at +5V. The anode of D3 should be at -2.50V. Pad 7 of IC3 should be at +12V,

and pad 4 should be at -12V. Finally, check IC4 (pad 14 at +5V, pad 15 at -2.50V). Disconnect the supplies and fit the remaining components.

Testing

So, for the last time in this series, give the board a thorough visual inspection for any solder blobs or splashes between tracks or pins. This check is particularly important for this project where there is a

mix of digital and analogue electronics working at different supply voltages.

With the board visually clean, apply power to both halves of the board and repeat the voltage tests carried out during construction. At this stage the output voltage could be any value between -2V and +5V, depending on the state of the DAC and the offset trim of IC3. However, it should not be anywhere near either of the analogue supply rails, indicating

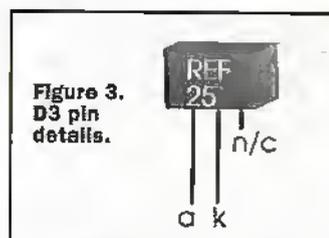


Figure 3. D3 pin details.

saturation of IC3. If it is, switch off and investigate.

Further testing and setting up requires the use of our old friend the IBUS test program (Figure 4). Set all of SW1 to the 'ON'

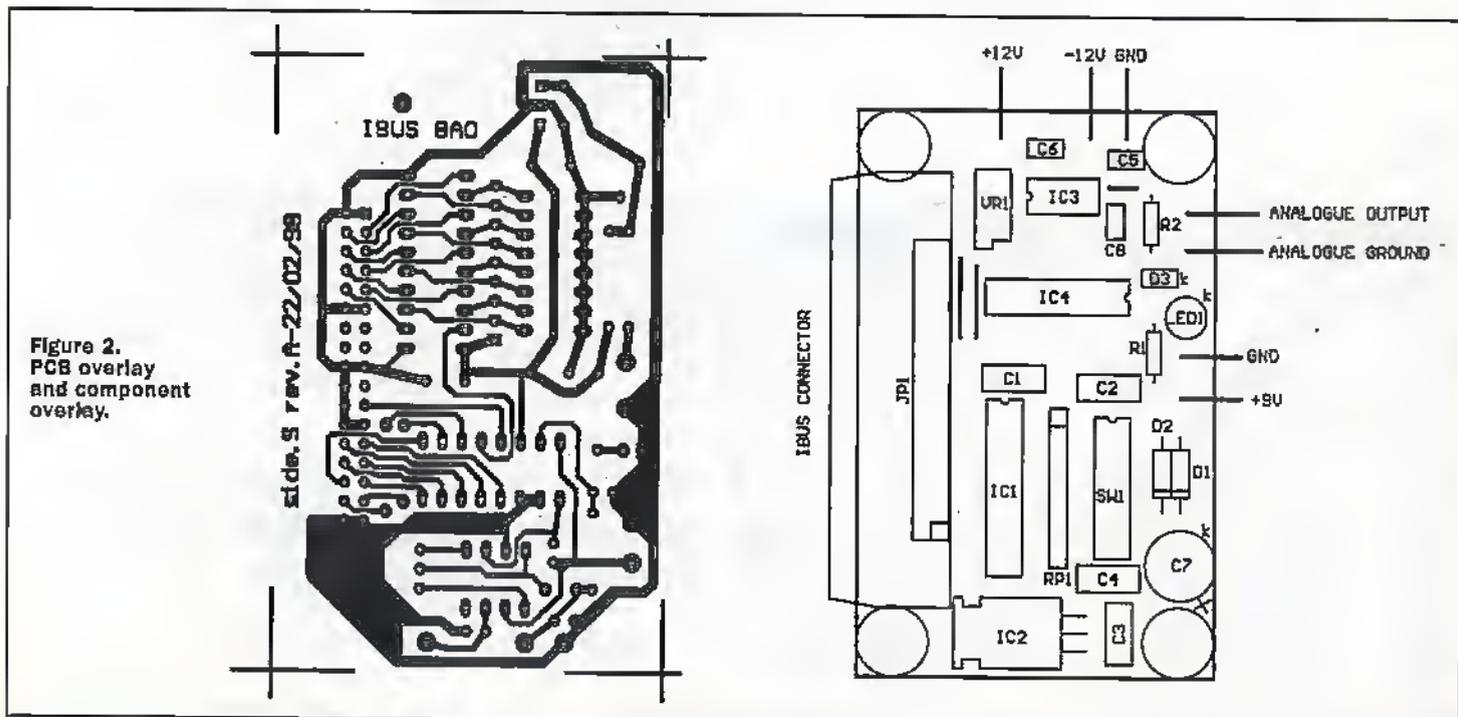


Figure 2. PCB overlay and component overlay.

position. Then connect the board to the IBUS Parallel Port Adaptor, which should also be connected to your PC's printer port, and start the test program.

Enter the IBUS address '00' into the Address box and a value of '00' into the Write box. This has now written a value of zero into the DAC. Connect a multimeter to the output of the board and measure the voltage. Then use a small screwdriver or trim tool to adjust VR1 for an output of exactly 0.00 volts. Finally, enter the value 'FF' into the Write box and check that the output voltage is 2.49V.

Application

In its basic form this module is a computer-controlled low current voltage source. Wherever you use a voltage to control something, this module can automate that system. Here are three example applications for this versatile module. As always, these are only ideas suggested by the author, there are many more possible applications of this module.

The first idea is for a computer-controlled power supply (Figure 5a). In this application the 8-bit analogue output module (8AO), shown in the diagram, generates a reference voltage for the error amplifier. The voltage divider connected across the output sets the scale and resolution of the power supply, with the error amplifier driving the pass-transistor.

The second idea uses several modules to control an analogue music synthesizer, the predecessor to today's modern digital synthesizer and now regaining popularity among electronic musicians. For the example shown (Figure 5b) three modules are required to control the frequency of the VCO (voltage-controlled oscillator), the cut-off

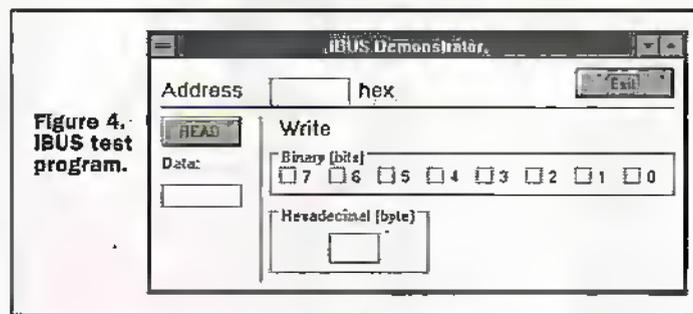


Figure 4. IBUS test program.

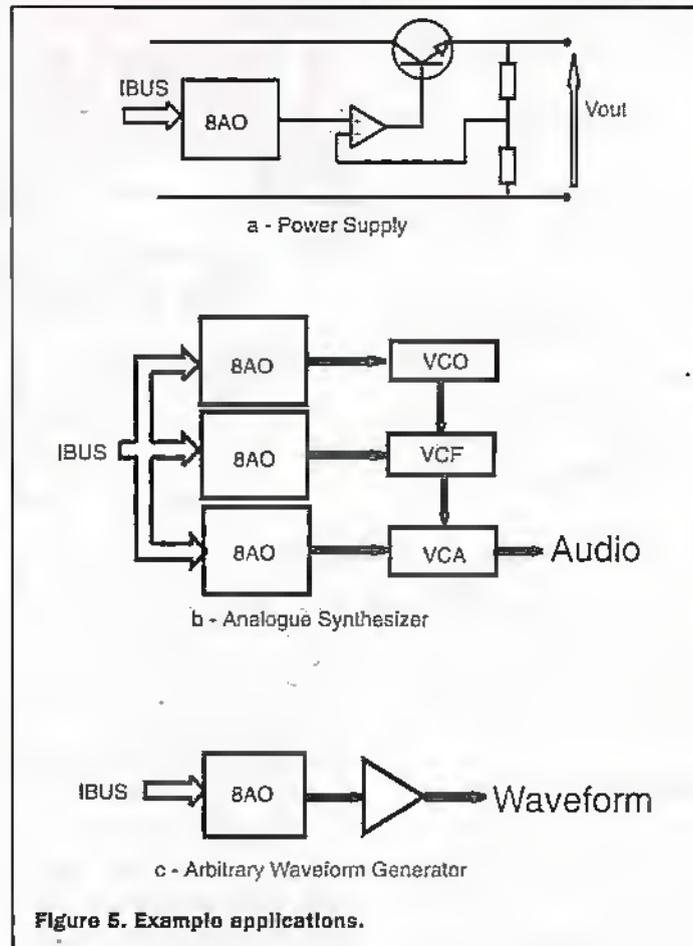


Figure 5. Example applications.

frequency of the VCO (voltage-controlled filter) and the gain of the VCA (voltage-controlled amplifier). The control program for this synthesizer would include a number of envelope generators and modulation sources and, if

your computer has a MIDI interface, could even respond to MIDI commands.

The final application idea will be useful to those experimenting with low frequency (up to several hundred Hertz) circuits. Quite often a special, or arbitrary,

waveform is required as a stimulus to a circuit. Using this module and appropriate software you could 'draw' the required waveshape on the computer screen with a light-pen or mouse, and then play this waveform through to the output module, and into your circuit.

The author has experienced such a system which was used for simulating the environment of an aeroplane. A recording was made of the vibration in the cockpit, which was then digitized and stored in a computer. Then, during development of new equipment, it could be tested for mechanical durability by being bolted onto a vibrator—a big loudspeaker coil and magnet two feet in diameter—and continuously replaying the cockpit noise into the vibrator causing the work surface to vibrate, so simulating the intended operating environment. At the time it all seemed very Heath Robinson!

Parting is such sweet sorrow...

This is the last module in the IBUS PC interfacing series. Next month we will look back at the complete series of modules, and look at a number of examples using these modules, together with some hints and tips on using the IBUS in your own projects. I hope you have enjoyed this series, and get as much out of building and using them as I have had in designing and describing them. I wish you great success in your future interfacing adventures.

Acknowledgements

The author would like to express his thanks to Cambridge Consultants Ltd, Cambridge, for their continued help in providing development facilities for this project.

PROJECT PARTS LIST

RESISTORS – all 5% 0.25watt unless stated

R1	330R	G330R
R2	8k2 (see text)	G8K2
VR1	10k multiturm preset	UH25C
RP1	4k7 8-way SIL resistor pack	RA29G

CAPACITORS

C1-6	100n ceramic	RA49D
C7	1,000uF 25V radial electrolytic	AT52G
C8	10pF ceramic	WX44X

SEMICONDUCTORS

IC1	74LS688	KP49D
IC2	LM7805	QL28F
IC3	TL071	RA67X
IC4	AD7524	VQ52G
D1,2	1N4001	QL73Q
D3	REF-25Z (see text)	DB58N
LED1	5mm red LED	WL27E

MISCELLANEOUS

JP1	34-W IDC right-angled PCB header.	FA44X
SW1	8-W DIP switch	QY70M

OPTIONAL

IC sockets, PCB, solder, wire, 7 x PCB pins

The software accompanying this project, supplied on a 3.5in. disk, and a set of foil pattern transparencies (two originals) are available from the author at the address below. The disk costs £1.0 and the foils cost £5. A pre-programmed CPLD for the Parallel Port Adaptor is still available, priced at £15. Postage is £2.50 for the UK, £5 for everywhere else. Please send your order, with cheque or postal order payable to 'Neil Johnson', to:

Neil Johnson, IBUS Module, 2 Chapel Field,
Dixter Road, NORTHAM, East Sussex, TN31 6PQ, UK.

Get more from VISUAL BASIC 3

PART 3

This month Mike Holmes looks at Kernels, DLLs and ProfileStrings.

Since the days of the 8-bit home computer, DIY BASIC programmers have looked at commercial software running on their machines, thinking "How does it do that?", or "Why haven't I got a BASIC instruction that does that?"

Deeper investigation usually revealed the program's heavy reliance on machine code, which is faster and more efficient than interpreted BASIC, together with frequent use of utility routines buried in some mysterious entity called the 'kernel'.

In essence, the 'kernel' is a block of software containing all the low level routines required for basic I/O (Input/Output). All the intricate, labour intensive machinations required to scan for a depressed keyboard key, display something on the screen, activate disk drives and read/write I/O ports bit-by-bit are contained in the kernel.

Use of the kernel by a program is usually the result of a need to access something that the high level programming language can't, but without having to 'reinvent the wheel'; that is, write specific machine code to do it. All the code required for accessing any hardware the machine might possess already exists in the kernel.

In the PC the kernel is, like everything else, loaded in from a system boot-up disk. PC DOS programmers may already be familiar with the technique for calling the DOS kernel, using what are called 'interrupts', and the hefty tomes that describe their manifold functions and usage in intimate detail.

Window API Functions

Windows is very similar in principle. The main differences are that, Visual Basic needs a named reference to the API (Application Programming Interface) routine - Windows does not allow it to simply make a call to an address as with the DOS 'interrupt' example; and B, the essential Windows API routines are spread throughout three main files. These are:

Library name	File
USER	USER.EXE, the program that is Windows
GDI	GDI.EXE (Graphical Display Interface), the thing that draws everything on the screen in Windows 3.x, either KERNEL286.DLL or KERNEL386.DLL; in Windows '95, KERNEL32.DLL

To this list other, more specific DLLs (Dynamic Link Libraries) are added by applications for specific tasks peculiar to themselves, but more of this later.

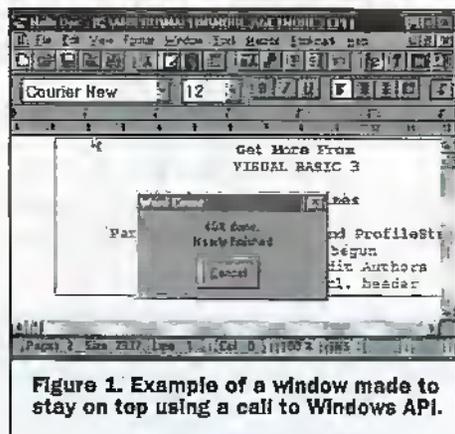


Figure 1. Example of a window made to stay on top using a call to Windows API.

Windows That Stay On Top

Figure 1 shows an example that anyone can try using Visual Basic 3 and Windows 3.1 or over. A typical application would be a progress display while code in another module is executing. This is not possible if the progress window is shown modally ('Show 1' method). Clicking on the main window causes the display window to lose focus, as in Figure 1, but it remains uncovered, that is, it 'stays on top'.

In Visual Basic, create a new module and save it as 'FRMONTOPBAS'. In the declarations section write:

```
Option Explicit
Defint A-Z

Declare Function SetWindowPos Lib
"user" (ByVal h, ByVal hb, ByVal x,
ByVal y, ByVal cx, ByVal cy, ByVal
f) As Integer
Declare Function GetVersion Lib
"Kernel" () As Integer
Global Const SWP_NOMOVE = 2
Global Const SWP_NOSIZE = 1
Global Const OnTopFlags = SWP_NOMOVE
Or SWP_NOSIZE
Global Const HWND_TOPMOST = -1
Global Const HWND_NOTOPMOST = -2
```

This is used in a globally accessible procedure that forces a form to stay on top. It calls SetWindowPos(), specifying the handle of an existing non-topmost window and HWND_TOPMOST as the value for the second parameter (hb), to set the form 'h' to TOPMOST, use the following API call:

```
Success =
SetWindowPos(frmCurrent.hwnd,
HWND_TOPMOST, 0, 0, 0, 0,
OnTopFlags)
Success% is <> 0 where successful. Note
that this attribute was introduced in
Windows version 3.1, so a GetVersion() API
call is required to determine whether the
application is running under Windows
version 3.1 and so is allowed to make the
call. The complete procedure looks like:
Sub FormOnTop (frmCurrent As Form)
```

```
Dim Success, Ver
' Get operating system version.
Ver = GetVersion()
Select Case Ver
' 2563 = Windows 3.1, 24323 =
Windows 95
Case 2563, 24323: 'OK
Case Else: Exit Sub 'can't do
it, Wrong Windows version
End Select
```

```
Success =
SetWindowPos(frmCurrent.hwnd,
HWND_TOPMOST, 0, 0, 0, 0,
OnTopFlags)
End Sub
```

The routine should be created in the same module. It quits if the version number does not match either of its recorded constants (Exit Sub). The routine is very simply called by:

```
FormOnTop FormName
or
FormOnTop Me'
```

To restore the form to normal, frmCurrent is made NON-TOPMOST using the same API call. Add the very similar following routine to FRMONTOPBAS:

```
Sub OnTopRelease (frmCurrent As Form)
which is exactly the same as above except
that the last line reads:
```

```
Success =
SetWindowPos(frmCurrent.hwnd,
HWND_NOTOPMOST, 0, 0, 0, 0,
OnTopFlags)
```

Getting Information About Windows

The GetVersion() kernel function is just one of a series able to return information about the Windows environment. It is not unusual (but not typical) for applications to display some of this information in their 'About' pop-up window.

It has to be said it looks very clever when seen by the 'average' user, and as a Visual Basic programmer you are now in a position to add a similar display of Windows environment data in an 'About' window of your own design, courtesy of the API calls.

Create another module saved as WININFO.BAS. In the declarations section this will contain the following API definitions:

```
Declare Function GetVersion Lib
"Kernel" () As Integer
Declare Function GetWinFlags Lib
"Kernel" () As Long
Declare Function GetFreeSpace Lib
"Kernel" (ByVal wFlags As Integer)
As Long
Declare Function GlobalCompact Lib
"Kernel" (ByVal dwMinFree As Long)
As Long
Declare Function SystemHeapInfo Lib
"toolhelp.dll" (shl As SYSHEAPINFO)
As Integer
```

Note that another library has crept into the picture, viz TOOLHELP.DLL. This is only to be expected as an application relies more and more on external API and other library calls.

Back to the present example - to be useable by the Visual Basic code calling these, the addition of some constants will make it more readable:

```
' Constants for GetWinFlags.
Global Const WF_CPU286 = &H2
Global Const WF_CPU386 = &H4
Global Const WF_CPU486 = &H8
Global Const WF_80x87 = &H400
Global Const WF_STANDARD = &H10
Global Const WF_ENHANCED = &H20
```

And the SystemHeapInfo() function (just to be awkward!) expects to be given a data structure (effectively a C language 'struct' or 'union' type 'variable'):

```
' Type for SystemHeapInfo.
Type SYSHEAPINFO
  dwSize As Long
  wUserFreePercent As Integer
  wGDIFreePercent As Integer
  hUserSegment As Integer
  hGDIsegment As Integer
End Type
```

Now you can create a new form with a control array of five label objects, to be made into an 'About' window. The form will be shown modally and all of the essential code is contained in the load event:

```
Sub Form_Load ()
  Dim msg$ ' Status information.
  Dim nl$ ' New-line.
  nl = Chr$(13) + Chr$(10) ' New-line.
  Dim Ver, ver_major$,
  ver_minor$, status$, memory%

  CentreForm Me 'see Part 2
  issue 125
  Label1(0).Caption = "About " +
  App.Title
  Label1(2).Caption = Version '
  Global string or constant
  Label1(3).Caption = Author '
  Global string or constant
  Label1(5).Caption =
  "Initialising . . ."
  ' Get operating system version.
  Ver = GetVersion()

  ver_major$ = Format$(Ver And
  &HFFF)
  ver_minor$ = Format$(Ver \
  &H100, "00")
  msg = "Environment:" + nl
  msg = msg + "Microsoft Windows
  version "
  msg = msg + ver_major$ + "." +
  ver_minor$ + nl
  ' Get CPU kind and operating mode.
  msg = msg + "CPU: "
  status% = GetWinFlags()
  If status% And WF_CPU286 Then
  msg = msg + "80286"
  If status% And WF_CPU386 Then
  msg = msg + "80386"
  If status% And WF_CPU486 Then
  msg = msg + "80486"
  If status% And WF_80x87 Then
  msg = msg + " with 80x87"
  msg = msg + nl
  msg = msg + "Mode: "
  If status% And WF_STANDARD Then
  msg = msg + "Standard" + nl
  If status% And WF_ENHANCED Then
  msg = msg + "Enhanced" + nl

  ' Get free memory.
  memory% = GetFreeSpace(0)
  msg = msg + "Memory free: "
  msg = msg + Format$(memory% \
  1024, "###,###,###") + "K" + nl
  memory% =
  GlobalCompact(&HEFFFFFF)
  msg = msg + "Largest free
  block: "
  msg = msg + Format$(memory% \
  1024, "###,###,###") + "K" + nl

  ' Get free system resources - the
  API SystemHeapInfo only became
  available in Windows version 1.1.
  msg = msg + "System resources:
  .
  If Ver >= &H310 Then 'can do
  it. else wrong version
  Dim shi As SYSHEAPINFO
  shi.dwSize = Len(shi)
  If SystemHeapInfo(shi) Then
  If shi.wUserFreePercent <
  shi.wGDIFreePercent Then
  msg = msg +
  Format$(shi.wUserFreePercent) + "%
  Else
  msg = msg +
  Format$(shi.wGDIFreePercent) + "%
```

```
End If
End If
Else
  msg = msg + "n/a"
End If
Label1(5).Caption = msg
Refresh
End Sub
```

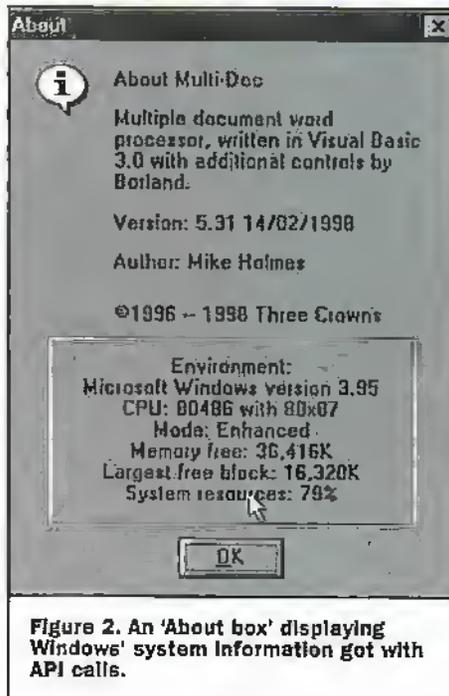


Figure 2. An 'About box' displaying Windows' system information got with API calls.

An example of such a form is shown in Figure 2 (although it doesn't have to look exactly like this). The window can be invoked modally via a menu option using the instruction 'FrmAbout.Show 1', provided Windows has access to TOOLHELPEDDL, and WININFO.BAS is included in the project.

In the particular instance of Figure 2 the version number, matched using 'Select Case' in the same way as with the form-on-top example, is also used to determine which style of information icon is shown at top left - either Windows '95 (as Figure 2) or the previous, round, white on blue 3.x version. These icons were assigned to a two element image array at design time, the one required being brought to the fore using the ZOrder 0 method at run time.

Now we can see how the above API calls can be employed to discover things like free memory remaining, and user and GDI resources, in order to generate warning messages.

Getting Windows' Paths And 'Buffering'

If you are writing Visual Basic applications for yourself, you know what your Windows' paths are. If however, you are writing for someone else, it isn't always going to be a hard and fast rule that their Windows directory will be 'c:\windows' and that the system directory might be 'c:\windows\system'. Indeed, their Windows may not even be installed on internal hard disk 'C:', or even the same machine given that Windows allows its system directory to reside on a local area network server!

Before your application can begin to read and write initialisation (*.INI) files or access Windows directories for some other

purpose, it needs a categorical reference to where they are. The trick is never to make reference to Windows directories explicitly, that is by 'c:\windows', but to return the real path to a string variable using API, whatever it may be. The following is the declarations section of a module I created for this purpose, called WINDIR.BAS:

```
Declare Function GetWindowsDirectory
  Lib "Kernel" (ByVal lpBuffer As
  String, ByVal nSize As Integer) As
  Integer
Declare Function GetSystemDirectory
  Lib "Kernel" (ByVal lpBuffer As
  String, ByVal nSize As Integer) As
  Integer
```

Unfortunately neither of these API functions returns an actual string, just its length, so you can't use 'path\$ ='. To retrieve the characters, each must be given the location of a 'buffer' to write to. The 'buffer' is a dimensioned string variable whose base address, lpBuffer, is passed using 'ByVal':

```
Function GetWindowsDir () As String
  Dim temp$, X
  temp$ = String$(145, 0) ' Buffer of
  size 145
  X = GetWindowsDirectory(temp$,
  145) ' Make API Call
  temp$ = Left$(temp$, X) ' Trim
  Buffer
  If Right$(temp$, 1) <> "\" Then '
  Add \ if necessary
  GetWindowsDir$ = temp$ + "\"
  Else
  GetWindowsDir$ = temp$
  End If
End Function
```

A virtual copy called GetWindowsSysDir() should also be made, but where the instruction 'X = GetWindowsDirectory(temp\$, 145)' is replaced with 'X = GetSystemDirectory(temp\$, 145)'. It is then possible to immediately return the running Windows directories using either:

```
StrVar1$ = GetWindowsDir$()
StrVar2$ = GetWindowsSysDir$()
```

You could create globally readable string variables to store the results, by adding:

```
Global winDir$
Global winSysDir$
```

to the declarations section of the above functions by itself can be used as the path as and when required:

```
Open GetWindowsDir$() +
"control.ini" For Input As #1
```

It doesn't matter what the Windows path actually is, the functions will always return it correctly to your application code, whatever it may be called.

Accessing Initialisation Files

I first came across this rather long-winded method for transferring a string using a 'copy buffer' while investigating how to read and write Windows initialisation (*.INI) files. Of course the next to useless VB API reference help does not indicate, for the benefit of the novice, the fact that the string passed by reference to the API function must not be an empty one. That is, it must be filled with characters to a suitable length using the String() function, and not left as "".

There are several useful examples for API calling protocol in the demonstration example application called 'IconWorks' supplied with Visual Basic. This is where I discovered what I was doing wrong.

Because the calling code is part of an EXE, the program, but the function is external, contained in a link library, the only data that can be passed between them is that which can be accommodated on the CPU stack. Whereas short and long integers are okay, it does not include strings, since these comprise an indeterminate number of bytes and can be very large.

So instead Visual Basic must pass the base address of where the string is physically stored by value (ByVal). In Windows this is done using the 'virtual memory model', i.e. direct 32-bit addressing (instead of the more familiar DOS method, using indices to 64K segments and offsets within).

Just to prove it, it is possible to create a custom DLL wherein a called routine displays the address it has received, and it turns out to be a 6- or 7-digit number, an absolute offset from DOS memory zero to several megabytes, where the string is actually located.

Consequently the DLL or API routine accesses this area using a 'far pointer', to use the 'C' parlance. The API routine either reads or writes the string 'buffer' by transferring one character at a time, while incrementing the pointer. It must also know where the end of this storage space is so that it does not 'run off the end', which is usually disastrous, and which is why another number representing the string size is invariably provided as a second parameter.

However, Visual Basic also adds a zero byte to the end of any string passed by value - although this is only of any use if the called routine recognises it as the termination character!

Demonstrating both these methods, here is something else everyone can try. While custom controls for accessing initialisation files exist, they are not strictly necessary. You just need to create a text file that can be merged into a VB module at the declaration level, be it a form or BASIC type, and containing the following:

```
Declare Function WriteProfileString
Lib "Kernel" (ByVal lpAppName$,
ByVal lpKeyName$, ByVal lpString$)
As Integer
Declare Function GetProfileString
Lib "Kernel" (ByVal lpAppName$,
ByVal lpKeyName$, ByVal lpDefault$,
ByVal lpRetString$, ByVal nSize%) As
Integer
Declare Function
WritePrivateProfileString Lib
"Kernel" (ByVal lpAppName$, ByVal
lpKeyName$, ByVal lpString$, ByVal
lpFileName$) As Integer
Declare Function
GetPrivateProfileString Lib "Kernel"
(ByVal lpAppName$, ByVal lpKeyName$,
ByVal lpDefault$, ByVal
lpRetString$, ByVal nSize%, ByVal
lpFileName$) As Integer
```

There are two important things to note about these; firstly, the path to the *.INI file will always be the Windows directory by default; and secondly, in the case of the first two declarations, the *.INI file is always WIN.INI.

To summarise the parameters:

'Get'
lpAppName\$ in the INI file, the 'section header' or title enclosed between square brackets []
lpKeyName\$ in the INI file, the 'key-word' to which a value is assigned,
 by =
lpDefault\$ the default text to use if this entry does not exist in the file

lpRetString\$ string buffer to which the value assigned to the key name by = is returned if it exists, else the contents of lpDefault\$
nSize% the size of the string buffer
lpFileName\$
 Get/PrivateProfileString only the name of the INI file. If no path is given, the Windows directory is assumed

```
Write
lpAppName$ as above
lpKeyName$ as above
lpString$ text to assign to KeyName
by =
lpFileName$ as above
```

As a beginning, many applications save the size and position of their main window to an *.INI file on closing, to reinstate these values next time they load. Your form can include the following in its QueryUnload event procedure:

```
Dim x, datastr$, ws
If Form1.WindowState = 1 Then
Form1.WindowState = 0
' MUST NOT save as minimised
ws = CInt(Form1.WindowState)
Form1.WindowState = 0 'restore
normal if maximised
datastr = Str$(Form1.Left) +
"," + Str$(Form1.Top) + "," +
Str$(Form1.Width) + "," +
Str$(Form1.Height)
x =
WritePrivateProfileString("Window",
"WindowSize", datastr, "MYPROG.INI")
datastr = Str$(ws)
x =
WritePrivateProfileString("Window",
"WindowState", datastr,
"MYPROG.INI")
```

which, on the form unloading, creates an initialisation file called MYPROG.INI in the Windows directory that reads like:

```
[Window]
WindowSize= 0, 15, 9600, 6465
WindowState= 0
```

The application's main window can then recover this information during its Load event procedure:

```
Dim x, retstr$, temp$
retstr$ = String$(255, 32) '
the read buffer
' must dimension this string as
its address is passed
x =
GetPrivateProfileString("Window",
"WindowSize", " 0, 0, 9600, 6480",
retstr$, Len(retstr$),
"MYPROG.INI")
See below
x =
GetPrivateProfileString("Window",
"WindowState", "0", retstr$,
Len(retstr$), "MYPROG.INI")
Form1.WindowState =
Val(Left$(retstr, x))
```

Although for convenience the window size was saved as a string of four numbers separated by commas, this cannot readily be used by the Move method to resize the window. So a word extraction function was created to pick out each value in turn:

```
Insert in the above above at
temp = Left$(retstr, x)
Form1.Move
Val(ExtractWord$(temp, 1, ","))
Val(ExtractWord$(temp, 2, ","))
Val(ExtractWord$(temp, 3, ","))
Val(ExtractWord$(temp, 4, ","))
```

ExtractWord\$() itself is very simple, comprising:

```
Function ExtractWord (ByVal Text As
String, Index As Integer, TrapChar
As String) As String
Dim temp$, i
```

```
temp = Text + TrapChar
ExtractWord = ""
For i = 1 To Index
ExtractWord = iExtract$(temp,
TrapChar)
temp = Mid$(temp, InStr(temp,
TrapChar) + 1)
Next i
End Function
iSee Part 2
```

So ExtractWord\$() is also useful for extracting other sub-strings separated by a common, known delimiter character.

I hope you get the general idea, anyhow. The above can be copied and modified to read and write anything you want in initialisation files of your own making - examples can include status flags, colours, settings for numerical conversion algorithms (save and recover whichever was last selected), the 'checked' values of menus, option buttons and check boxes, and even lists of names of the most recently loaded files to overwrite the entries provided for same in a file drop-down menu.

Customised Dynamic Link Libraries

As mentioned in Part 1, many applications have their own DLL's - *Dynamic Link Libraries* - for specific functions peculiar to themselves. The pitfalls that apply to API's - the problems of string passing being just one - are also present.

The biggest problem with accessing a lesser-known DLL is not knowing how its routines' parameters must be passed, and quite honestly without this vital information you are not going to get anywhere. (You can use Windows '95's QuikView utility to display the headers of DLL's as well as EXE's; this will show a list of the 'exported' or externally accessible routines, but still won't indicate the form of data they require.)

Getting it wrong invariably results in a 'Bad DLL calling convention' error, or even the dreaded 'This application has caused a General Protection Fault and will be terminated'...

'Any' Versus 'ByVal'

Take the case of a DLL written in a totally different language, such as 'C' or, in this case, Pascal. To illustrate the point I shall use a custom DLL that I made called 'UTILITY.DLL', that was written in Visual Pascal.

This contains a number of marginally useful things, the first of which is a device for displaying a start-up logo for an application while it loads. Originally containing a default picture fixed at design time, the procedure was expanded to be able to load any Windows bitmap (*.BMP) that it is given the name of when called. The Visual Basic declaration for it is:

```
Declare Sub OpenLogo Lib
"utility.dll" (ByVal lpPicName As
Any, ByVal plen As Integer)
Declare Sub CloseLogo Lib
"utility.dll" ()
```

lpPicName is a string, the name of the bitmap file, optionally preceded by a path. But instead of specifying by value as string, as in the previous API examples, here we have to use 'As Any', otherwise Visual Basic will pass the base address with the inference that it is for a string (with a zero terminator). The trouble with this is that

ELECTRONICS and Beyond



Figure 3. A custom DLL routine that displays an application start-up window, showing any chosen bitmap for a logo, passed to it as a file name.

strings per se are an alien concept for Visual Pascal — like 'C', it uses character arrays in place of strings, literally dimensioned arrays of single bytes. This becomes apparent when you look at the equivalent Visual Pascal declaration in the DLL source code:

```
procedure OpenLogo(lpPicName: PChar;
  pLen: Integer); export;
```

lpPicName becomes a far pointer of type 'PChar', that is, a pointer to a character array. Hence Visual Basic must provide the base address as 'raw', 'As Anything'. As Any overrides what is called type checking, which, if it comes out as the wrong type, causes the 'Bad DLL convention' error.

With the As Any override, the use of:

```
OpenLogo "maplin.bmp",
  Len("maplin.bmp")
```

gives rise to the result shown in Figure 3. This designed window, during its Pascal FormCreate event, invoked by the local OpenLogo procedure, firstly loads its image object with the picture. Then it sets an image property to force it to fit the size and shape of the picture, resizes the window to the image, centres itself on screen and then makes itself stay on top of all other windows. The 'OK' button is repositioned relative to the new shape. The window has no border or title bar, so any 3D borders must be integral with the picture.

Because the window is not shown modally by Visual Basic, VB code is allowed to run normally, but anything it displays is always behind the DLL's logo form. This window can be removed in one of three ways: by clicking on the 'OK' button, by double-clicking on the picture, or when it has finished its start-up processes, by the VB application itself:

```
CloseLogo
```

The one serious problem with this being that the window must be loaded, otherwise CloseLogo results in a General Protection Fault. Windows cannot unload a window that doesn't exist — it's a definite naughty! So how can the program find out? Windows' own USER.EXE comes to the rescue:

```
Declare Function FindWindow Lib
  "user" (ByVal lpClassName As Any,
  ByVal lpWindowName As Any) As
  Integer
```

The FindWindow() API function retrieves the handle of the window whose class name and window name match the specified strings. (It does not search child windows.) Parameter ClassName points to a string that contains the window's class name.

WindowName points to a string that specifies the window name (the window's title). The function returns the handle of the window that has the specified class name and window name if successful. Otherwise, it is 0. Hence, the proper way for the

program to unload the DLL logo window is:
If FindWindow("Tc3Logo", "c3Logo") >
0 Then CloseLogo

to prevent an error if it's not there.

Now that we've got the hang of using 'string buffers' and passing string pointers indiscriminately As Any, consider this:

```
Declare Function MessageDLL Lib
  "utility.dll" (ByVal lpMsg As Any,
  ByVal mLen As Integer, ByVal msgType
  As Integer, ByVal btnType As
  Integer, ByVal lpHName As Any, ByVal
  hLen As Integer, ByVal Hc As Long)
  As Integer
```

of which the Pascal equivalent in the DLL is:

```
Function MessageDLL(lpMsg: PChar;
  mLen, msgType, btnType: Integer;
  lpHName: PChar; hLen: Integer; Hc:
  LongInt): Integer; export;
```

Can you work out which parameters are strings, and which specify the sizes of these strings? MessageDLL() provides an alternative to Visual Basic's MsgBox() function having more options and buttons. An example is shown in Figure 4. The extensions are worth summarising:

The message to be displayed is passed as lpMsg, its length as mLen. Thus far, the function is not too different from VB MsgBox() used as a function. The deviations are msgType and btnType, which are separate and not Orred together into one number. Also lpHName, specifying a help file name with or without optional path (if no path then Windows directory is assumed); hLen as the length of lpHName, and Hc specifying the context number of the help topic to display.

These must be supplied even if no help button is required, but can be blank as in:

```
x = MessageDLL(Msg$, Len(Msg$), 64,
  0, "", 0, CLng(0))
```

else:

```
x = MessageDLL(Msg$, Len(Msg$), 64,
  8, "c:\utils.hlp", 11, CLng(21001))
```

where btnType = 8 specifies 'OK' plus 'Help' buttons. In which case the help file name is assigned to the DLL's internal Pascal equivalent of the 'helpname' property for its 'application object', whereupon it can then

Permutations, msgType:

Value	Style	Like
0	Name of DLL in title bar, no icon	VB no icon
16	'Error' in title bar, red 'X' icon	VB 'STOP'
32	'Confirm' in title bar, blue '?' icon	VB Query
48	'Warning' in title bar, yellow '!' icon	VB Exclamation
64	'Information' in title bar, blue 'i' icon	VB Information

Permutations, btnType:

Value	Style	Like
0	OK	VB OK
1	OK,	Cancel VB OK, Cancel
2	Abort, Retry, Ignore	VB Abort, Retry, Ignore
3	Yes, No, Cancel	VB Yes, No, Cancel
4	Yes, No	VB Yes, No
5	Retry, Cancel	VB Retry, Cancel

Extensions to btnType, non-VB:

6	Cancel
7	Cancel, Help
8	OK, Help
9	OK, Cancel, Help
10	OK, All, Cancel
11	Yes, No, Help
12	Yes, No, Cancel, Help
13	Yes, No, All
14	Yes, No, All, Help
15	Yes, No, All, Cancel
16	OK, Ignore
17	OK, Ignore, Help
18	Yes, No, All, Cancel, Help
19	Abort, Retry, Ignore, Help

Returns:

1	OK pressed)
2	Cancel pressed)
3	Abort pressed)
4	Retry pressed) like VB
5	Ignore pressed)
6	Yes pressed)
7	No pressed)
8	All pressed	extension

Figure 4. A custom DLL routine as an alternative to Visual Basic's MsgBox() function with extensions, including a 'Help' button.



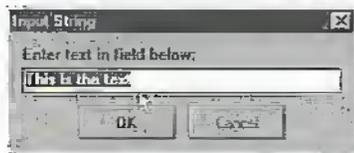


Figure 5. Smarter alternative to the standard Visual Basic InputBox() function, courtesy of a custom DLL.

simply call up the topic by reference to its context number when the 'Help' button is clicked. Well it works, anyway.

Alternative InputBox

A 'made up' InputBox\$() was already covered in Part 2 as a vast improvement over the conventional one. As a variation, UTILITY.DLL possesses one too, with one essential difference. Bear in mind that, following what was said already about string buffers; because it 'returns' a string, InputDLL() must be passed a fully dimensioned string, not an empty one.

```
Declare Function InputDLL Lib "utility.dll" (ByVal lpCaption As Any,
ByVal clen As Integer, ByVal lpPrompt As Any, ByVal pLen As
Integer, ByVal lpValue As Any, ByVal vSize As Integer) As Integer
```

Pascal definition:

```
Function InputDLL(lpCaption: PChar;
clen: Integer; lpPrompt: PChar;
pLen: Integer; lpValue: PChar;
vSize: Integer): Integer; export;
```

I leave it to the reader to work out which parameters do what – the basic order is identical to normal VB InputBox\$().

InputDLL() is a function that recognises a

zero terminator in lpValue, the text to input, as it is also provided as default text for the input field. The Visual Basic string pointed to by lpValue must be dimensioned and filled with zero bytes:

```
Dim retstr$
retstr$ = String(255, 0)
```

```
or padded out with same:
retstr$ = "This is the text" +
String(239, 0)
```

That way, the highlighted text appearing in the input field of the window is the right length, as in Figure 5. InputDLL() returns the length of the typed or accepted text and writes it to the 'string buffer' (as retstr\$ above) pointed to by lpValue. You then take the Left\$ of the contents using this length, same as for the Get[Private]ProfileString() API function.

Quite unlike InputBox\$(), however, InputDLL() returns -1 if its window is cancelled or closed, which should be trapped by code – this is so it can return an empty string which may actually be valid – the one thing InputBox\$() cannot do.

Finally

It's worth mentioning that UTILITY.DLL includes a few other useful things, three of which are functions that can simply be read as numeric values. These include:

```
Declare Function GetDiskSize Lib
"utility.dll" (ByVal DriveID As Integer) As Long
```

Returns total size in bytes of specified drive number, where 0 = current, 1 = drive A, 2 = B, 3 = C, etc. Returns -1 if error.

```
Declare Function GetDiskFree Lib
"utility.dll" (ByVal DriveID As Integer) As Long
```

Returns number of free bytes on specified drive number, where 0 = current, 1 = A, 2 = B, 3 = C, and so on. Returns -1 if error.

```
Declare Function DriveType Lib "utility.dll"
(ByVal DriveID As Integer) As Long
```

DriveID specifies which drive is to be determined (0 = drive A, 1 = drive B, 2 = drive C, and so on). Returns a type number specifying removable (floppy), fixed (hard) or network, or -1 if error.

```
Declare Function CopyFileDateTime Lib
"utility.dll" (ByVal lpFile1 As Any, ByVal
lpFile2 As Any) As Integer
```

Transfers the DOS date-time stamp of filespec at lpFile1 to replace that pointed to by lpFile2. Strings at lpFileX must be zero terminated. Returns True (-1) if OK, False (0) if error.

```
Declare Function WriteFileDateTime Lib
"utility.dll" (ByVal lpFile As Any, ByVal
lpDateTime As Any) As Integer
```

Overwrites DOS date-time stamp of filespec at lpFile with a replacement date-time coded as Visual Basic internal floating point date-time value, and provided in string form, e.g. Str\$(CDbl(Now)). Both strings must be zero terminated. Returns True (-1) if OK, False (0) if error. Ever noticed how a complete set of installation files for a commercial application all have the same date and time to the nearest second? Now you know!

Next month, a slight retrograde step – Visual Basic for DOS?

If you can find a use for UTILITY.DLL and would like a copy of this and other useful add-on modules for Visual Basic 3, please apply privately to the author, PO Box 5773, Laindon, Essex SS15 5JF.

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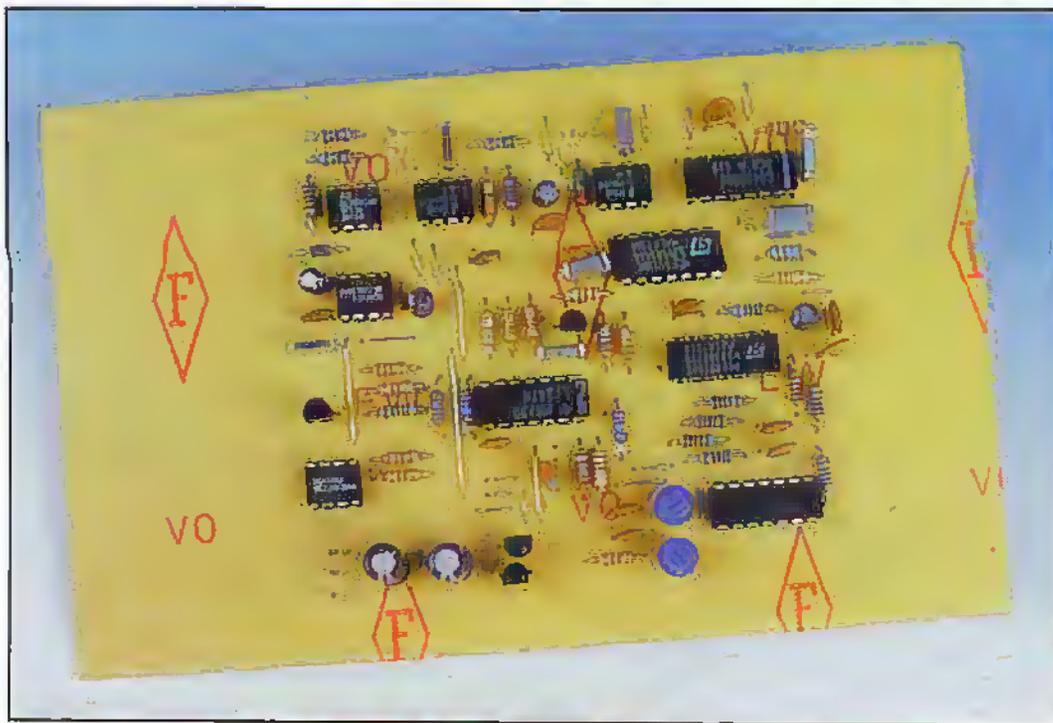
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ON-SCREEN VIDEO LEVEL METER

PART 2

Ian Berry continues his circuit description.

Pulse bits

The input video signal is terminated by R3 to ensure the correct operating level. IC1 is a sync separator which removes the video information and extracts the timing information. This consists of horizontal sync, used in the clamp and sample-

and-hold, vertical sync, used to generate the blanking signal, and a burst gate signal. The burst gate signal, as its name suggests, is present only where the reference colour burst occurs in the video waveform. This is useful as it produces a pulse which occurs after horizontal sync but before the

start of the line video information. (Figure 9) This burst gate signal is inverted by IC4B and used to discharge the rectifier hold capacitor at the start of each line of video. Thus the level held from the previous line is lost and will not affect the next line to be measured. The horizontal sync pulse is inverted by IC4A before being used by the ramp generator. IC1 also gives a vertical sync pulse. By itself this is too narrow to be used as vertical blanking so it is used to trigger the first half of IC3, a dual monostable multivibrator. The time period of this half of IC3 is set by C4/R6 to give an output pulse about 1.5ms in length. The trailing edge of this pulse will occur just after the start of the visible part of the picture at the top of the

screen. This pulse edge is used to trigger the second half of IC3 the period of which is set by C3/R5 to be just less than the duration of the active frame of picture. The output of the second half of IC3 is used to gate off the display during the vertical interval where there is no active picture information.

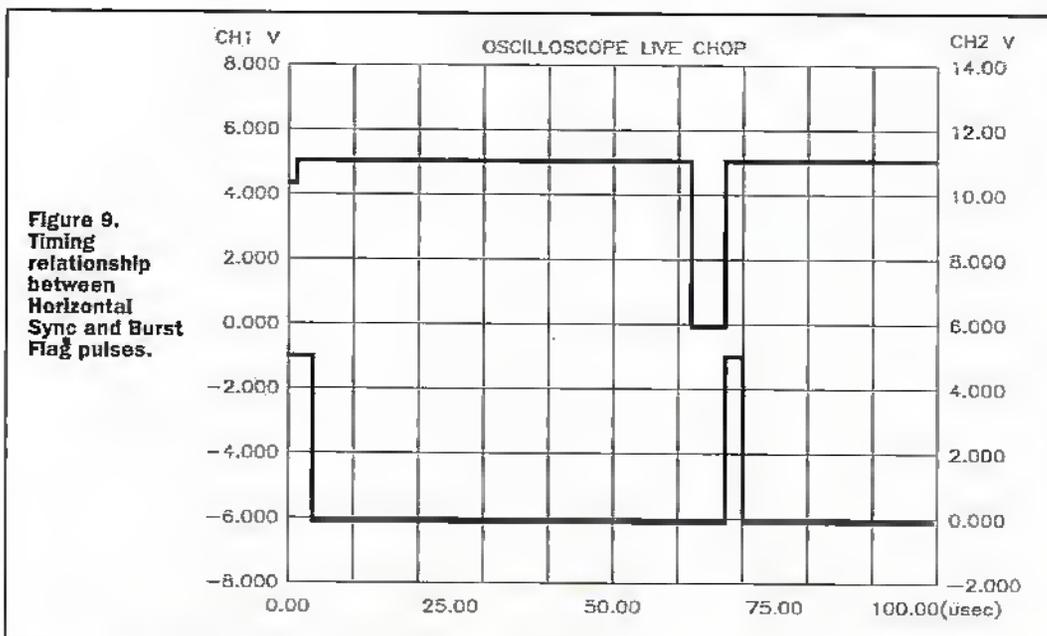
The reset input of IC3B is held high by R7. Provision is made to take this pin to ground with an external switch. The effect of this is to gate-off the display not only during the vertical interval, but during the active picture as well, thus removing the display completely.

The ramp generator is a simple integrator formed by IC5a and C6. The value of C6 is chosen so that the ramp is one video line long, about 60µs (Figure 10). Horizontal sync pulses are applied to the gate of TR1 which switches R9 across C6 during the line sync period. This discharges C6 ready for the start of the next line whereupon another rising ramp is generated. Incidentally, if R10 is connected to -5V instead of +5V the ramp will fall instead of rise. IC5b amplifies the ramp signal by about twice or so and R13 and R14 set the dc conditions of the ramp signal at pin 7 of IC5b. Varying the ratio of these two resistors, and hence the dc level at pin 5 of IC5b, will move the whole level display to the left or to the right on the monitor screen. The amplified ramp signal is applied to all three positive inputs of the comparator.

Vertical sync pulses from IC1 are used by IC3 to generate a blanking signal. IC3 is a dual monostable. The first half extends the vertical sync pulse such that the falling edge at pin 7 occurs just after the start of the picture information at the top of the picture. This is used to trigger the second half of IC3, the period of which is set by R5 and C9 to be more or less during the picture information occurring from the top of the picture to the bottom. So the blanking signal serves to make sure the measurement display is only present during the active part of the picture.

Video bits

The input video signal is also applied to the input of the video clamp circuit of IC2. This circuit is in the form of a sample and hold circuit. Within the IC is an analogue switch under the control of the clamp



pulse input. During the active part of the line (clamp pulse-high) the input video is passed through C2 to an internal amplifier. When the clamp pulse is low, pin 2 of the IC is disconnected from the input of the amplifier and taken to a fixed dc level set by the reference voltage on pin 3. When the clamp pulse again goes high, pin 2 is again connected to the input of the amplifier. In this way the voltage on the pin 2 side of C2 is re-established at the start of each line. C2 is fed from a low impedance source (the 75Ω termination) and is small enough in value to be relatively immune to changes in the input DC. The amplifier within IC2 has a very high input impedance so that the small value of C2 will not affect the low frequency response of the video signal. The negative input of this amplifier is brought out to pin 1, and this may be used to set the overall gain of the circuit. The net effect of the clamp circuit is to give a video signal where the most negative part of the sync signal is always set at 0V. (It is possible to make the bottom of sync sit at a different dc by changing the dc input at pin 3).

The clamped video is rectified by D1. This BAR28 is chosen to have as small a forward voltage drop as possible. The quoted figure is 410mV and as the video level at this point is about 2V peak-to-peak this gives a sync pulse of about 0.6V peak-to-peak which means that the upper bit of the sync pulse will be included. This in turn means that the measurement of the video signal will extend all the way down to black level. C13 smooths the rectified signal. Too large a value at this point will result in an average reading rather than a peak reading, and small areas of overexposure will not be indicated. TR2 is turned on by the BF signal which occurs just after the horizontal sync signal to discharge C13 so that it can commence to charge again from zero during the next line. Fig. 8 shows the time relationship between the two pulses. If this were not done, C13 would simply retain the maximum value reached at any point in the picture. IC8 is an analogue switch working as a sample and hold circuit. It is operated by the horizontal sync pulse which occurs just before the BF pulse used to discharge C13. It serves to pass the charge on C13 onto C14 where it is

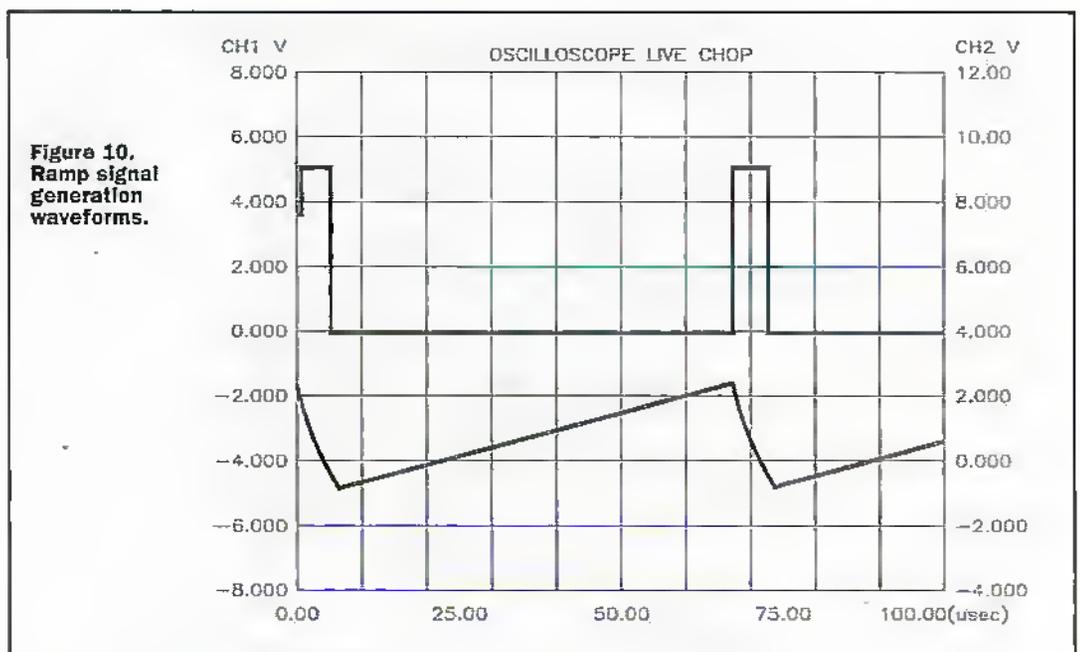


Figure 10. Ramp signal generation waveforms.

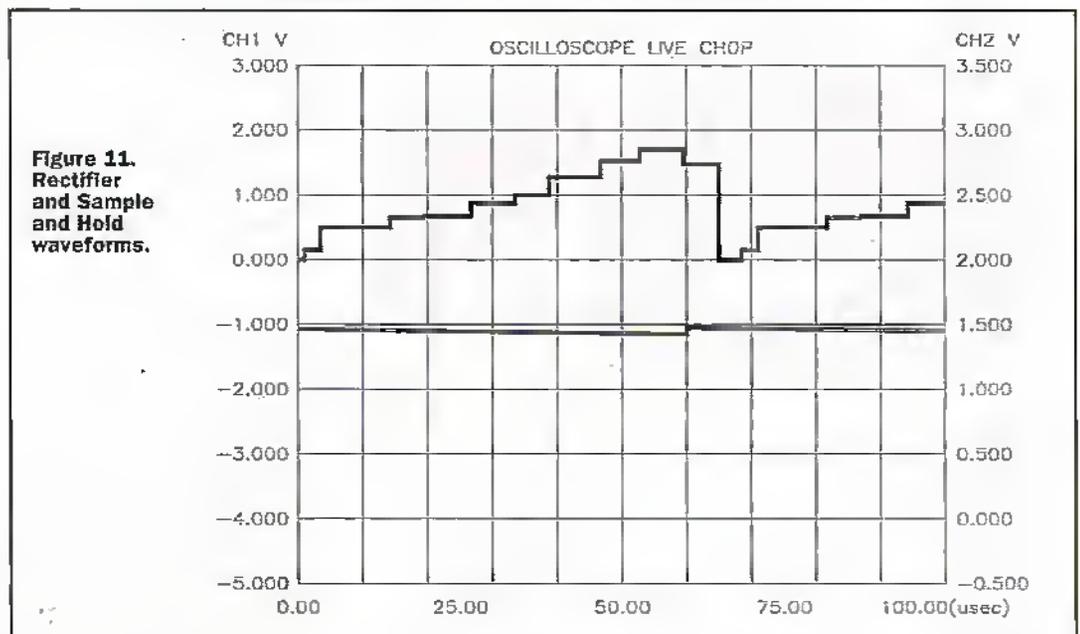


Figure 11. Rectifier and Sample and Hold waveforms.

held during the sync and blanking period. Figure 11 shows how part of the sync pulse is within the measuring range, and also that the output of the sample and hold circuit (the bottom trace) is a dc level corresponding to the whitest part of the staircase of the upper trace. The input signal at this point is colour bars which have a series of steps from black level to peak white as can be seen in Figure 11.

The dc level on C14 is amplified by IC5c the gain of which is selected such that the black to white display takes up about 1/4 of the screen width. R23 and R24 serve to set the DC offset of the signal at pin 14 of IC5c. This signal is input to the negative input of the comparator IC6c and, together with the ramp signal on the positive input, will generate a pulse whose rising edge indicates the relative level of the

video signal. The two other comparators, IC6a and IC6b, have dc on their negative inputs set by two potentiometers VR1 and VR2. These dc levels together with the ramp signal will generate two more pulses whose rising edges will indicate the black cursor and the white cursor. The fixed dc levels from the potentiometers means that the cursor bars will not move irrespective of the video level, but may be set to a preset position on the screen. There is no means of setting the span of the video indicating bar (i.e. how far to left and right the start and finish extends). Calibration is performed by moving the cursor bars to positions found to be black level and white level by applying a known video signal. Figures 12 and 13 show typical comparator outputs for the two cursors in relation to the ramp waveform.

The pulses from the comparator are too long to use directly. They extend from the point at which the comparator changes state to the end of the current TV line. This would give a very wide white block beginning at the black cursor bar and extending over the rest of the picture. In order to generate a thin bar the comparator pulses are differentiated by C9/R17, C10/R18, and C11/R19 respectively. R33, R34, and R35 are the pull up resistors required by the output circuitry of the comparator. Figure 14 shows a typical spike produced after differentiation. The three differentiated spikes are combined in IC7a, with the input clamp diodes of the CMOS circuit conveniently doing away with the negative going spikes from the falling edges of the comparator pulses - which are generated by the falling section of the ramp

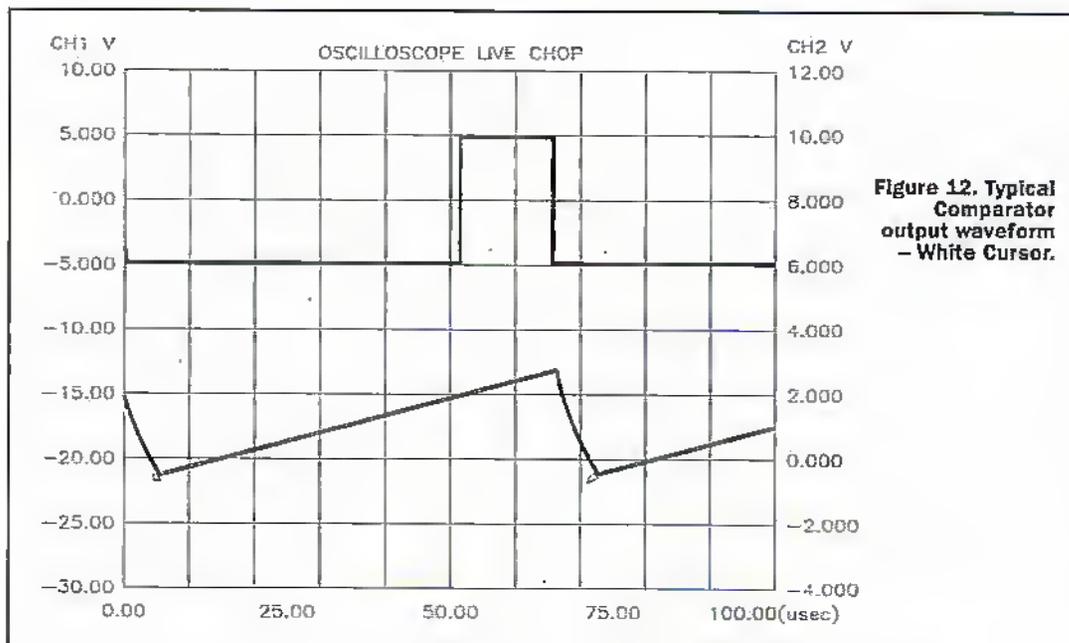


Figure 12. Typical Comparator output waveform - White Cursor.

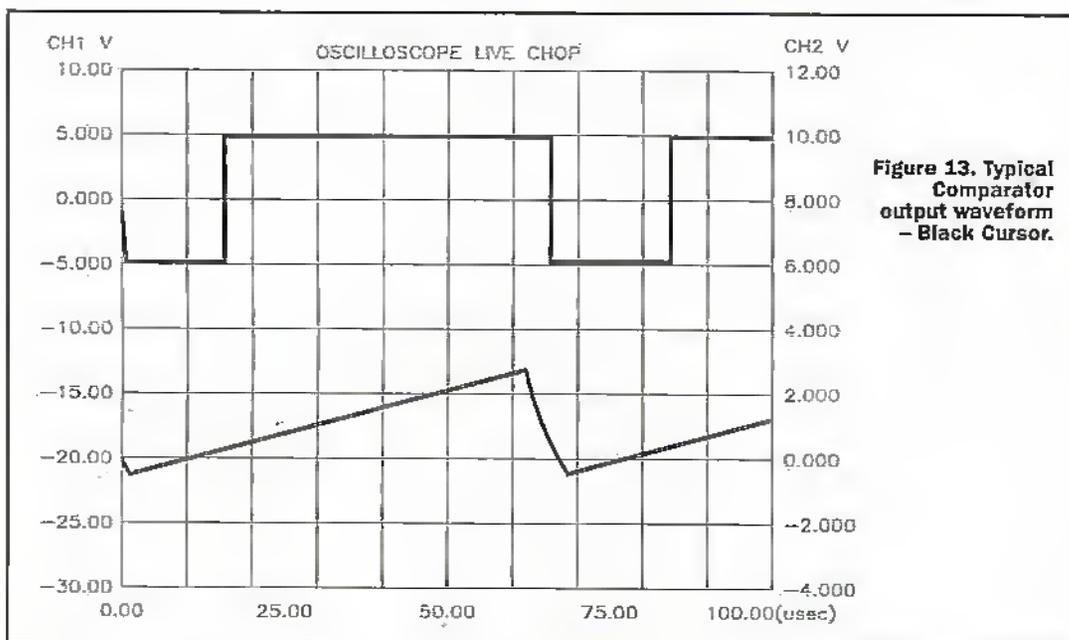


Figure 13. Typical Comparator output waveform - Black Cursor.

generator and occurs during the line sync interval. The output of IC7a is used directly to generate the white portion of the display bars, or fill signal. These narrow pulses are also integrated by R20/C12. The comparator action of IC7b gives sharp edges to the resulting stretched pulse, the values of R20 and C12 being chosen to give a stretched pulse of about twice the width of the pulse at the output of IC7a. This forms the basis of the key signal used to cut the hole in the video signal. To ensure that the start of the fill signal from IC7a is not lost, the output of IC7a is combined with the output of the stretched pulse from IC7b by IC7c. This will ensure that the hole cut in the video signal will start at the beginning of the white fill signal. This can be seen on the main Timing Diagram, Figure 5, see part 1.

At this point the pulses from

the comparator, and the stretching gates of IC7, will extend throughout the whole of the video signal, including the vertical blanking. Although this would not be displayed by the monitor, it could upset the timebase circuits and give picture rolling or other distortions. Accordingly, the vertical blanking signal generated by IC3 is used to gate off the key signal during the vertical blanking period. IC4c performs this function, its output being inverted by IC4d to make it the correct polarity to be used as the switching waveform for IC9. It is not necessary to gate off the fill signal as with no key signal no extra signals will appear in the picture display on the monitor.

IC9 is another analogue switch, but this time a double throw version. The switch from one input to the other is performed by the key signal.

This switch input requires logic level and the key signal is used directly. Of the two analogue inputs, input one is the clamped video signal from IC2, and the other is the white fill signal from IC7a. This fill signal is at logic level, 0V to 5V, and so requires attenuation and level shifting to make it compatible with the video signal it is to be combined with. IC5d has a gain of approximately a half as set by R29 and R28. R25, R26, and R27 level shift the resulting pulse such that the negative part of the pulse is at the same level as the black part of the video signal. The reduction in level by a gain of less than one sets the positive part of the pulse to be slightly above the whitest part of the video signal. An op-amp is used at this point as a high-to-low impedance convertor. If the attenuation were done by a simple two resistor divider either the values would be so

large as to affect the frequency response of the fill signal, making it smear horizontally, or so low as to load the output of IC7a excessively. The combination of both black and white in the bars means that the display should then be visible on just about any type of picture content. There are slight switching spikes visible on the final waveform but these will not affect the picture monitor.

To make the output from the unit compatible with normal video inputs and outputs IC10 is used as a video line driver to give a 75Ω drive at the output. This IC is capable of driving two back terminated 75Ω loads so provision is made on the PCB for another 75Ω output resistor, R32, which need not be fitted.

The power supply requirements are modest, $\pm 5V$ at about 40 to 50mA per rail. However, the use of dc level shifting in some of the stages, and particularly the black and white cursor line generators using VR1 and VR2, do require the power rails to be regulated. IC11 and IC12 are simple, 100mA series regulators to set the power rails to $\pm 5V$. The input voltage needs to be between $\pm 9V$ to $\pm 12V$, and the unit will work on two PP3 batteries. Due to the mixture of logic switching and analogue circuits plenty of power supply decoupling is needed, and this is the function of C17 to C25. C7 and C8 serve to keep any power supply rubbish off the preset inputs to the comparators from VR1 and VR2. Any power supply ripple at this point would make the fixed cursor lines fuzzy.

In use

The unit's video output should be more or less the same level as its input to within a few percent but as this should only be displayed on a monitor, and not recorded or used in other applications, this is not critical. Any video signal can be used at the input and its level displayed on a monitor, however, due to the nature of the sync separator used to extract timing information, signals with less than perfect sync pulses will cause a slight jitter in the displayed lines of the level display. Off-air signals (from the BBC etc.) and particularly signals from VHS tapes will show this effect, but signals from video cameras etc. and more professional off-tape pictures (Betacam, for example) should not.

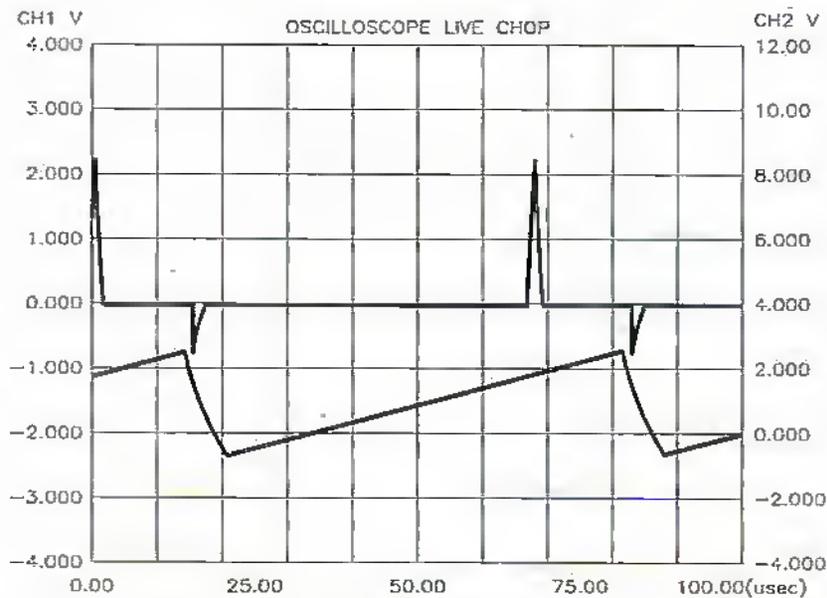


Figure 14. Typical Comparator output after differentiation.

Changing component values

Several of the components can be adjusted to 'customise' the display to an extent. VR1 and VR2 will allow the two cursor lines to be positioned more or less anywhere across the picture on the monitor. Changing the value of R12 will change the overall width of the display. Reducing the value of R12 will reduce the height of the ramp signal which will increase the width of the display components. The display could be reduced to less than half the screen width, for example. Bear in mind that as the display is made narrower, the resolution of video level will be reduced. Varying R13 or R14 will move the entire display across the screen to the left or right. If R12 is changed it is likely that R13 or R14 will also require changing. Beware of increasing the gain of IC5b too much, or adding too much offset by varying R13 or R14, as this may cause the Ramp

waveform to become clipped at either the positive or negative ends. This would give non linear measurement results. Increasing the value of R17, R18, and R19 will give thicker bars in the display. These need not be set to the same value. The cursor bars could be left thin and the video level bar made thicker for example. Changing the value of R20 will change the ratio of white and black in the display bars. The black part can be made thicker or thinner as required. This will not affect the thickness of the white part of the bars. Changing the components around IC5c will have much the same effect as changing the components around IC5b, except that now only the video level bar will be affected. Reducing the gain at this point will change the width of the video level bar between the cursors but will also reduce the level resolution. Increasing or decreasing the value of R29 will change the gain of IC5d which will change the video level of the white part of the

display. It could be made 'whiter than white' or reduced to some value to give grey. R25 would also require tweaking to maintain the black part of the display at black level. Beware of setting the white bars to too high a level, as this will give problems in the video line driver, IC10, and also possibly in the monitor picture. Finally, slight changes in R30 will allow setting the output level to exactly match the input level if this is thought necessary. To increase the output level beyond the 1V peak-to-peak value, a resistor can be added between IC10 pin 2 and ground. However, as the power rails are only $\pm 5V$ IC10 will soon clip the output waveform if the gain is increased too far.

Calibration

The ideal way to calibrate the unit is to use a video signal whose exact level is known. Colour Bars or a greyscale test signal are to be preferred - preferably calibrated with a standard oscilloscope or

waveform monitor. (Fig.15) Calibration consists of inputting a sync signal with no video information (a black signal) and setting the black cursor bar with VR2 to coincide with the video level bar. These should both be near the left side of the picture. Change the input to a known video test signal calibrated as above and set VR1, which controls the white cursor bar, to coincide with the video level bar which should now be near the right side of the picture.

Without a verifiable test signal calibration is a little more difficult. The best way to proceed in this case is with a video camera. Connect the unit to the video from the camera. Check the camera produces a picture through the unit and then apply the lens cap. This must be a light-proof type and not a translucent type used for white balance in some cameras. This should give a fairly accurate black signal. Use VR2 to make the black cursor bar and the video level bar coincide as above. Setting the white level is somewhat more difficult. Set the camera to shoot an exterior picture which includes a fair amount of sky. Choose a day with fairly broken clouds. Open the camera iris until the clouds disappear and the sky becomes a uniform white colour. Now close the iris again until the clouds reappear. At this point the exposure is more or less correct and, providing the camera gives a standard 1V peak to peak signal, the white part of the sky should be at peak white. Set the white cursor bar with VR1 to coincide with the highest indication of the video level bar. In Fig. 16 the side of the house is in sunlight and is actually at a higher video level than the sky. Details of the pattern in the rendering can just be seen on the screen so the white cursor bar can be set to coincide with this part of the display.



Figure 15. Colour Bars with superimposed display



Figure 16. Typical exterior with superimposed display.

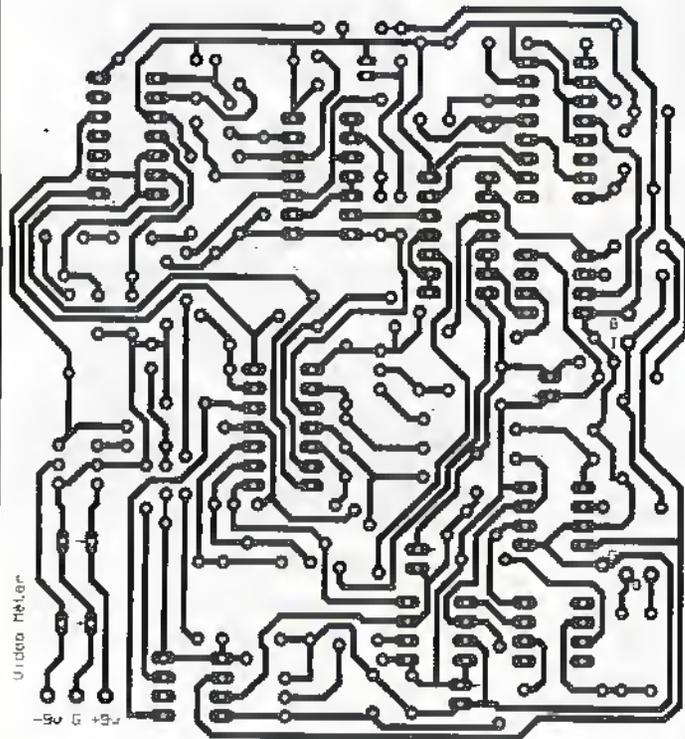


Figure 17. PCB track layout.

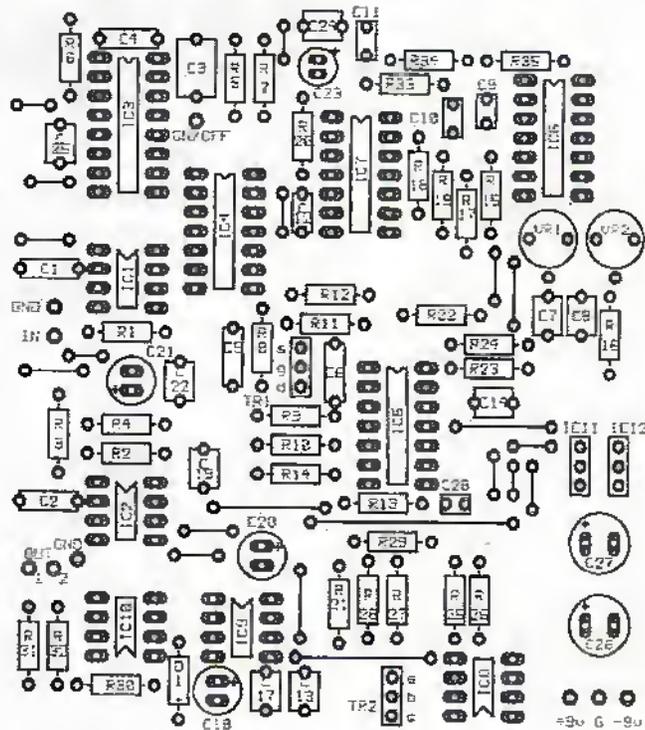


Figure 18. PCB Component overlay.

Construction Notes

Figure 17 shows a suggested PCB layout together with Figure 18, which is a component overlay. There should be no problems with construction either with the suggested PCB layout or with another design. It is even possible to build the circuit on Veroboard, if desired. The main problem to watch out for concerns the input to IC2, the clamp circuit, and the input and output of the sample-and-hold circuit, IC8. Both these points are fairly high impedance parts of the circuit, and PCB tracks, or Veroboard strips,

should be as short as possible to avoid pickup of external signals or crosstalk from other parts of the board. Both these problems would give rise to measurement errors.

If you use the suggested board layout take care to insert the ICs the correct way up as ICs 8 and 10 are up-side-down in relation to the other ICs. I know this gives me a problem as I tend to design board layouts with the ICs all the same way round, and then insert the components on autopilot. In this case the board layout required these two ICs to stand

on their heads. The prototype board has the ICs soldered in but it makes rather more sense to use IC sockets, if possible.

The power supply requirements are quite modest. With $\pm 9V$ the unit should draw about 40 to 50mA maximum from each rail. Two Alkaline PP3 batteries will power it for a little while, but switch-off when not in use. A multi-pole switch could be used to bypass the video signal when the unit is not powered in order that the picture can still be seen on the monitor. The two series regulators are rated at 100mA

each which is more than adequate, but beware of applying too high a power supply voltage as it is possible to exceed the power rating of the regulator, while still only drawing the 40 or 50mA or so required by the circuit. Any on/off indicators or other lamps or LEDs are best connected to the unregulated power rails.

Acknowledgments

Thanks should go to Hamlet Video International for their kind permission to use the pictures of their Micro Scope and its display.

PROJECT PARTS LIST

RESISTORS

R1	680K Min Res
R2,4	330R Min Res
R3,31,32	75R Min Res
R5	120K Min Res
R6	82K Min Res
R7,24	10K Min Res
R8	1M Min Res
R9	470R Min Res
R10,25	33K Min Res
R11	6K8 Min Res
R12	12K Min Res
R13,22,29	2K7 Min Res
R14	3K9 Min Res
R15,17-20, 33-35	1K Min Res
R16,26,28	4K7 Min Res
R21	22K Min Res
VR1,2	10K Cermet Preset

MAPLIN ORDER CODE

M680K
M330R
M75R
M120K
M82K
M10K
M1M
M470R
M33K
M6K8
M12K
M2K7
M3K9
M1K
M4K7
M22K
WR42V

CAPACITORS

C1,5	100nF Poly Layer
C2	10nF Poly Layer
C3	470nF Poly Layer

C4	47nF Poly Layer
C6	4n7 Poly Layer
C7,8,15-17,19, 22,24,25	100nF Ceramic
C9-11,28	150pf Ceramic
C12	33pF Ceramic
C13,14	1nF Poly Layer
C18,20, 21,23	10uF 16V Radial
C26,27	100uF 16V Radial

SEMICONDUCTORS

D1	BAR 28	Q013P
TR1	BF244A	QF16S
TR2	BC549	Q015R
IC1	EL4581CN	AJ52S
IC2	EL4089CN	AJ59P
IC3	HCF4528BEV/HCF4098BEY	QX29G
IC4	HCF4011BEY	QX05F
IC5	LF347	NP84F
IC6	LM339	UH31J
IC7	HCF4075BEY	QW45Y
IC8	DG417	AX45Y
IC9	DG419	AX47B
IC10	EL2020CN	UR06G
IC11	LM78L05ACZ	QL26D
IC12	LM79L05ACZ	WQ85G

Diary Dates

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

May 1998

- 5 May.** Multichip Modules and RF ICs IEE Conference, London. Tel: (0171) 240 1871.
- 6 May.** Cellular Manufacture & New Product Introduction, IEE Technical Visit, Mayhem Instruments, Worcestershire. Tel: (0171) 240 1871.
- 6 to 7 May.** Data Warehouse Storage & Performance, The Commonwealth Institute, Kensington, London. Tel: (01908) 373311.
- 12 May.** PLD/FPGA Day, Exhibition and conference, Ascot. Tel: (0181) 316 3297.
- 12 to 13 May.** Battery Conference and Exhibition, Solihull. Tel: (01372) 367000.
- 12 to 13 May.** Digital Mapping Show, Novotel, London. Tel: (01853) 652661.
- 12 to 14 May.** Internet World International, Olympia, London. Tel: (01865) 388000.
- 12 to 14 May.** Digital Interactive Marketing, NEC, Birmingham. Tel: (0171) 357 6161.
- 13 May.** Electric Cars Colloquium, Austin Court, IEE Midlands Engineering Centre. Tel: (0171) 240 1871.
- 13 to 14 May.** Embedded System Show, London. Tel: (0171) 681 1000.
- 14 May.** Technology Investor Conference, London. Tel: (0171) 256 5364.
- 18 to 19 May.** Television Distribution Conference, London. Tel: (0171) 637 4383.
- 18 to 20 May.** Cable & Satellite Conference, London. Tel: (0181) 910 7717.
- 19 May.** IEE Broadband Digital Radio Conference, Birmingham. Tel: (0171) 240 1871.
- 19 to 20 May.** Printed Circuit Interconnection Federation Conference, Chalfont. Tel: (0171) 515 1166.
- 20 to 21 May.** Communications in Public Safety, GAFEX Centre, Manchester. Tel: (01322) 660070.
- 21 May.** Mobile Communications and RF Workshop, London. Tel: (0181) 316 3174.

June 1998

- 1 to 2 June.** Electronics: The Next 30 Years, Warwick. Tel: (0171) 267 4898.
- 2 to 4 June.** Environmental Technology Exhibition, Birmingham. Tel: (0181) 910 7910.
- 3 to 4 June.** Electronics Forum Exhibition, Manchester. Tel: (01799) 528292.
- 3 to 4 June.** Instrumentation South West 98 Exhibition, Bristol. Tel: (01822) 614671.
- 4 to 5 June.** Online Help Conference Europe 98, Olympia, London. Tel: (01844) 214690.
- 10 to 11 June.** VAC & SEMI 98 Exhibition, Scotland. Tel: (01822) 614671.
- 16 to 17 June.** European Conference on Vehicle Electronic Systems, Coventry. Tel: (01372) 367000.
- 17 to 19 June.** Government Computing Show, The Royal Horticultural Hall, London. Tel: (0171) 587 1551.
- 17 to 18 June.** Business Intelligence, Olympia, London. Tel: (0181) 879 3300.
- 23 to 25 June.** Networks Telecom Exhibition and Conference, Birmingham. Tel: (0181) 742 2828.

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

What's On?

European Commission Launches 1998 European IT Prize

The European Commission has announced the launch of the 1998 European IT Prize – a £460,000 award scheme designed to encourage IT innovation

across Europe. The programme is run by the Commission in conjunction with Euro-CASE – the European Council of Applied Sciences and Engineering.

Now in its fourth year, the prize aims to raise the profile of Europe in Information Technology, a marketplace often dominated by the North American and Asia-Pacific regions.

The European IT Prize will be awarded to companies who have the most novel products with a high IT content and evident market potential. The product must be a demonstrable prototype and, if already marketed, it should have been introduced into the market after 1st June, 1996.

Up to three grand prizes of almost £130,000 each will be awarded to the overall winners and a further 25 runners-up prizes of £3,300 will also be awarded.

One such innovative product was the ModelMaker from UK based company 3D Scanners which was a Grand Prizewinner in 1996. The ModelMaker product was the first handheld device that can accurately and quickly scan physical objects to make colour 3D computer models.

The closing date for applications is 28 April 1998, by mail to the European IT Prize/Euro-CASE office, 28, Rue Saint Dominique, 75007 Paris. Alternatively, all information is available on the Web at www.it-prize.org.

Swatch Talk Is the Talk of the Trendwatchers at CeBIT

The first Swatch with an integrated telephone, introduced at the CeBit telecommunications show in Germany this month, was awarded the 'Best of Show Award' by Byte Magazine.

"Swatch Talk continues the tradition at Swatch of cutting edge technology with dynamic, fun design," said Nicolas Hayek, CEO of Swatch. "Now, the next time my watch tells me it is time to call someone, I

need look no further. A flick of the wrist and I'm connected with two vital accessories – a Swatch and a telephone – rolled into one."

Swatch Talk is the latest addition to a history of continuous innovation. In 1991, Swatch introduced Swatch the Beep, the first pager in a watch. It was followed in 1997 by Swatch the Beep Midi, the world's smallest pager integrated into a Swatch. For further information, check: www.swatch.com.

Intel Demonstrates Technology to Power a Billion PCs

Intel senior vice president Dr. Albert Yu demonstrated processor technologies that will power a future in which the world is connected by over a billion Intel architecture PCs and more than a hundred million servers at CeBIT, last month in Hanover, Germany.

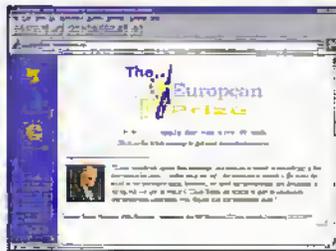
"One billion connected PCs will lead to a new world of innovation, driving the development of applications ranging from visual electronic business solutions for corporate users, to new forms of entertainment and communications for consumers," said Dr. Yu.

In his speech, Dr. Yu presented the evolution and future of the Intel microprocessor and platform in several technology demonstrations targeting business and consumer applications. Dr. Yu demonstrated one of the fastest Intel processors ever shown which, when introduced, will power desktop PCs and volume servers and workstations. This processor, based on the P6 micro architecture, contains the design headroom to achieve more powerful systems in the future.

For the first time in Europe, Dr. Yu showed a simulation of Intel's IA-64 technology, which will be used in Intel's forthcoming Merced processor, scheduled for production on Intel 0.18-micron process technology in 1999. Dr. Yu demonstrated how IA-64 processor technology uses a new design philosophy called Explicitly Parallel Instruction Computing (EPIC) that overcomes the performance limits of traditional processor architectures, while maintaining full compatibility with software that runs on Intel's 32-bit processors.

Dr. Yu also demonstrated the Intel Celeron processor for the basic PC market segment, scheduled for introduction in April 1998.

The Celeron processor will bring the superior floating point and multimedia performance of the P6 micro architecture to low-cost Basic PCs. Intel, the world's largest chip maker, is also a leading manufacturer of PC, networking and communications products. For further information, check: www.intel.com.





Maplin Appoints Retail Operations Director

Maplin has appointed Graham Caldwell as retail operations director, taking overall responsibility for the company's 48 high street outlets and three superstores.

Mr Caldwell (39) brings to Maplin extensive senior level retail experience. His career spans management positions at Office 1, The Business Superstore, Texas Homecare, The Reject Shop and Safeway Foodstores.

The role of retail operations director is a new one, and has been created following Maplin's substantial investment in its retail portfolio. Of the company's 51 retail outlets, 23 are either new or have been refitted in the last two years, reflecting the company's focus on the growth opportunities offered by its retail arm.

"Maplin's range and wide appeal means that it occupies a unique place in high street and out-of-town retail," said Mr Caldwell. "My brief is to capitalise on the many opportunities available to us, and one of my first steps will be to oversee a recruitment and development programme which targets, attracts and retains top performers at store management level and below."

Maple @ Maplin

Maplin has signed an agreement with Maple Computers which will see the development of Maple showrooms throughout the chain's high street stores. As part of a forward looking partnership, the two companies have joined forces in a bid to make buying computer technology even easier for the consumer: Maplin sales staff will be fully trained in using the equipment, which means that customers will have the advantage of trying out hardware and multimedia products before they buy.

The introduction of the 'Maple @ Maplin' initiative coincides with the launch of Maplin's mail order catalogue on CD-ROM format. Showroom installations will be completed by September, so in order to ensure that customers get the chance to 'play' with the new catalogue, Maple computers have been specially set up for demonstration in all the Maplin stores.

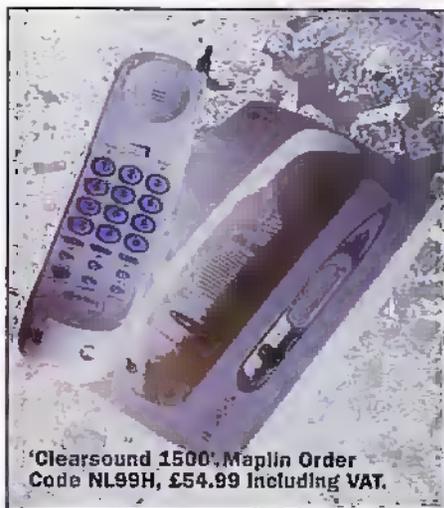
Maple, part of Canada's largest privately owned PC manufacturer, is one of the UK's fastest growing PC integrators.

MAPLIN NEWS

Cordless Clarity At Maplin

Recently approved for use in the UK by the DTI's Radio Communications Agency, the eight new channels allocated between 31MHz to 39MHz for cordless phones have been proved to make a marked difference to line clarity, according to tests carried out in Ireland, Holland and Spain.

Purchasers of new cordless phones from



'Clearsound 1500', Maplin Order Code NL99H, £54.99 including VAT.

Maplin will benefit significantly from clearer communication. The latest range has models which retail from prices under £50, all of which offer high specifications which conform to the new frequencies.

In the past, a cordless phone was virtually unusable outside a 40m range. Users can now move up to 75m away from the source and still have an extremely clear line, with barely audible interference. In fact, the signal is so good that at 40m the connection is as clear as that of an actual land line.

Other sources of potential interference around the home are fluorescent lighting and refrigerators. However, with the new frequencies, these household hazards no longer pose a problem, making directional interference a thing of the past.

PCs Get Extended Life At Maplin

An estimated 80,000,000 PCs Europe-wide are at risk from the year 2000 problem. Given that solutions need to be considered sooner rather than later, then the latest piece of software from Maplin - 'Prove It 2000' - maybe the answer (order code EW02C, price £34.99 including VAT).



A recent independent survey rated the 2000 test product number one out of 16 tested. It is suitable for use on all IBM compatible PC hardware, comprising a single diskette which runs from the floppy disk drive. This ensures that it does not interfere with the operating system or hard drive applications.

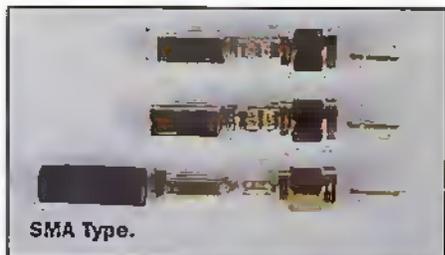
The user is guided through eight simple tests which include checking the real time clock, the BIOS and the operating system, as well as leap year and non-leap year compliance. Additionally, a hardware report gives a clear indication of pass or fail, with full explanation of each test. In many cases, the BIOS problem will be automatically fixed.

The disk also contains a help file with additional telephone and web site addresses. Technical support and advice is supplied by Softbank Services Group.

SMA and SMB Sub Miniature Coaxial Connectors

Two new ranges of 50Ω miniature RF coaxial connectors have been recently introduced by Maplin.

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SMA Type.



SMB Type.

The use of brass bodies and PTFE insulators make these connectors more cost-effective than their stainless steel counterparts. The SMA range is nickel plated and used at frequencies up to 12.4GHz, while the SMB series is gold-plated and operates up to 4GHz. Both products have minimum ratings of 500 cycles and utilise gold-plated pins and contacts, and are available in cable fixing, panel mounting and PCB mounting varieties.

A selection of pre-terminated and fully tested coaxial assemblies are also available, including a range of SMA microwave assemblies that are supplied with an individual performance plot and can operate up to 18GHz.

For more information, store locations and mail order details, telephone 01702 554002.

Security

ELECTRONIC SYSTEMS & CIRCUITS

PART 9

Ray Marston looks at a miscellaneous collection of security circuits in this penultimate episode of the series.

Most of the previous episodes of this series have each looked at a specific class or type of electronic security circuit. This month's episode looks at a miscellaneous collection of security circuits that can be used in the home, in commerce or industry, but which do not fit into any of the specific classes of circuit described in earlier chapters. These circuits include ones that are activated by the presence of a liquid, steam, or gas, by sound, by the failure of ac power supplies, by the close or near proximity of a person or object, by a human touch, or by the breaking of an ultrasonic beam.

Liquid- and Steam-Activated Circuits

Basic Principles and Circuits

Liquid- and steam-activated circuits have several practical applications in the home and in industry. Liquid-activated circuits can be made to sound an alarm or activate a safety mechanism when the water in a bath, a cistern or the liquid in a tank or vat reaches, or exceeds, (or falls below) a preset level, or when flooding occurs in a cellar or basement, or when an impact wave is generated as a person or object falls into a swimming pool or tank, etc. Steam-activated circuits can be made to sound an alarm or activate a safety mechanism when high-

pressure steam escapes from a valve or fractured pipe, or when steam emerges from the spout of a kettle or container as the liquid reaches its boiling point.

Impure water (including tap water, sea water, and most rain water and steam) and many other liquids have a fairly low electrical resistance, but normal air has an ultra-high electrical resistance. Consequently, one of the simplest electronic ways of detecting the presence or absence of conductive liquids (or vapours) is to use a pair of metal probes as sensors, and to connect their outputs to a resistance-activated 'switch' circuit in the basic way shown in Figure 1.

Here, when the liquid is in contact with both probes simultaneously the probe-to-probe resistance is relatively low, and under this condition the output voltage of the resistance-activated switch is also low. But when the liquid is not in contact with both probes at the same time their probe-to-probe resistance is very high, and under this condition the output voltage of the switch is high. The circuit's output can thus be used to activate an alarm or other device when the liquid (or vapour) is present or absent, or is above or below a preset level.

In practice, the resistance appearing across the probes depends on the type of medium that is being detected.

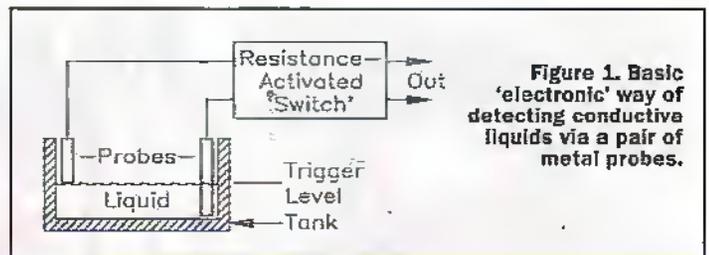


Figure 1. Basic 'electronic' way of detecting conductive liquids via a pair of metal probes.

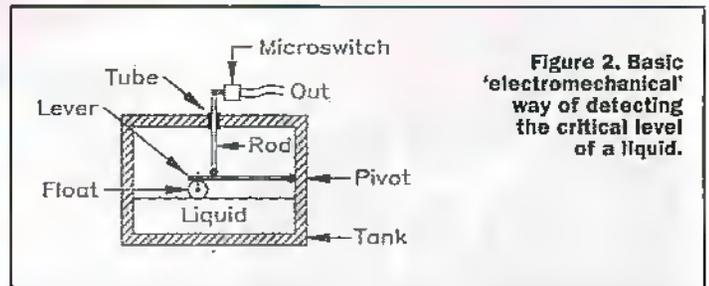


Figure 2. Basic 'electromechanical' way of detecting the critical level of a liquid.

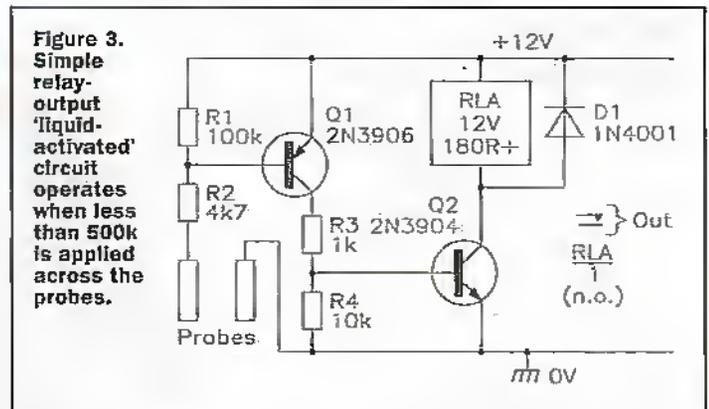


Figure 3. Simple relay-output 'liquid-activated' circuit operates when less than 500k is applied across the probes.

In the case of rain or tap water it may typically be in the range 1k Ω to 10k Ω when the probes are 10mm apart, but in the case of steam or many oils the resistance may be several megohms or greater. On some applications, the metal container or tank that holds the conductive liquid can act as one of the two metal 'contact' probes.

Note that the above liquid-detection technique is not suitable for use with highly volatile, corrosive, or highly-resistive liquids. In such cases, the presence/absence of the liquid may best be detected by using an electromechanical method, such as that shown in Figure 2. Here, the liquid is contained in a sealed tank, and its level is sensed by a float that is anchored to a pivoted lever that drives a rod that passes out of the top of the tank via a close-fitting tube. The rod thus rises and falls in sympathy with the liquid level, and activates an external microswitch when the level goes above or below some preset limit.

Figure 3 shows a practical example of a simple non-latching liquid-activated circuit that operate a relay when a liquid with a resistance of less than about 500k Ω contacts both probes simultaneously, e.g.,

when the water in a bath or cistern reaches a certain level. The circuit uses a 12V supply, and the relay's RLA contacts can be used to activate any type of external electrical device. When the probes are open-circuit, Q1 and Q2 are cut off and the circuit consumes a standby current of less than 1mA, but when a resistance of less than about 500k Ω is applied across the probes sufficient current flows in Q1's base to drive Q1-Q2 and the relay on.

Note that the sensitivity of the Figure 3 circuit can be reduced by simply reducing the value of R1; the maximum resistive sensitivity is roughly 18 x R1, and falls below 180k Ω when R1 has a value of 10k Ω , and below 60k Ω at an R1 value of 3k3 Ω . Conversely, the sensitivity can be greatly increased by raising the R1 value and using a super-alpha-connected pair of transistors in place of Q1. Figure 4 shows how the above circuit can be modified in this way, so that it can be activated by probe resistances of up to 20M Ω , e.g., by steam or high-resistance liquids.

LM1830 IC Circuits

When in use, liquid-level detector circuits of the simple types shown

in Figures 3 and 4 pass a small dc current through the liquid under test. In theory, this dc current can result in an electroplating action in which metal slowly migrates from one probe to the other, eventually degrading the 'source' probe. This problem does not occur if an ac test current is used, and a dedicated 'fluid-level detector' IC that uses this technique is widely available, at modest cost. Such a device as manufactured by National Semiconductor and is known as the LM1830 - Figure 5 shows the outline and simplified internal circuit of the IC.

The LM1830 can be used to detect and indicate the presence or absence of water or any other liquid that presents a resistance of less than 100kΩ between its pin-10 (detector input) and pin-11 (GND) 'probe' points. The IC houses an oscillator (which gives ac drive to the water-detecting metal probe), a 13kΩ reference resistor, a balance detector, and (available on pin-12) an open-collector npn common-emitter output stage that can sink up to 20mA maximum. The oscillator frequency is set via an external capacitor (1nF gives 7kHz operation) wired between pins 1 and 7, and the IC can operate from supplies in the 9V to 25V range and consumes a typical standby current of 5.5mA.

Figure 6 shows the LM1830 IC's basic application circuits as a low-liquid-level alarm with an LED output. The (a) circuit uses two separate probes, one of which is grounded, but in the (b) circuit - in which the liquid is stored in a metal tank - the metal storage tank is grounded and acts as one of the circuit's two 'probes'. The IC's internal oscillator is set at 7kHz via C1, and the non-grounded metal probe is taken to the pin-10 'detector' input and is ac driven via C2 and the internal 13kΩ reference resistor. When the liquid level is 'high' (i.e., in contact with the probe) the probe-to-ground resistance is below the 13kΩ reference value, and under this condition the output LED is off. When the liquid level is low the probe-to-ground resistance is high (greater than the 13kΩ reference value), and under this condition the output LED is driven by a 7kHz squarewave signal and thus illuminates.

The basic Figure 6 circuit can be usefully modified in a variety of ways, as shown in Figures 7 to 10. Figure 7 shows it modified to give an audible 700Hz tone output (set by C1) into an

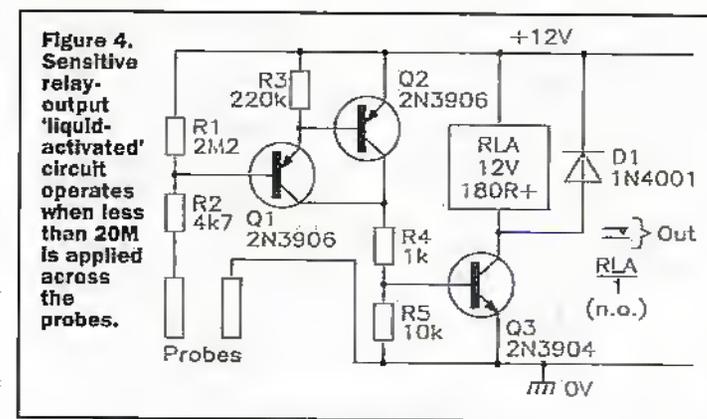


Figure 4. Sensitive relay-output 'liquid-activated' circuit operates when less than 20M is applied across the probes.

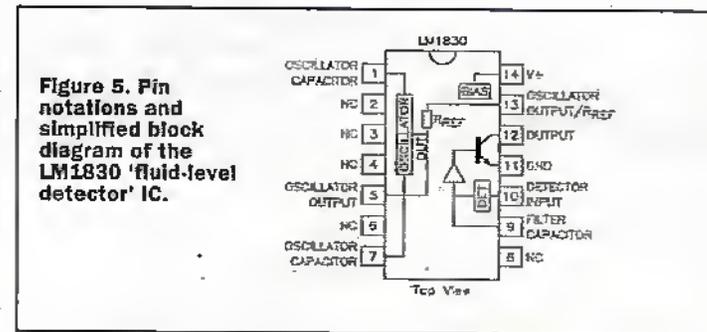


Figure 5. Pin notations and simplified block diagram of the LM1830 'fluid-level detector' IC.

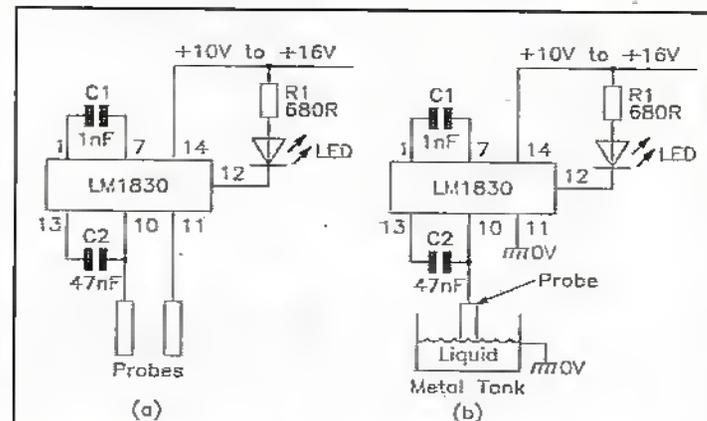


Figure 6. Basic LM1830 low-fluid-level warning circuit with LED output, using (a) separate probes and (b) a single probe.

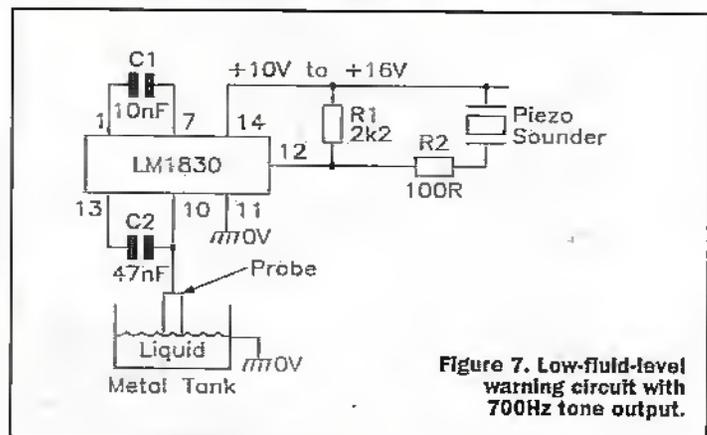


Figure 7. Low-fluid-level warning circuit with 700Hz tone output.

inexpensive piezo sounder.

The LM1830 IC has a mean output current limit of 20mA maximum, and Figure 8 shows how the available output power can be boosted via an external emitter-follower stage. The IC can be used with an external (rather than the internal) reference resistor of up to 100kΩ maximum (1kΩ minimum), to

enable it to test liquids with resistance values of up to 100kΩ.

Figure 9 shows the circuit modified to give relay output drive via pnp emitter-follower Q1, by using C3 to convert the output-stage-driving signal to dc. This circuit also shows supply-line transient protection given to the IC via R1; this modification is recommended

for use in automobile circuits, where - under very exceptional circumstances - supply transients may reach peak values of 40V to 50V.

Finally, Figure 10 shows the relay-driving circuit modified to give an over-level warning action (in which the relay is off when the liquid level is low) by using npn common-emitter amplifier Q1 as the relay driver.

A Gas-Activated Alarm Circuit

Leaking highly-flammable gases such as iso-butane, methane (natural or 'town' gas), hydrogen, and ethanol, etc., all present potentially explosive and life-threatening hazards. Fortunately, they can easily be detected - even in gas-to-air concentrations of less than 0.5% - by a simple, and easy-to-use device, that is readily available from major component suppliers and is known as a 'hot-wire' gas sensor. The heart of this sensor is a coil of fine-platinum wire that is coated with high temperature oxides and a special catalysis.

A hot-wire gas sensor actually consists of a pair of thermally matched hot-wire elements, one of which is gas-sensitive and is known as the 'detector', and the other of which is not gas-sensitive and is known as the 'compensator'. In some cases, the matched detector and compensator are supplied as individual units, which are each enclosed within an individual fire- and explosion-proof wire mesh, and in others they are combined in a single unit and share a common fire/explosion-proof mesh. In either case, they are meant to be used in the basic circuit shown in Figure 11.

In Figure 11 the compensator (R1) and detector (R2) are wired in series to form a gas-sensitive potential-divider on one side of a Wheatstone bridge, R3-RV1-R4 form an adjustable potential divider on the other side of the bridge, and RV1 is adjusted so that V_{out} is normally zero. The compensator and detector have a low hot-wire resistance, and when wired as shown, and powered from a suitable voltage source (typically 2.2V or 3V ac or dc), pass a current (typically 150mA to 400mA) that raises the hot-wire temperature to about 350°C in gas-free air.

The resistances of the detector and compensator both vary with ambient temperature and humidity levels, etc., but

are matched so that they vary equally in both devices, so that (when wired as shown in Figure 11) they maintain a constant division ratio in the absence of

out its voltage and current ratings. With that current rating in mind, select a suitable 12V dc power supply. Now – without wiring the gas sensor in place –

place, power the circuit up, and trim RV2 so that the alarm/siren is off. Let the unit warm up for a minute or two, then – using a high-impedance digital multimeter – trim RV2 so that pin-2 of IC2 is 25mV above that of pin-3. The unit is now set and ready for use, and should activate the alarm if the sensor is temporarily placed in a box and exposed to a modest concentration of gas (such as a brief squirt of butane gas) for half a minute or so. Note that most flammable gases are heavier than air, and that in normal domestic situations the gas sensor should thus be mounted a few inches above floor level, in a position where it is unlikely to be damaged by

passing feet or by the movement of furniture, etc.

A Sound-Activated Switch Circuit

Prior to the advent of modern highly-reliable PIR movement detectors, sound-activated alarms were widely used in commercial security systems. Most of these alarms were easily false-triggered by the natural sounds that occur inside buildings (such as the cracks or groans that occur as a building cools at night or warms up in the morning), or sounds originate outside the buildings but are audible within them (such as loud traffic, aircraft noise or thunder). In some systems, the latter problem was overcome by using internal and external sound detectors and – by using sound-level comparison techniques – only activating the alarm if the internal sounds were louder than the external ones.

Today, sound-activated alarms are rarely used in security systems, but sound-activated switches are widely used. They are used mainly as relay-driving 'precautionary warning' devices that switch on a security light and/or a pre-recorded 'verbal warning' message, or activate a sound- or video-recorder system whenever a suspicious sound is heard in a protected area. In most of these sound-activated switches, the sounds are picked up via a cushion-mounted electret microphone insert (which thus responds mainly to air-conducted – rather than structure-conducted – sounds) and the resulting signals are then amplified, converted to dc via a rectifier and filter, and then fed to a non-latching relay-driver via a special signal-conditioning circuit.

Figure 13 shows a practical relay-driving sound-activated switch circuit that is powered from a 12V dc supply. Here, the cushion-mounted electret microphone insert is powered from a stable 4.7V supply derived from the +12V line via

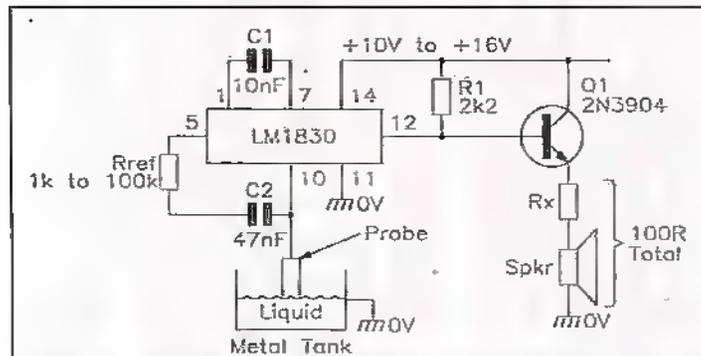


Figure 8. Low-fluid-level warning circuit with external reference resistor and boosted audio output.

gas. When gas is present, the detector's special catalysis effectively, but safely, burns the gas that strays within the safety mesh and which surrounds the hot-wire, thus raising the hot-wire's temperature and resistance, thereby reducing the voltage appearing on the detector/compensator junction and upsetting the balance of the bridge. This action typically makes the circuit's V_{out} value fall by about 25mV at gas concentrations of 4000ppm (= 0.4%) with methane, or 2000ppm (= 0.2%) with isobutane.

Figure 12 shows the circuit of a practical gas alarm that is powered via an external 12V dc supply and which drives a ready-built, solid-state commercial alarm/siren unit under the 'alarm' condition. Here, the basic gas detector (which is similar to that of the Figure 11 circuit) is built around R2-RV2-R3-R4-R5 and is powered via a stable low-voltage dc supply derived from the 12V line via voltage regulator IC1, and has its output fed to the alarm/siren unit via voltage comparator IC2 and transistor switch Q1. The circuit's action is such that the voltage on pin-2 of IC2 is normally about 25mV above that of pin-3 (settable via RV2) under 'clean air' conditions. Under this condition, IC2's output is low and Q1 and the alarm/siren are off, but the pin-2 voltage falls below that of pin-3 when significant gas concentrations are detected, and under this condition IC2's output switches high and drives Q1 and the alarm/siren on.

Before starting to build the Figure 12 circuit, first locate a suitable hot-wire gas sensor (order code FM87U) and find

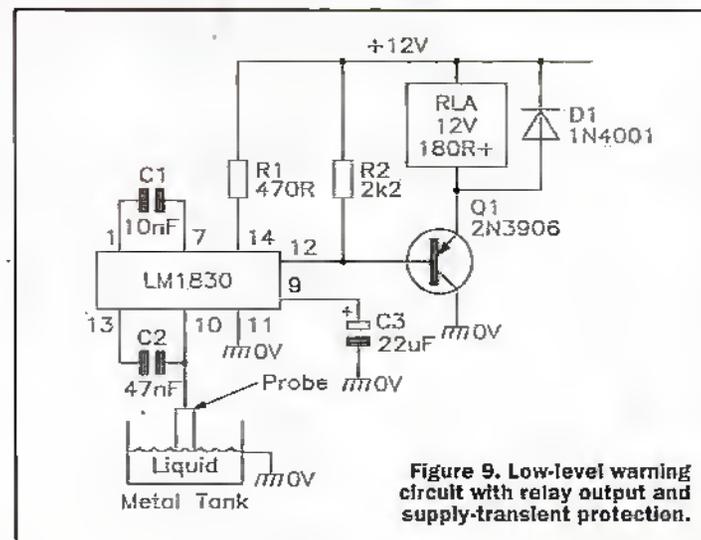


Figure 9. Low-level warning circuit with relay output and supply-transient protection.

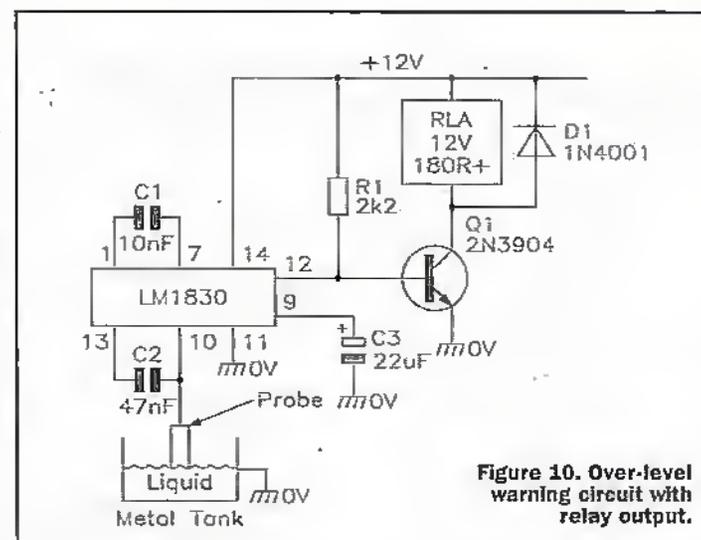
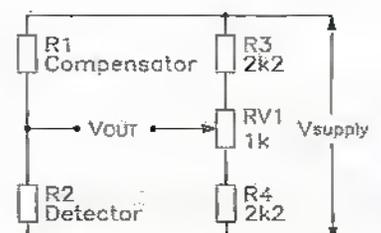


Figure 10. Over-level warning circuit with relay output.

build the IC1 voltage regulator section of the circuit, taking care to fit IC1 to a heat sink that will dissipate 1W per 100mA of working load current, and then power it up and trim RV1 so that (when powering a dummy load) it produces the precise specified working voltage of the gas sensor (usually 2.2V or 3V).

Now build the rest of the circuit, fit the gas sensor in

Figure 11. Basic gas detector circuit using 'hot-wire' gas sensors.



Zener diode ZD1, and has its output amplified by common-emitter amplifier Q1 and then passed on to the pin-3 input of the 3140 op-amp via C3-R5. The 3140 op-amp can respond to input signals all the way down to zero volts, and in this circuit is used in the open-loop voltage comparator mode and acts as a super-efficient high-gain signal rectifier that has its 'threshold' level (and thus the circuit's sensitivity) fully variable from zero to +200mV via RV1. The diodes D1-D2 act as clamps that limit the pin-3 peak-to-peak signal amplitudes to safe values, and must be germanium or Schottky (rather than silicon) signal diodes.

In Figure 13, D3-R8-C4-R9 and R10 act as the unit's special relay-driving signal-conditioning circuitry. Here, D3 and C4 peak-detect the pin-6 output voltage of the 3140 op-amp, and C4's resulting charge provides base drive to relay-driving common-emitter amplifier Q2. Note that C4's 'charge' time (which protects the circuit against activation by brief noise transients) is controlled by R8. Its 'discharge' time (which ensures that — once they have been triggered on — Q2 and RLA only turn off again

when all noise trigger signals has been absent for a few seconds) is controlled by R9, and that these components provide the circuit with good immunity to false-triggering and relay-chatter problems.

To set up the Figure 13 circuit, connect an analogue dc voltmeter between pins 6 and 4 of the 3140 op-amp, then trim RV1 so that the meter reading is zero at low sound input levels, but rises high enough to activate Q1 and RLA at the desired 'trigger' sound-amplitude level.

Power-Failure Alarm Circuits

Electrical power-failure alarms can be made to activate when ac power is removed from a deep-freeze unit, or when a burglar deliberately cuts the ac power lines, or when a machine overloads and blows its fuses. Figure 14 shows a very simple relay-output power failure alarm that can activate any type of external alarm device via the relay's contacts. Here, the power-line input is applied to a step-down transformer that gives an output of 12V at 100mA. This output is half-wave rectified by D1 and smoothed

by C1, and the resulting dc directly powers the coil of relay RLA, which has a coil resistance of 220Ω or greater. RLA has one or more sets of n.c. change-over contacts that can be used to activate an external alarm device.

Thus, when ac power is applied to the Figure 14 circuit the relay is driven on and contacts RLA/1 are open, and the alarm is thus off. This circuit typically consumes about 820mW from the ac power lines under this condition. When ac power is removed from the circuit, the relay turns off and its RLA/1 contacts close, thus activating the external alarm.

Figure 15 shows a power-failure alarm that produces an output in a ready-built piezo siren unit. Here, when ac power is applied to the circuit, the ac input is stepped down to 12V by T1 and is rectified and smoothed by D1 and C1, and roughly 12V dc is developed on the D1-D2 and D2-D3 junctions, and LED1 is illuminated via R1. Under this condition Q1 is driven to saturation via R2, and Q1's collector pulls the R4-R5 junction down to near-zero volts. As a result, zero base drive is applied to Q2, so the piezo alarm is off and no current is

drawn from the 9V battery. When ac power is removed from the circuit's input, R1-LED1 rapidly discharge C1, and the D1-D2 junction quickly falls to zero volts and Q1 turns off; under this condition current reaches Q2's base from the 9V battery via D3-R4-R5, and Q2 and the siren thus turn on.

Note that the Figure 15 circuit can, if desired, be used with higher battery and T1-secondary voltages, provided that the resulting V1 provided is at least 2V greater than V2 (the battery voltage).

A Proximity-Activated 'Alarm' Circuit

A proximity-activated alarm is a circuit that activates when a person or large object touches or comes close to a sensing antenna. The antenna may simply consist of a length or loop of wire, or may be a metal object (such as a sheet of foil or wire mesh hidden under a carpet, a safe, or a storage cabinet) that is connected to one end of a wire antenna.

Most proximity-activated alarm circuits work on the capacitive loading principle, in which the gain of an L-C oscillator is adjusted to a critical point at which oscillation is barely sustained, and in which the antenna forms part of the oscillator's tank circuit, and in which the circuit's 0V supply line is grounded. Consequently, any increase in the antenna-to-ground capacitance, such as is caused by touching or nearing the antenna, causes enough damping of the tank circuit to bring the oscillator gain below the critical level, and the oscillator ceases to operate. This cessation of oscillation is then used to make the alarm

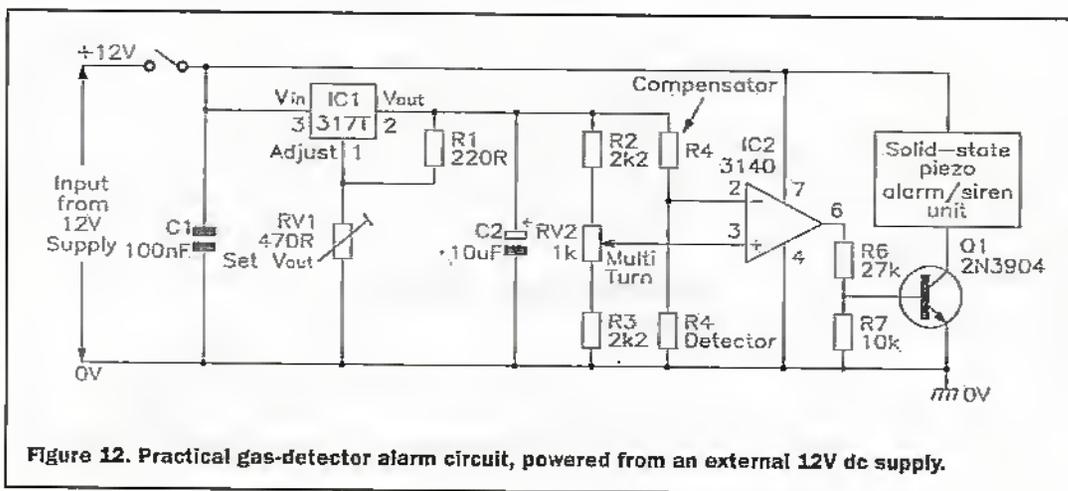


Figure 12. Practical gas-detector alarm circuit, powered from an external 12V dc supply.

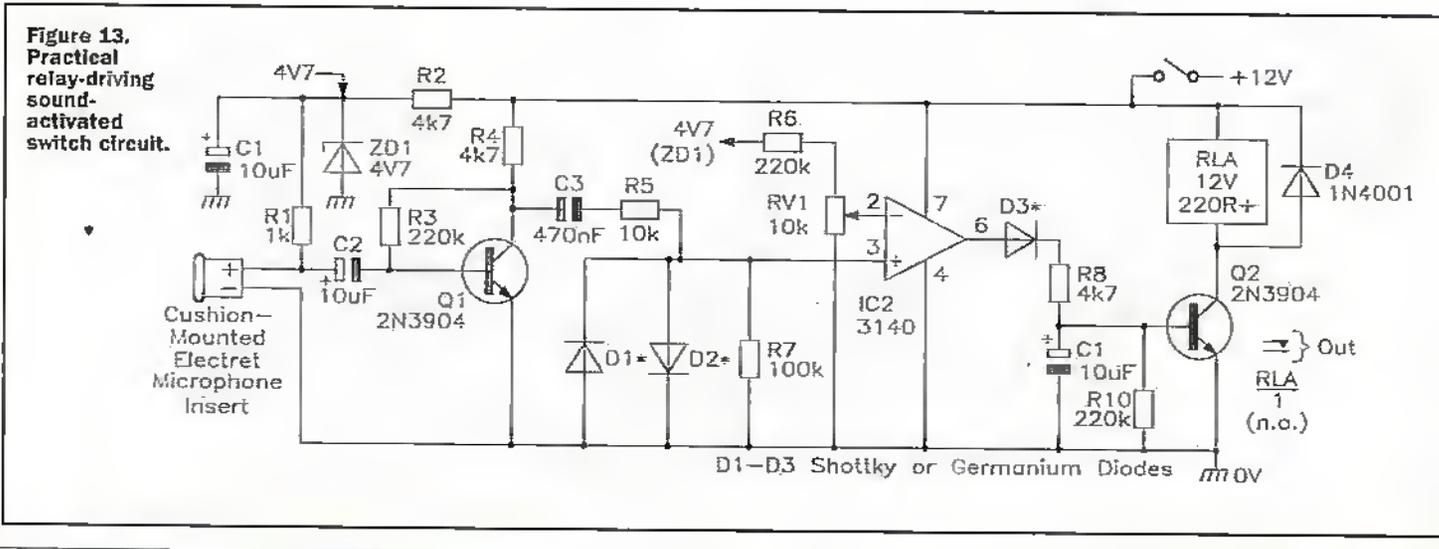


Figure 13. Practical relay-driving sound-activated switch circuit.

D1-D3 Schottky or Germanium Diodes

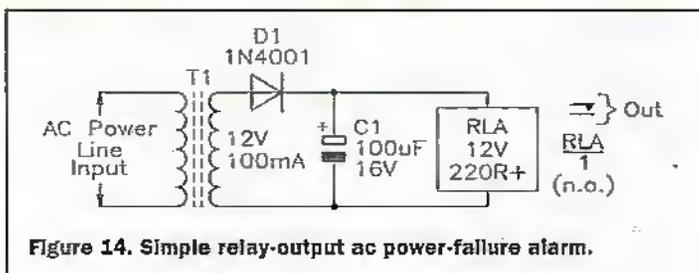


Figure 14. Simple relay-output ac power-failure alarm.

generator activate.

Figure 16 shows a practical relay-output proximity-activated alarm circuit that uses the above operating principle. Here, transistor Q1 is wired as a Colpitts oscillator, with gain adjustable via RV1, and the antenna is coupled to Q1 base via C5. The output of this oscillator, which operates at about 300kHz, is made available at a low impedance level across R4 via emitter-follower Q2. This signal is rectified and smoothed via the C1-D1-D2-R6-C7 network, to produce a positive bias that is applied to the base of Q3 via R7. Q3 is wired as a common-emitter amplifier, with R8 as its collector load, and Q4 is wired as a common-emitter amplifier with the relay coil used as its collector load and with Q4's base connected directly to the collector of Q3.

Thus, when the Figure 16 circuit is operating normally, the oscillator output produces a positive bias voltage that drives Q3 to saturation and thus removes Q4's base drive; Q4 and the relay are thus off under this condition. However, when the circuit's antenna is touched or externally loaded, the oscillator ceases to operate so removing Q3's base drive. Q3 then turns off, so Q4 is driven to saturation via R8, and the relay is thus driven on under this condition.

Note that the Q1-Q2 section

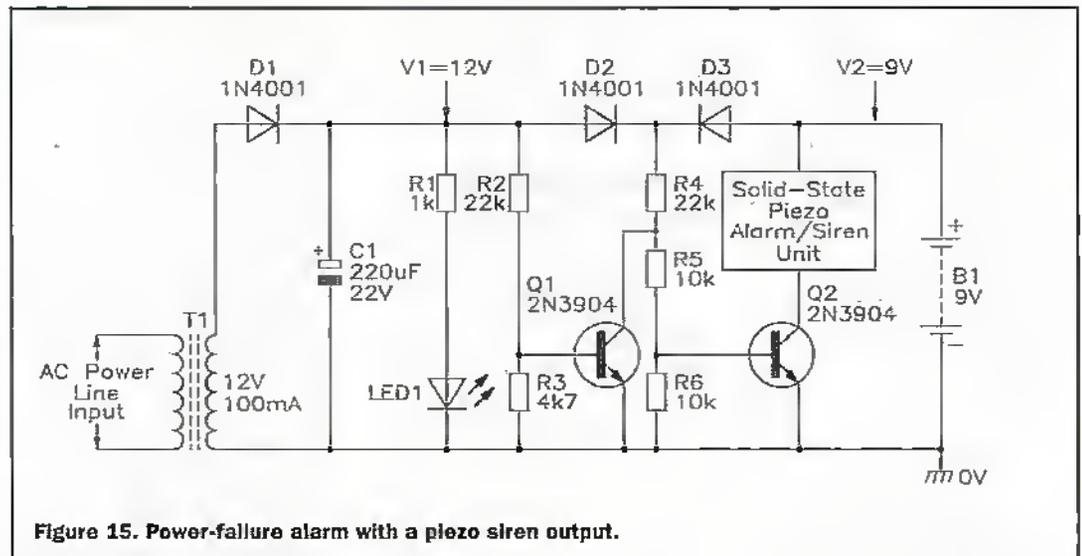


Figure 15. Power-failure alarm with a piezo siren output.

of the circuit is powered via a 6.2V regulated supply formed by R5 and ZD1, thus enhancing the oscillator's stability. Also note that D1 and D2 must be germanium or Schottky signal diodes, and that the circuit can — if desired — be used to give a directly-driven 'siren' output (via a ready-built piezo alarm module) by simply using the siren module in place of RLA and removing D3 from the circuit.

To set up the Figure 16 circuit, simply connect a suitable antenna, trim RV1 so that the relay turns on, then back RV1 off slightly so that the relay just turns off again. Check that the relay turns on again if the antenna is touched or closely approached, and goes

off again if the touch is removed; if necessary, trim RV1 for maximum sensitivity.

The final sensitivity of the Figure 16 circuit depends on the setting of RV1 and on the size and type of antenna used. If the antenna is very small, such as a short length of wire, the circuit will act as little more

than flexible (or mobile) contact point, such as one or more metal studs. The best circuits of this type work on either the capacitive loading principle described in the preceding section of this article, or, if they are designed for use only in the general vicinity of ac power lines, are activated by the power-line

than a touch alarm, but if the antenna is a large sheet of metal foil or wire mesh, the circuit may be sensitive enough to activate when a person approaches within a foot or two of the antenna. It pays to experiment with different types of antenna, to get the 'feel' of the circuit. Remember, that the antenna must be well isolated from ground, and that the circuit's 0V rail must be wired to an effective ground connection.

A Touch-Activated Circuit

Touch-activated circuits are intended to perform some kind of switching action when a person touches a fixed (rather

radiated ac 'hum' that is picked up by an electrical contact when touched by a human finger. Figure 17 shows a practical circuit of the latter type.

The Figure 17 'hum-detecting' circuit activates relay RLA when a finger touches a single metal stud or contact point, and is designed around a CMOS 4001B quad 2-input NOR gate IC and transistor Q1. Here, gate IC1a is wired as a simple pulse-inverting amplifier and has its high-impedance input terminal taken to the metal touch contact via R2; the contact is biased high via R1, and IC1a's output is thus normally low. When a human finger touches the circuit's contact terminal, its induced ac

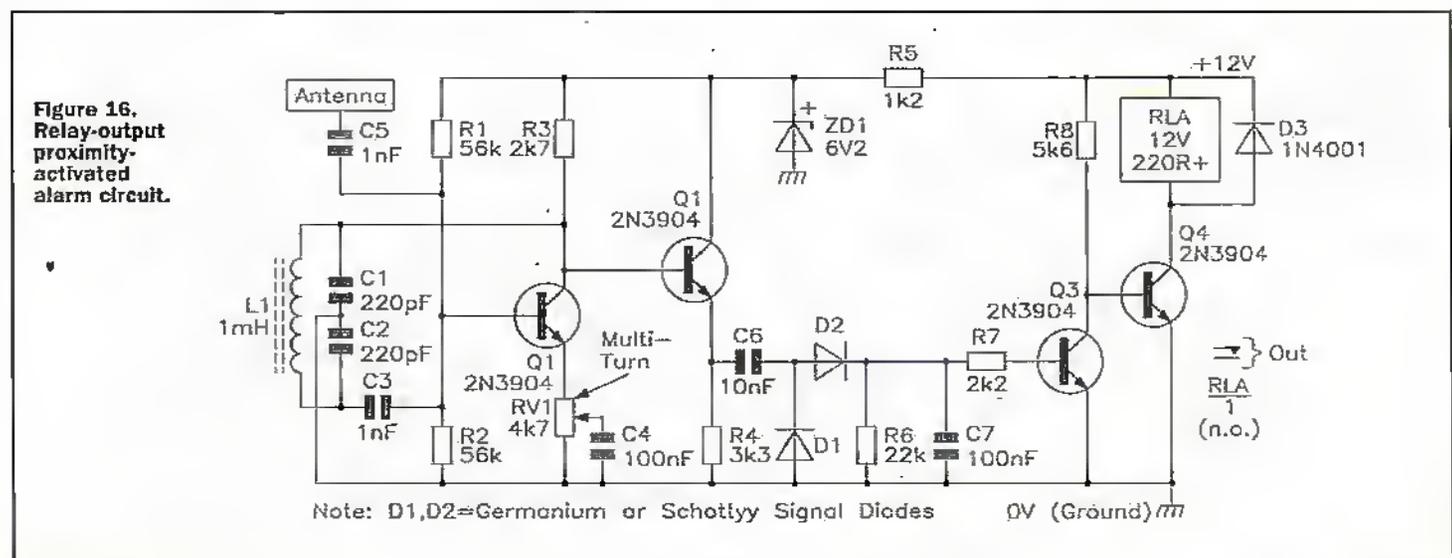


Figure 16. Relay-output proximity-activated alarm circuit.

Note: D1, D2 = Germanium or Schottky Signal Diodes

0V (Ground) mm

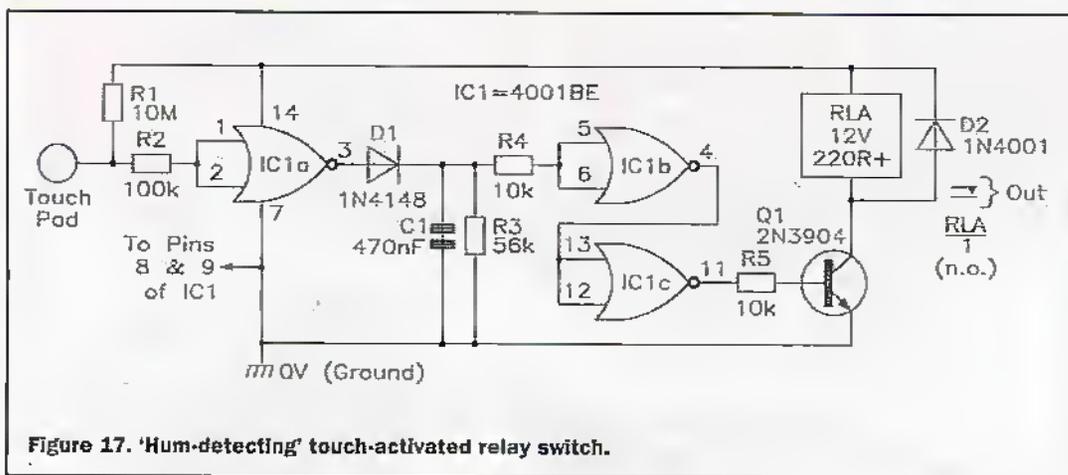


Figure 17. 'Hum-detecting' touch-activated relay switch.

input of an amplifying detector stage that is built around Q2-D1 and C2. Normally, when the beam is unbroken, the output of this detector stage is high, so Q3 is driven to saturation and Q4 and the relay are cut off. When the beam is interrupted, the output of the detector stage falls to near-zero volts, so Q3 turns off and Q4 and the relay are turned on via R7. An external alarm can be activated by the closing of the RLA/1 contacts. Thus, RLA is normally off, but turns on when the ultrasonic beam is interrupted.

'hum' signal reaches IC1a's input, is amplified and inverted, and appears as a large amplitude squarewave at IC1a's output. This squarewave is rectified and smoothed via D1-C1-R3, is buffered by gates IC1b-IC1c (which act together as a non-inverting buffer), and then drives relay RLA on via R5 and Q1.

Note when using the Figure 17 circuit that its 12V supply must be derived (via an isolating transformer) from the ac power lines, that the 0V supply rail must be grounded, that the relay's contacts can be used to activate external circuitry or alarms, etc., and that the circuit consumes a quiescent current of only 1mA or so. The circuit's touch contact should not be larger than about 10cm² (to avoid unwanted pick-up); if the contact is more than a few inches from IC1a's input terminal, the connecting leads may have to be screened to avoid unwanted pick-up.

An Ultrasonic 'Beam' Alarm Unit

This unit can be used in the same type of application as an IR light-beam alarm, but works

on ultrasonic principles. It consists of an ultrasonic transmitter (Tx), operating at about 40kHz, which is aimed at a matching relay-driving ultrasonic receiver (Rx) unit. When an ultrasonic link exists between the Tx and Rx, the relay is off, but when the link is broken the relay turns on and activates an external alarm or some other electrical or electronic device. This particular unit is a very simple design, with a maximum operating range of only a few metres and is suitable for security protection for passages and open doorways, etc.

The unit makes use of a modestly priced matched pair of ultrasonic transducers of the type used in many remote-control applications. These devices are normally designed to operate at about 40kHz, and consist of a dedicated Tx transducer and a matching dedicated Rx transducer. Such devices are readily available from major electronic component suppliers.

Figure 18 shows the circuit of the unit's transmitter module, which typically consumes an operating current of 2.5mA from a 9V supply or 3mA from a 12V supply. Here, Q1 and Q2

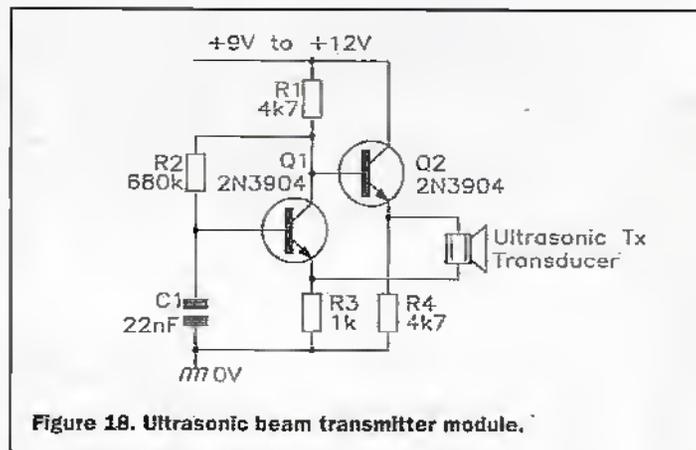


Figure 18. Ultrasonic beam transmitter module.

are configured as an emitter-coupled oscillator, with the Tx transducer used as the emitter coupling element, so that the circuit oscillates at the transducer's resonant frequency (about 40kHz) and radiates a matching ultrasonic signal.

Finally, Figure 19 shows the circuit of the unit's receiver module. Here, the Rx transducer is pointed towards the transmitter and responds to the transmitted signal in much the same way as a directional microphone. The output of the Rx transducer is fed directly to the base of common emitter amplifier Q1, and appears in amplified form at Q1 collector. It is then fed, via C1, to the

The Figure 19 circuit consumes a typical current of 5mA from a 12V supply. To set up the circuit, turn off the Tx unit, connect a dc voltmeter (with a sensitivity of at least 20kΩ/V) across C2, then trim RV1 so that the voltage just falls to near-zero; RLA should turn on under this condition. Now turn on the Tx unit, aim it at the Rx unit, and check that the C2 voltage rises to at least 2V and that RLA turns off. If desired, RV1 can be further trimmed to obtain absolute maximum operating range.

Next month's concluding episode of this series will deal with electronic security circuits designed for use in automobiles.

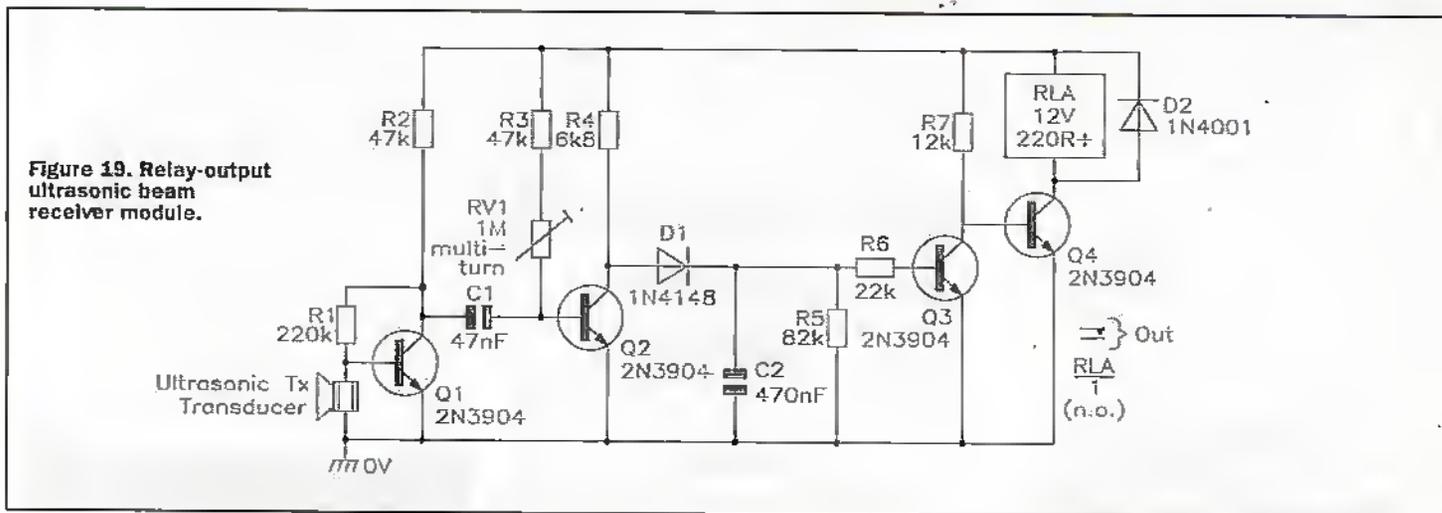


Figure 19. Relay-output ultrasonic beam receiver module.

TECHNOLOGY WATCH



with Martin Pipe



In last month's Technology Watch, we examined the principles behind biometric validation, that is using a unique physical attribute to identify a particular person. This month, I am going to look at something loosely related. *Truster* has been developed by Makh-Shevet, a small software company in Israel, and is a rather unique Windows 95 program that claims to determine whether an individual is telling the truth. Sounds like something out of the X-Files, doesn't it? Lie detection isn't anything particularly new, and polygraph testing has been a tool of the police and secret services for years. Traditional polygraph lie-detection equipment, which sells for \$10,000 or so, relies on the monitoring of various physical parameters including heartbeat, blood pressure and sweat. These might change if the subject is exhibiting the pressure, excitement or emotional conflict associated with lying.

Sensors strapped to the body measure these parameters. Sweat, for example, will change the electrical resistance of the skin by a small, but perceptible amount. The latter phenomenon forms the basis of all those simple lie detector projects that you probably built when you were learning about electronics. Unfortunately, some people are more convincing liars – at least as far as polygraph testing is concerned. They might not sweat so much, or their blood pressure might not increase sufficiently to be registered by the machine. I can imagine that secret agents receive some kind of 'polygraph deception' training along these lines. Done properly, polygraph testing is highly complex and has to take into consideration ambient conditions and the physical properties of the test subject. At best, an accuracy of between 85% and 90% can be achieved. Many people are understandably sceptical about polygraph testing, and the results cannot be submitted as evidence in a court of law.

Truster, which was originally conceived for the questioning of terrorists, monitors another physical parameter in its search for the truth – the voice. Academic researchers have discovered that when under the stress associated with lying, the amount of blood entering the subject's larynx is involuntarily reduced, causing the voice to flutter. However, these changes are too minute to be detected by human ears. These flutters provide all kinds of information about the subject's emotional and physical condition. *Truster's* patented voice analysis algorithms

tune in to these, and can hence differentiate between lying, and nervousness, emotional conflict or pain. Makh-Shevet reckon that *Truster* can detect whether the person you are talking to is lying, outsmarting you, exaggerating, unsure of his words or telling the truth. When vocal stress is detected, the appropriate message appears on the screen. These include 'telling the truth', 'high level of excitement', 'confused, subject is not sure', 'he/she is exaggerating', 'being sarcastic', 'inaccurate' and 'false statement'. Once the conversation has ended, *Truster* produces a report for further examination. The software includes an automatic calibration system, and the ability to filter out unwanted background noise.

Getting the voice into the PC in the first place needs nothing more complicated than a run-of-the-mill soundcard. A telephone adaptor (hmm... is it BAPT approved?) that plugs into the soundcard and allows telephone conversations to be analysed in real-time. Previously-captured recordings and other sources (such as microphones) can also be handled. According to its developer, the basic version of *Truster*, which sells on its web site (<http://www.truster.com>) for \$149, will run quite happily on a P75 PC with 16Mb RAM. Ease-of-use is said to be excellent – just connect up the audio source, start the program and "sit back and watch the screen". We hope to test these claims with a full review of the software in a future edition of *Electronics*.

There are two other versions available – 'Bigger Brothers,' if you'll excuse the awful (but deliberate) pun! These offer more features, and are priced accordingly. *Truster Pro* (\$749) offers additional analysis modes designed for interviews and investigations, and will provide a detailed report on how each question was answered. Level 1 (2499), meanwhile, is a complex vocal stress analyser intended for advanced security and law enforcement agencies. Most interestingly, the latter is claimed to work



with multiple participants. This has to be conducted off-line, presumably because a lot of processing is involved. Versions of the software are available for English, Japanese, Cantonese, Czech and German customers, amongst others. *Truster's* analysis process is reputedly language-independent, and so the multiplicity probably stems from user interface needs.

The system was evaluated on hundreds of individuals prior to its release. Under carefully-monitored conditions, they were told to read stories that contained obvious false facts. Their speech was picked up by microphones connected to PCs running *Truster*. An average 85% success rate was achieved – not bad, for a system that can be acquired for rather less than the polygraph's \$10,000 asking price – even if the PC's purchase price is factored in. That 85% relates to Israeli test subjects – *Truster's* developers found that with the Japanese, the rate was closer to 100%. Apparently, this is because the Japanese are more self-critical! *Truster* is an excellent example of PC application diversity. Its relatively inexpensive price makes it accessible to consumers, and not just gadget freaks, insurance companies and government departments. Do you have doubts relating to the faithfulness of your girlfriend or husband? Is that supposedly independent financial advisor recommending the right product for your needs, or is he/she simply pushing the one that pays the most commission? Have your kids done their homework on time? Can you rely on the accuracy of the source you've been given, or has he/she been pressurised into lying? Should you place trust in this politician? Do you want to follow this deal through?

All of these questions could be answered, to some degree, by *Truster*. That said, Makh-Shevet put a disclaimer in the instruction manual to the effect that they "will not bear any responsibility for direct or indirect results from use of the system". Out of interest, the *Truster* web site contains an analysis of statements made by President Clinton on January 26th. These statements, made at a White House press conference, related to Clinton's alleged sexual relations with Miss Lewinsky. *Truster's* conclusion? "The subject never lied but apparently there were SOME inaccuracies".



E-mail your comments or suggestions to Martin Pipe at whatnet@ix.computink.co.uk.



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Radio COMMUNICATION PRODUCTS

PART 5

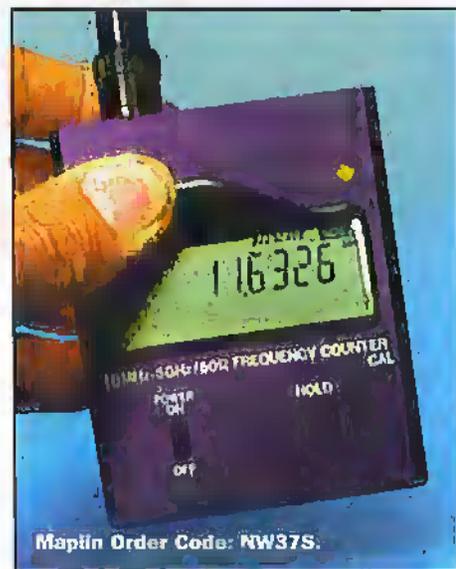
by Harry Watkins

More New Catalogue Items

Digital frequency counters

Pocket sized digital frequency counters have been around for some time now. I spoke of frequency counters in a previous article so I won't go over the background information again here. The first generation of counters have been significantly improved by adding extra features and refining old ones. For example, the first counters had LEDs which have long been replaced by LCDs. This means easier to read displays and longer battery life. Also, their increased sensitivity allows for better signal reception.

Watson have just introduced a range of frequency counters onto the market at prices to suit any budget or requirement. Frequency counters are not only essential test instruments, but also make excellent digital displays for analogue transceivers, and of course they are used to find out the exact frequency of a transmission for monitoring purposes. In some instances they can aid in the detection of bugs.



Maplin Order Code: NW37S.



Maplin
Order Code:
VN08J

The Watson 'HUNTER' (Maplin order code NW37S priced at £59.99) is a high speed frequency counter with 100Hz resolution and is within the budget of any radio enthusiast. It covers the very wide range of 10MHz to 3GHz. It weighs only 210g and its dimensions are 80(H) x 68(W) x 31(D)mm (excluding aerial). There is a 50Ω BNC socket on the top of the unit (7-section telescopic aerial supplied). Also supplied are an internal 4 x AA 600mAh NiCd battery pack, an ac charger (12-16 hours) and comprehensive instructions. The unit can also be powered by a 9V dc 300mA external power supply (not supplied).

The Hunter features an 8-digit LCD, low power consumption giving an average six hour battery life. The unit is easy to operate with only a few simple controls. These are on/off switch and a hold button for freezing the display when it locks onto a signal. There is also a calibration trimmer for accurate frequency measurements. In use, once the batteries have been charged and the aerial



Maplin Order Code: NW38R.

connected, it is simply a matter of switching the unit on and waiting.

The next model up in the range is the Watson 'FC-130' (Maplin order code VN08J priced at £79.99) and is already a very popular frequency counter with radio enthusiasts. It is exactly the same as the Hunter but with the following extra features: covers 1MHz to 3GHz, a 10-digit LCD, low battery indicator, an ultra sensitive synchronous detector, 16-section bargraph to show RF signal strength and a high speed 300MHz direct counter with 0.1Hz resolution and 4 selectable gate speeds. The range switch should be switched to the 300MHz position for frequencies between 1MHz and 300MHz and switched to the 3GHz position for frequencies between 10MHz and 3GHz. The gate button has four positions and selects the gate or measurement time. A longer gate time means counting for a longer period and results in higher accuracy.

I find that by using a known transmitter, such as my VHF hand held, I can test a frequency counter and quickly find out such information as best gate time to use and which range to switch the unit to. But even without a transmitter, it does not take very much experimenting with the counter to get the best out of the unit.

The Watson 'SUPER-HUNTER' frequency counter (Maplin order code NW38R priced at £149.99) is the top of the range. It boasts an enormous 10Hz to 3GHz frequency coverage. It weighs 250g and measures 100(H) x 68(W) x 31(D)mm (excluding aerial). There is a dual purpose (via switch) BNC socket on top of the unit (7-section telescopic aerial supplied) giving 50Ω input for range 1MHz to 3GHz and 1MΩ input for range of 10Hz to 50MHz. Also supplied are internal 4 x AA 600mAh NiCd battery pack, an ac charger (12-16 hours) and fully comprehensive instructions. The unit can also be powered by a 9V dc 300mA external power supply (not supplied).

The Super Hunter features a 10 digit LCD, low power consumption giving average six hour battery life. There is an LED back light for the display, a hold button to lock the display as well as an automatic hold, a low battery indicator, and a beeper. This unit measures frequency and period with 4-selectable gate speeds. It has a 16-section

Maplin Order Code: NW42V.



bargraph to show RF signal strength, a high speed 300MHz direct counter with 0.1Hz resolution and there is even a built in filter which prevents the display of random noise. The function button selects the frequency, or period, and has four settings. One each for displaying frequency, or period, as these are received, and two settings for automatic hold of the first frequency or period captured.

General notes on frequency counters

When using a frequency counter with an aerial for signal pick-up, random counts may appear. This is normal, and is due to the high gain amplifier circuitry amplifying weak signals and noise in the absence of a strong, readable signal. Never exceed the maximum signal input level as internal damage will occur.

The supplied telescopic aerial is the best for general purpose use. This is because its length can be adjusted to suit the frequency. As a rough guide, collapse the aerial to its minimum length for UHF and fully extend it for HF and VHF. An alternative resonant aerial may offer better results in some cases.

The most often asked question regarding frequency counters is how far away from the transmitter will the counter work. The distance that the counter can read signals depends on many factors, such as type and location of transmitting aerial, transmitter output power, type of receive aerial and any obstacles in the way of signals. Some typical distances are: Cordless phone - 0.3m, Cellular phone - 3-20m, CB radio - 2-8m, VHF and UHF two way radio 3-30m.

Transceivers and receivers

The EUROSONIC KH-104 80-channel 4W FM hand held CB transceiver (Maplin order code NW42V) is priced at £119.99. This is the first of no doubt many hand held CB's with all 80-channels on it. We looked at 80-channel mobile CB's in part 4 so no need to give the background again. Suffice to say that the frequencies are split into two sets of 40-channels (UK) 27.601MHz to 27.991MHz and (EU) 26.965MHz to 27.405MHz. All the 80-channel CB's are only legal for use in the UK, so beware if you take your car abroad and forget you have it installed in your vehicle.

On taking the unit out of its box the first thing I noticed was its very small size compared with what the older 40-channel only type transceivers, it measures 147mm(H) x 65mm (W) x 35mm (D) and weighs just 200g without batteries. The unit is supplied with a flexible aerial, belt hook, carrying strap and dry cell case for 8 x AA batteries (batteries not supplied) and, of course, instruction book and warranty card. The unit can also operate from 6.5-15.6V dc. There are sockets for microphone and speaker, or earpiece, and for the charger/external dc supply.

The controls are simplicity itself, on the top of the unit are the two knobs for on/off, volume and squelch, just where I like to see them. On the side of the unit there is a PTT switch where the thumb naturally rests when holding the radio, and just above the PTT, there are two more buttons for channel up

and channel down. There are six other buttons on the front of the radio, these are for last channel recall, key lock, high/low power, beep on/off, scan-key for scanning through the channels and dual watch for monitoring two channels at the same time. There is also a back light for the LCD and channel 9/19 emergency switch. All-in-all this is a super transceiver whether you need to use one frequently, or just to keep in the glove box of a car for an emergency. An excellent buy.

The Track Air TAD-1 (Maplin order code NW46A) sells for £49.99 and is what the airband fraternity has been waiting a long time for. This realistically priced digital airband receiver measures a compact, pocket size 63mm(W) x 115mm (H) x 20mm (D) - excluding retractable telescopic aerial. There is a 3.5mm stereo headphone socket and earphones, and the unit is powered from 2 x AAA size batteries (not supplied). Its frequency coverage is: FM1 - 8S to 108MHz in 50KHz steps, FM2 - 108 to 140MHz in 50KHz steps, AM1 - 108 to 124MHz in 12.5KHz steps and AM2 - 124-140MHz in 12.5KHz steps.

A switch on the side of the unit selects either the built-in speaker or the earphones, and also the aerial from the built-in rod to the headphones allowing you to listen with the rod aerial folded away. There are also switches for on/off and key lock. The unit has five memories selected by individual buttons on the front of the unit. Additionally, there are two extra buttons for switching between the four bands and for writing to the memories. The rotary volume control is conveniently situated on the top of the unit. The up/down frequency buttons are located on the front panel next to the LCD. A mono/stereo switch enables interference free listening to weak stations. I am sure that this receiver will soon be a regular sight both at air shows and the viewing galleries at your local airport.



Maplin Order Code: NW46A.

Demon News

Demon Internet has, by the time you read this, undergone a major upgrade to its Usenet News service to help eliminate speed and propagation issues. The new service is based on *Network Appliances* file servers. Like the service it replaces, the new News service uses multiple front end servers to support customer connections, which allows simple expansion in customer connection capability, but has the additional power needed to support ever growing demands being placed on Demons News services.

The new News service is necessary not only because of greater numbers of users signing up with Demon, but also because of the huge increase of 'spam' that is infiltrating UseNet News services everywhere. Apparently, Demon has a daily volume of news which peaks at around 22Gb. Of this, only 40% comprises genuine news articles.

Some 30% is of spam and other unwanted content, and the remaining 30% is cancel messages to cancel spam.

Free for all

There's been a slew of Internet service providers who want to get in on the free email bandwagon recently. None bigger than BT, which is to launch *Mill-e-Mail* later in the year. Part of BT's Millennium programme announced in February, *Mill-e-Mail* is World Wide Web based, which means that users can access the service from anywhere in the world they may visit as long as they can get Internet access. By being Web based, email services like this ensure that users aren't tied to specific access points such as the office, or home. An added bonus is that any other of a user's email accounts can be accessed at the same time.

For education users, *Mill-e-Mail* offers schools and colleges the opportunity to

control mail and folders. Every student in a school could therefore have an email folder, setup and maintained through the school account. Teachers can then also block email from known offending domains or allow email only from approved correspondents.

A related free service for Websites has been announced by Zyris. Its *ZyWeb* service (that's pronounced z-eye web, as in high web) offers a free Website to everyone, simply by logging your computer onto the *ZyWeb* Website at <<http://www.zy.com>> and signing up. The free Website is offered under the *ZyWeb Lite* service, in which you can use the In-built Web design tools to create your own pages. You can give it a URL that even contains your own name. *ZyWeb Lite* offers 2Mb of Web space, one email address and a limited number of page design templates. Your free pages, however, have to carry banner advertising from advertisers (that's what pays for the free service).

ZyWeb Home costs £48 a

year and offers 5Mb of Web space, 50 Web page design templates, 5 email addresses, and you can remove the banner advertising of the Lite version. A third version, *ZyWeb Business* costs £200 a year, with 10Mb of Web space, 10 email addresses, feedback forms for customers and other benefits.

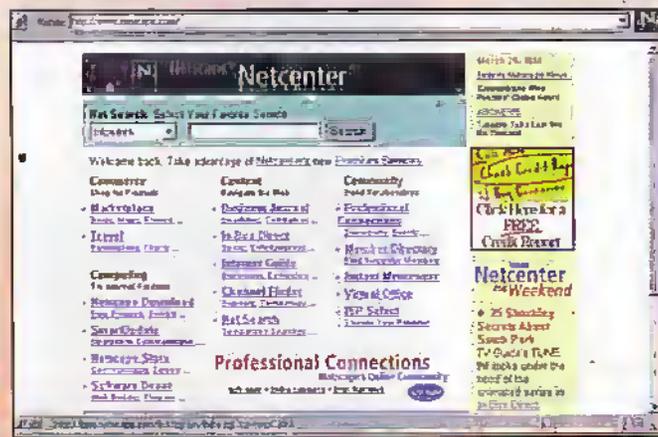
QuickTime Out

QuickTime 3 has been officially released, and it's available for free download at <<http://www.apple.com/quicktime/>>. Expect huge delays, though. It's a 6Mb plus download, and literally millions of people have already downloaded it. Both Mac and Windows formats are available and, as it's been recognised by ISO as the basis for the new MPEG-4 unified digital video storage mechanism (as reported last month), it represents the future for multimedia on IBM-compatible personal computers as well as Macintosh personal computers. Get it, while it's hot!

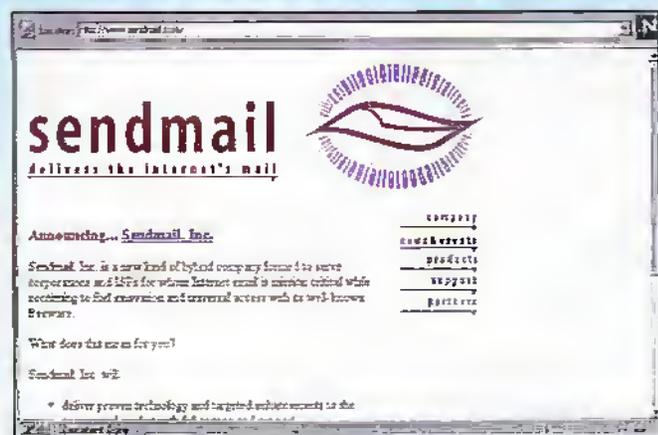
Netscape Plans To Boost Internet Service

Netscape at www.netscape.com is planning to expand its Netcenter site into a major Internet gateway, positioning it in direct competition with Yahoo!, Excite, America Online and Microsoft. The redesigned site will include more community features such as discussion groups, and Netscape is looking at ways to offer free e-mail service to users.

The move signals the consolidation of Web traffic around a few major 'hubs', which serve as the initial log-on point for Web users. Netscape already ranks number two in visitors, with 23.1 million users in February, second only to Yahoo!.



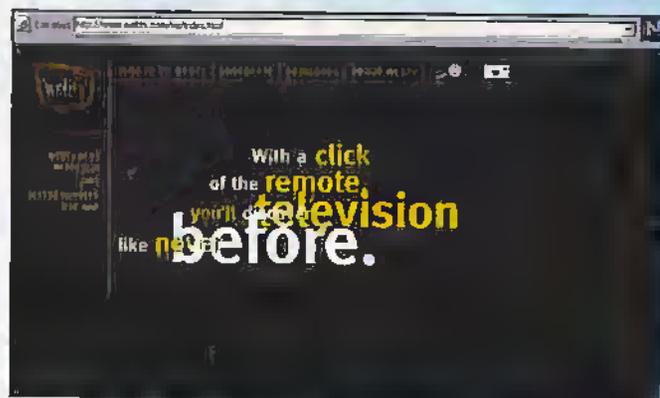
New Tool To Stop Junk Mail



A new version Sendmail at www.sendmail.com, the software used on about 75 per cent of the message routing computers on the Internet, will offer a number of features to block 'spamming', including the ability to reject mail from known spam addresses and to force spammers to reveal

their true Internet addresses. Eric Allman, who wrote the Sendmail program while working as a programmer at the University of California at Berkeley, is also creating Sendmail Inc to sell software and support services to businesses, while continuing to develop new features for the free version of the software.

WebTV and BT Begin UK Trials



Microsoft's WebTV Networks at www.webtv.com and BT at www.bt.com have announced that WebTV Networks has selected BT to be its Internet service provider to trial the WebTV product in the UK. The trial, to begin later this month, will involve a cross section of UK households.

The objective of the multi-phase trial is to gain technical, marketing and operational knowledge of the UK marketplace. During the trial, WebTV Networks will provide core technology and platform management, while BT will provide access through

BT Internet.

The WebTV Networks trial service will incorporate UK Internet content and will be tailored to address content developers' needs. WebTV Network's hardware licensees, including Pace Micro Technology and Philips Electronics, will provide PAL standard set-top boxes for the trial.

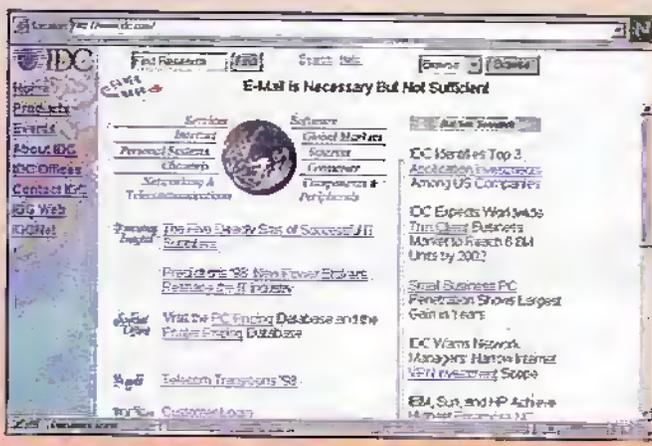
WebTV products and services are based on open Internet standards, ensuring that UK content providers will be able to reach this new audience with their existing Web sites without modification.

E-Mail is Necessary but No Longer Sufficient

E-mail, a tool that has become a necessary and critical aspect of business communications, is no longer sufficient for many users according to IDC at www.idc.com. This research reveals demand is on the rise for products that offer broader functionality through seamless integration between e-mail and other applications.

"During the past two years, the e-mail software market has been turned on its head by the rising demand for

products supporting Internet standards," said Mark Levitt, research manager of IDC's Collaborative and Intranet Computing research service. "For vendors that have focused exclusively on Internet e-mail, this development has been a double-edge sword; it has confirmed the correctness of their product strategies. At the same time, it has created a host of new, mostly larger competitors with products for Internet e-mail."



ISPs Say Internet Demand Exceeds Technology

Internet service providers and equipment vendors are warning that Internet bandwidth demands are growing much faster than the capacity of Internet backbones.

For instance UUNET Technologies at www.uunet.com reports that Internet traffic used to double every year, but now is doubling every three to six months. ISPs complain that new video

applications are straining current technology, and that it is difficult to build up the backbone without knowing in advance which Internet applications are going to prove most popular.

Technical Data Archive Site

Downloadable Maplin data sheets are now available on line from <http://www.maplin.co.uk/dataarch/dataarch.htm>

TV Will Not Bring the Internet to the Masses

During 1997, Woking-based Inteco at www.inteco.com, conducted over 40,000 interviews in Europe to study the developing picture and to forecast future changes in consumer interactivity and the associated market opportunities for its clients.

Last month, Inteco senior consultant Adam Daum presented a summary of how future home Internet access will develop and the respective parts the PC and the TV have to play.

"The PC will remain the primary platform for Internet access for the foreseeable future, but that doesn't mean it is about to become a standard feature of all PCs. Even in the US, with all its cultural, pricing and infrastructure advantages,

less than 50% of PC-owning households have access and 40% of households with a PC and a modem still aren't connected to the Internet.

"There are several factors which will slow the spread of Internet access in Europe: relatively high telecommunications costs, including almost universal

local call charges; poor local language content on the Web; lower PC ownership and usage at home and at work; and widely available alternative sources of information, for example Minitel, teletext and old media.

"ISPs still focus their marketing on the features of their particular service, not on the benefits of the Internet in general. This must change. Assuming it does, then this and other positive factors will help overall growth. For example, competition between telecommunications operators will drive time-based costs down and users will feel freer to explore and discover interesting content and services.



Macromedia Fires Up Web Designers

Macromedia at www.macromedia.com has introduced Fireworks, the first production tool to provide a unified environment for creating, optimising and producing high-quality graphics for the Web. Engineered from the ground up to address the needs of professional Web designers, the new tool incorporates such advanced features as a visual export preview, complete control over compression and colour palettes, automatic generation of button states and JavaScript rollovers, as well as text and effects which are editable all the time. Fireworks allows designers to create the most

compact graphics and GIF animations in the fewest steps.

The current workflow for creating Web graphics is complex and time-consuming. To create a simple animated GIF banner, a designer uses several tools, laying out text in a vector illustration tool, compositing the text with images in a bitmap application, and then optimising the size of the graphic in yet a third program. Adding image maps and animation requires additional utilities. Finally, the designer previews the image in a Web browser. Developers often undertake multiple iterations of this process, attempting to balance image size and quality.



Moreover, if the client requests a change, today's artist must start the process over since graphics are not readily editable in existing imaging tools. Fireworks solves both the workflow issue and the problem of editability by allowing designers to complete the entire process of creating and producing Web graphics in a

single, unified environment, keeping everything editable, all the time.

A pre-release beta version of Fireworks is currently available for download at no charge at www.getfireworks.com. Fireworks for Windows 95, Windows NT and Macintosh PowerPC will be available Summer 1998.

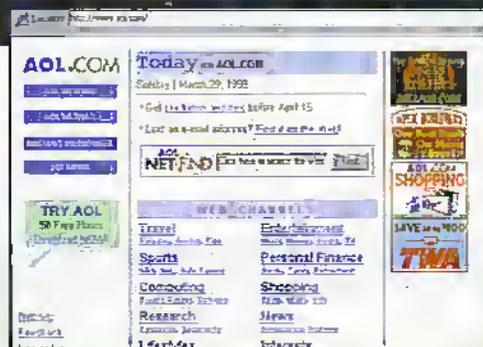
AOL's 10 Most Wanted Spammer List

AOL at www.aol.com has announced a new, more aggressive campaign against unsolicited e-mail, or 'spam'. Continuing its battle on behalf of its members, the company also warned that it might seek federal legislation to put spammers out of the business.

In a speech at the Jupiter Consumer Online Conference in March, AOL CEO Steve Case took spammers to task and announced AOL's 10 Most Wanted Spammer List, which included Loveroys Online, the Notoriously Nasty Spammer, PlanetLovejoy and loseweight.org. He said the company would build a case against each one and pursue them in court where possible.

"Like the online consumer, we're fed up with spam. We are adopting a block and tackle strategy against spammers. That is, we're going to block as many of their e-mails at the gateway as we can, and we're going to tackle them in court," Case warned. "The spammers on our '10 Most Wanted' list represent a severe impediment to the growth of the medium and are causing a significant depreciation of the experience for the average consumer. We look forward to taking them on one at a time."

AOL filed a law suit against a company it charged with using the AOL and aol.com trade names on a series of pornographic Web sites, as well



as in spam sent to AOL members promoting the sites.

The Company also announced that it had obtained a judgement in its anti-spam lawsuit against Prime Data Worldnet Systems. In addition, the company said that another spam defendant, Squeaky Clean Marketing, had agreed to

a permanent injunction which will bar Squeaky Clean Marketing from ever e-mailing AOL members again.

AOL has been fighting spam for many

months by giving its members tools to better control the e-mail they receive, providing an area online devoted to educating members about unsolicited e-mail at Keyword: Junk Mail, and by sending more than 500 cease and desist letters to spammers and following up with lawsuits against many of them.

Web Based Transactions Will Produce Largest Growth Area

Analyst house Ovum at www.ovum.com, has released findings which reveal that

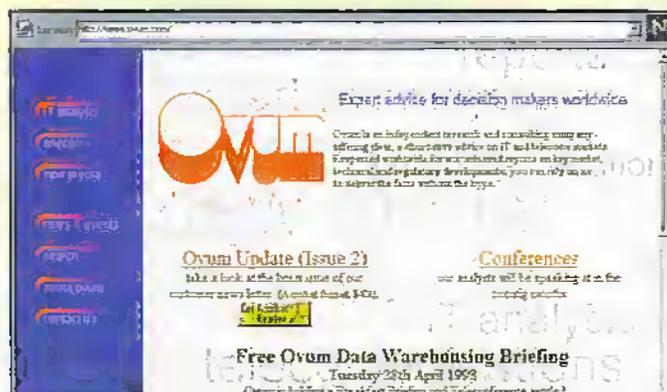
existing customers of the Internet will not generate the high growth rate of Internet

traffic currently predicted. New customers will lead to increased demand according to an Ovum report, Internet: Corporate and Consumer Views, which investigates the emerging issues and trends surrounding Internet usage.

According to Iain Stevenson, new media group manager and co-author of the report, "Users are optimistic about the Internet. However, the overall trend is geared towards extending the existing Internet applications to more users. Web transactions is the only new application that is



currently well established and will grow strongly. Videoconferencing and Internet telephony will achieve strong growth but from a very low user base today."



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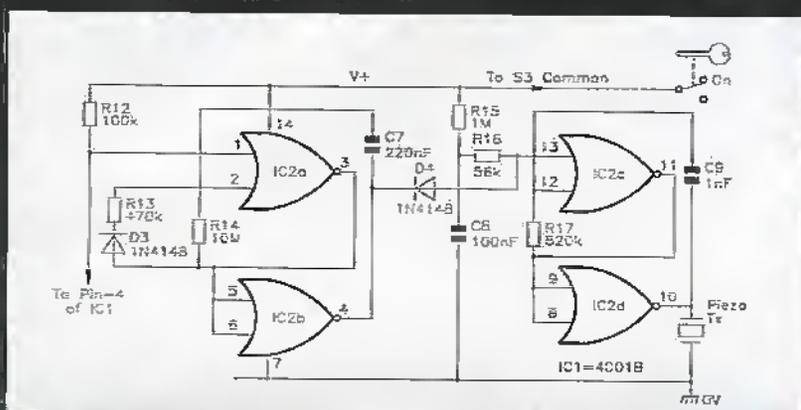
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Security Electronic Systems & Circuits - Part 7, Issue 124

In Figure 8, the junction R14/IC2b pin 5 & 6 must be connected to the anode of D3. A revised drawing is shown below.



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:



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



2 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.



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



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



5 Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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2 By sending a fax to: Fax (01702) 554001;
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