

AUSTRALIA'S DYNAMIC ELECTRONICS MONTHLY!

# Electronics Today

INTERNATIONAL



\$2.95 NZ\$3.75

JUNE 1986

**PC BOARD SHOPS  
NEW WAVE**

## FIBRE OPTICS ARRIVE



### PROJECTS:

**THE INTELLIGENT MODEM  
CAR DEMISTER TIMER**

**ELECTROSTATIC HAZARD ALARM  
MUSICIAN'S DIGITAL SAMPLER**

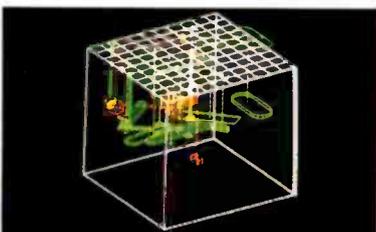
# Some CAD names come before others



*Pandora project, an incredible application in marine technology.*



*Overlay and grid definition in the Pandora application.*



*Demonstration of AutoCAD's 3D visualization capabilities.*

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INTERNATIONAL

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# Tektronix new digital oscilloscopes



## The fastest signal capture and A/D conversion yet.

Tek researchers have again run ahead, anticipating the higher performance levels required for design, trouble shooting, applied research and test and measurement.

The new Tek 2430, 150 MHz digital oscilloscope is a breakthrough in price/performance levels.

**A 100-megasample/sec sampling rate** makes the Tek 2430 spot on for fast conversion and viewing of analog or digital signals. This is achieved with a new proprietary charge coupled device.

**Capturing single shot glitches** as narrow as 2ns at any sample rate is now a constant reality with Tektronix new clocked peak detector. The 2430 gives

recording of two high-speed transients, simultaneously.

**High wave form update rate** allows 40-100 acquisitions per second with the sharp resolution required for digital design and trouble shooting.

**Fast control to screen response time** cuts user overcompensation in selection or adjustment.

**New concept in chassis design reduces cost.** While providing better protection for the components this new composite chassis also weighs some 30% less than similar models. To further reduce ownership costs the 2430 incorporates extensive self test/diagnostic and auto calibration features.

**A price/performance choice in portables.** There's also the new low cost Tek 2230 and 2220 digital models offering storage and non-storage bandwidths of 100MHz and 60MHz.

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IT IS INEVITABLE that the issue of the Federal Government breaking up or selling off Telecom will raise its head every few years.

Although the people who work for Telecom believe such an outcome would be a very bad thing, the means to prevent it lies precisely with them.

Don't get me wrong, I am not promoting the privatisation of Telecom. In fact I think those who are asking for changes are asking for something which will do them little if any good.

Virtually all of the demands for a Telecom sale or break-up come because people are dissatisfied with the service or from businesses that incur significant costs in use of their inter capital communications routes.

Telecom still uses revenue from these major routes to subsidise its activities in other areas, particularly services in more remote places. Given the business community's belief that this is costing them a lot of money it is little wonder it wants to have communications costs reduced. But it is here that I think the business community is misguided.

Because the great bulk of Telecom traffic is between the capitals the elimination of cross subsidies may not reduce its cost by very much at all.

Also the very nature of the telecommunications business is changing. There are three main cost components involved in carrying a communications signal, based on distance, bandwidth and the time taken to transmit the signal.

As technology crams more signals into the one cable duct, and with satellites, the distance element and hence the need for cross subsidies is becoming less and less important.

The other area of discontent and potentially the most damaging for Telecom is the quality of service. If enough people are dissatisfied, Telecom's position will be at risk even if no other organisation could do its job any better, and then Telecom employees might be affected.

Telecom suffers from the same management ills that affect all large organisations, public or private. The bigger they become the more management loses touch with its customers.

It also becomes easier for staff to lose touch and become less interested in serving the people who provide the organisation's revenue, its customers.

In my experience most people who work for Telecom are enthusiastic about Telecom and its customers. Yet there are a few, hopefully only a small few, who at best are lethargic and at worst actively discourage any enthusiasm from their colleagues.

Most Telecom people and people who work for similarly large organisations know the sort of person I mean. They are usually the major source of frustration and even anger of fellow workers and customers.

Telecom is no different from any other large private or public organisation in that in the long run the organisation's future is entirely in the hands of its staff and management.

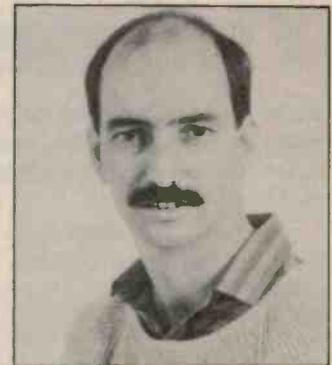
I don't know whether Telecom would be better run by private industry — I'm sure no one else does either.

But there is one thing I am absolutely sure about. If Telecom people want a future that they will have some control over they must provide a service that is unerringly a pleasure for its business and domestic customers to use.

If they don't make some changes about the people who are holding the organisation back they will get some change they really don't want.

*SUBSCRIBERS SHOULD NOTE that they can receive a free ETI publication with this issue. Because of packaging problems it has not been included. Subscribers who want the publication should write to ETI June Offer, PO Box 227, Waterloo NSW 2017.*

David Kelly  
Editor



**NEXT MONTH**

**COMPUTER AIDED DESIGN**

Why has it taken so long to introduce CAD in Australia? Perhaps it's because the advantages of computer aided design are not always obvious; perhaps it's endemic conservatism. We evaluate CAD in the light of its applications.

**VZ200 UPDATE**

A welcome project which among other things provides for more memory and a new keyboard.

**MODEM NEWS**

The full details! No kidding...

**CASSETTE TAPE REVIEW**

The audio review next month focuses on cassette tape. Louis Challis tests all the major brands of Type II chrome tape for their audio characteristics as well as durability and packaging. The result is a ranking with consideration to price and quality indispensable to anyone who values their recordings.

# The new 'Bee

After a gestation longer than an elephant's and with twice as many rumours, Microbee Systems announced the launch of its new computer, the all singing, all dancing Gamma at PC '86 last March.

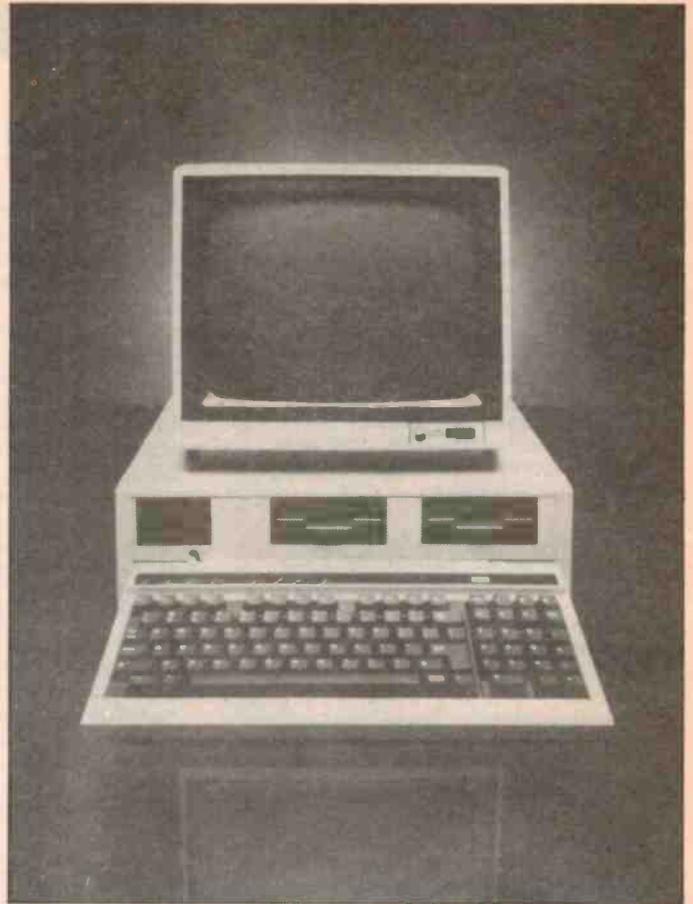
Centre stage is a 68000 16/32-bit processor running at 8MHz. A couple of Z80s keep it company. This controls a standard megabyte of RAM, expandable to four megs internally and to eight megs in total. It uses a 3.5 inch, double sided microflop for mass storage.

The graphics system will run high speed 720 x 350 pixels. A palette system allows 16 colours to be selected from a total of 4096.

The Gamma runs on CP/M 68K and Unix operating systems. In addition an optional card carries an 80186 co-processor so that it can run MS-DOS. Finally, it is compatible with CP/M80 8-bit software developed for previous 'Bees.

A break with the past is a separate low profiled, 92-pad keyboard. It has tilting feet to allow the operator to orientate the keyboard at a comfortable angle. The keyboard was designed in-house by Microbee to suit the Gamma and other modern computers.

According to Microbee Publicity Manager, Jim Rowe, the first production run of 'Bees has been given to software producers to write software for the machine. A release date has not yet been decided on but is likely to be later this year. Price is likely to be \$2500 or so, cheaper than its main competitor, the Commodore Amiga.



## NASA shuttles plans

According to NASA publicity, the space agency intends ferrying the orbiter Columbia to Vandenberg Air Force Base in July "to support site validation testing". Vandenberg is the new shuttle base controlled by the US military.

However, suspicion is growing that the US Air Force intends to use Columbia to loft a new spy

satellite even before the enquiry into the Challenger disaster reports to Congress. Currently the US has only one operational spy satellite, a KH11. It was to be replaced this year with a KH12, but this plan was put into limbo after the Challenger disaster because the satellite is too heavy to be carried by any other available rocket.

A plan to use a final back-up KH11 as an interim replacement ended in disaster when the Titan rocket carrying it exploded seconds after launch. This leaves the US with three options: either build a new KH11, wait for shuttle clearance, or do without space spying.

It appears that Air Force officials are now ready to force the

issue of shuttle clearance. New booster rockets have already been designed that do without the O rings responsible for the Challenger crash, and pressure will mount to launch on a "try it and see" basis. The names of the crew members have yet to be announced.

## WA traineeships

The WA Deputy Premier and Minister for Technology, Mal Bryce, and the Federal Minister for Employment and Industrial Relations, Ralph Willis, recently launched a program to train 100 teenagers in information and data processing.

The traineeships are part of the Commonwealth and State Government's commitment to improve the vocational training opportunities for young people

making the transition from school to work.

The program will provide on and off the job training. Trainees will be placed in a wide range of State Government departments while the Federal Government will meet the cost of the trainees attending TAFE colleges within the metropolitan area.

In addressing the trainees, Mr Bryce said suitably qualified

young people in the information technology field were in considerable demand.

"Almost every major office across the public and private sectors is opting for partial or complete office automation. There is a common belief that advances in information technology may be taking away jobs — the very opposite is the case.

"We very much need newly-qualified young people and this

program is the first in WA to recognise this need in such a comprehensive way," Mr Bryce said.

The traineeships have been organised by the WA Department of Computing and Information Technology, with the assistance of the WA Department of Employment and Training.

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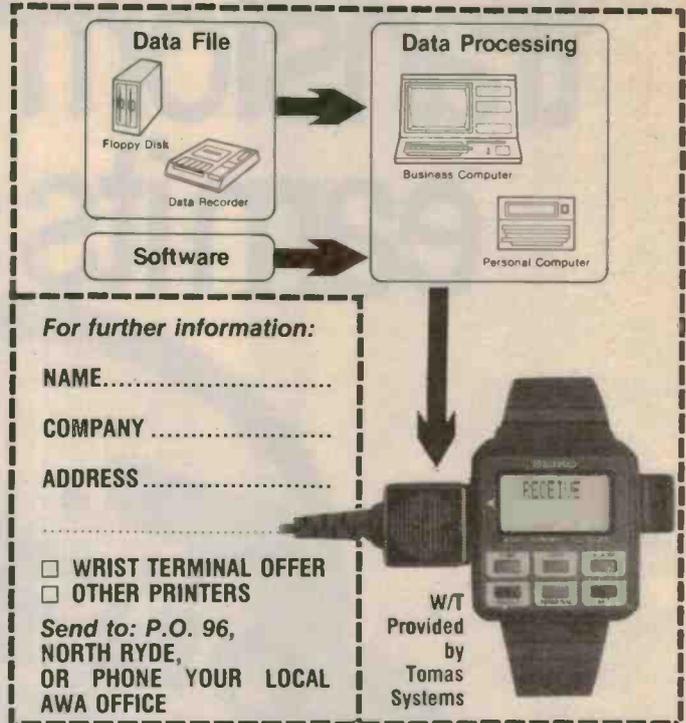


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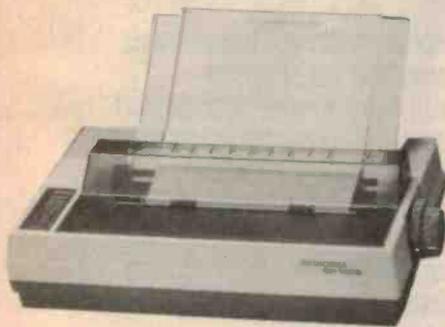
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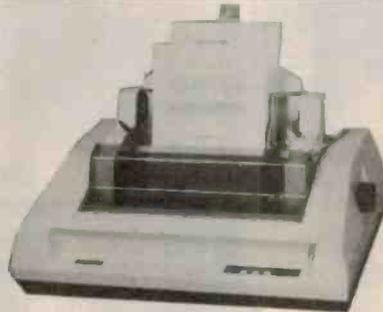
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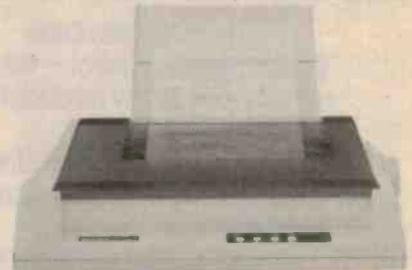
- 100 cps (Draft mode), 20 cps (Near Letter Quality) print speed, with reduced noise level.
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- Right, left margin set function.
- A variety of functions including: Underline, Bold print, Double Striking.
- A variety of print character sets including: Pica, Elite, Proportional, Elongated, Condensed, Italics, Super/Subscripts, and Italic Super/Subscripts.



### Features of BP5200

- 206 cps (Draft model) 103 cps (Correspondence mode) print speed, with reduced noise level.
- A variety of print character sets including Pica, Elite, Proportional, Elongated, Italic, Super/Subscripts, Italic Super/Subscripts.
- A variety of functions including underlining, bold-printing, double-strike, software-selectable line pitch specification.
- 4K byte communication buffer.
- Pin-feed and friction-feed both available.
- Paper width up to 15.5 inches.
- BP52201 — Centronics parallel with IBM character.
- BP5200A — 2 standard Interfaces (parallel and serial, 4K byte buffer expandable to 20K byte).

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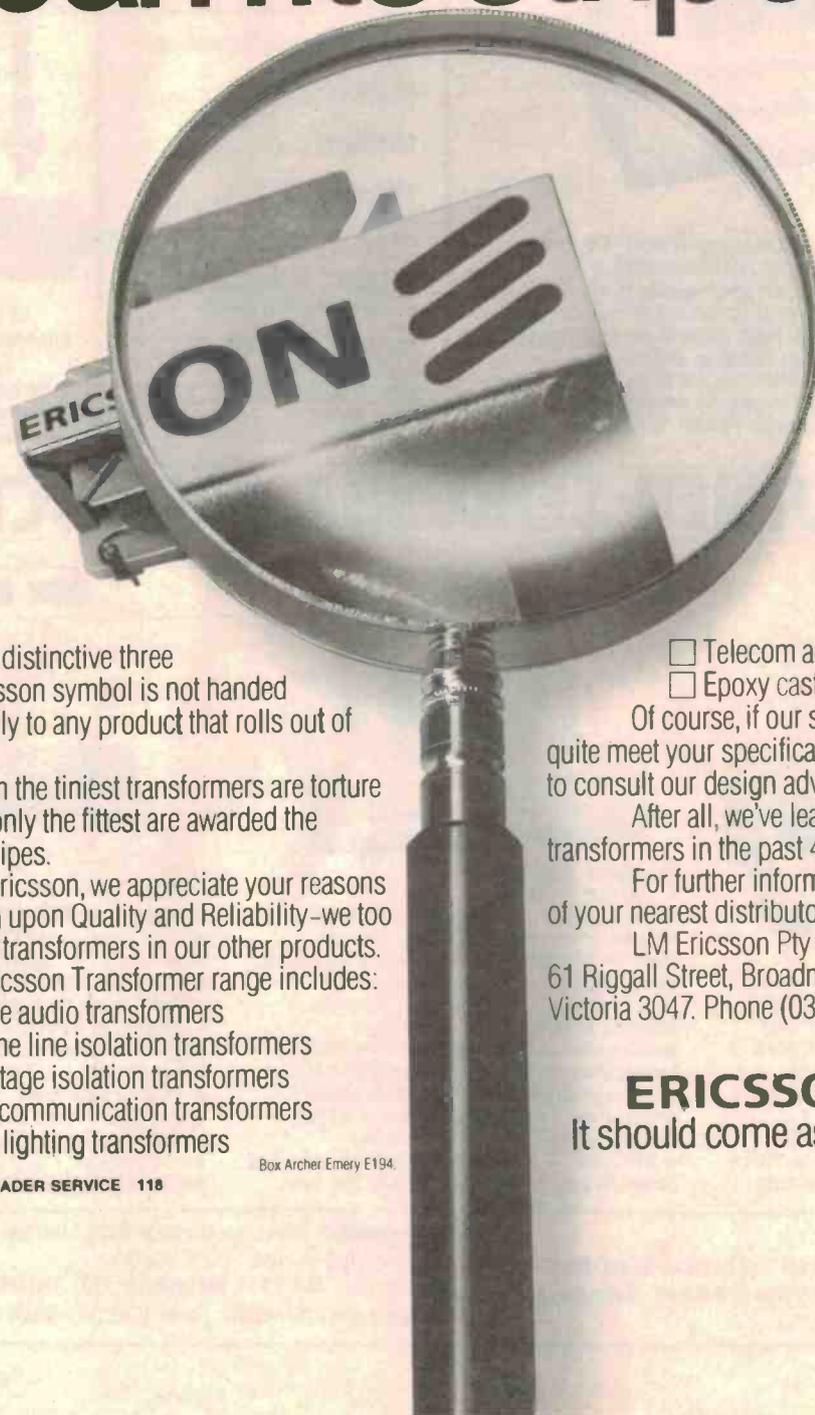


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**ERICSSON**   
It should come as no surprise.

## Optical fibre plant in Victoria

A new plant to make optical fibre cable opened in the Melbourne suburb of Noble Park last April.

The company which built the plant at a cost of \$20m is Optical Waveguides Australia, a consortium of Metal Manufactures, Australia's major manufacturer of cable and other conductors for power and communications, together with AWA, and Corning Glass Works of the USA.

The plant's initial capacity is predicted to be 100,000 fibre kilometres per annum. Its location was selected to be well removed from possible sources of industrial contamination and from major sources of ground vibration such as railways and heavy vehicular traffic.

Central to the operation are the fibre drawing facilities which

are installed in a three storey draw tower. The structure, which sits on an independent foundation of 250 tonnes of concrete, has been tuned to dampen any vibrations which may impair the high quality of the fibre produced.

The plant is expected to have a significant export capacity and to add to Australia's trade in high technology products.

Austral Standard Cable, major supplier of optical fibre cable to Telecom and other industrial users will utilise optical fibre cable manufactured at Noble Park for the Telecom link between Melbourne and Sydney when the new plant comes on stream. Overall, this project will use some 30,000 fibre kilometres of optical fibre.

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## BRIEFS

### Australia's largest electronics show

The 1986 Perth Electronics Show will run from July 30 to August 3 at the Claremont Showgrounds in Perth. Exhibitions of audio equipment, computers and peripherals, electronic business equipment, home appliances and photographic tools are what you can expect to see. For further information and details of special travel and accommodation arrangements, contact Chris Gulland on (09)382-3122.

### SMPTE conference

The second international conference of the Society of Motion Picture and Television Engineers is to be held from June 24 to 27 at the Sydney Showground. Papers and discussion will cover such topics as film and laboratory technology, television technology, sound in film, television and radio, video and film production. There will also be a comprehensive equipment and services exhibition to complement.

Enquiries about exhibition hours, programme and costs should be directed to SMPTE, PO Box 88, Willoughby, NSW 2068. (02)692-7222.

### New pcb holder from Scope

Scope Laboratories has a new tilt and turn circuit board work holder in its Panavise range. The new Model 333 rotates and locks in 45 increments and at four angles. It is adjustable to 200mm in height and comes with a heavy cast iron base with bench mounting holes as an option, and with spring mounted arms for quick load facility. It's yours for \$97. Scope is at 3 Walton St, Airport West, Vic 3042. (03)338-1566.

### Promoting Oz electronics in Asia

Scientific and professional equipment trade promotions are to be held later this year in Kuala Lumpur and Bangkok by Aus-trade, the government's successor to the Department of Trade. The South East Asian region has been identified as a priority market by the Australian scientific and professional equipment industry, according to a Trade Department study.

### Second chance for failed wafers

A plant which recovers wafers which have been rejected because of faults or errors in manufacture is operating in Riddings in the English midlands. The process used at the plant chemically removes all device structures from the wafer front face and etches out any diffused impurities from the back and edges. The front face is then polished and cleaned.

## NOTES & ERRATA

**Project 170, Precision CRO calibrator, Feb '85:** In order to make the attenuators conform to the front panel artwork, use the following resistor values: R=220R, R18=330R, R22=22R, R23=33R, R29=220R, R30=330R, R34=22R, R35=33R.

**The little electric store (Sept '85):** The caption of Figure 1 should read: 'The elliptical path of an electron around the nucleus in an electric field'. Figure 2 was placed on the page, rotated through 90°. Alternatively, read 'horizontal' for 'vertical' and 'vertical' for 'horizontal' in the caption.

**1986 ETI reference section, Jan '86 & Starting Electronics 13, April '86:** The pin connection package illustrated for the 7900 series regulators is incorrectly labelled. The correct package is reproduced below.

7905 7912 7915



# Lamborghini style...



# ...Alpine performance



ACTUAL SIZE



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## ALPINE

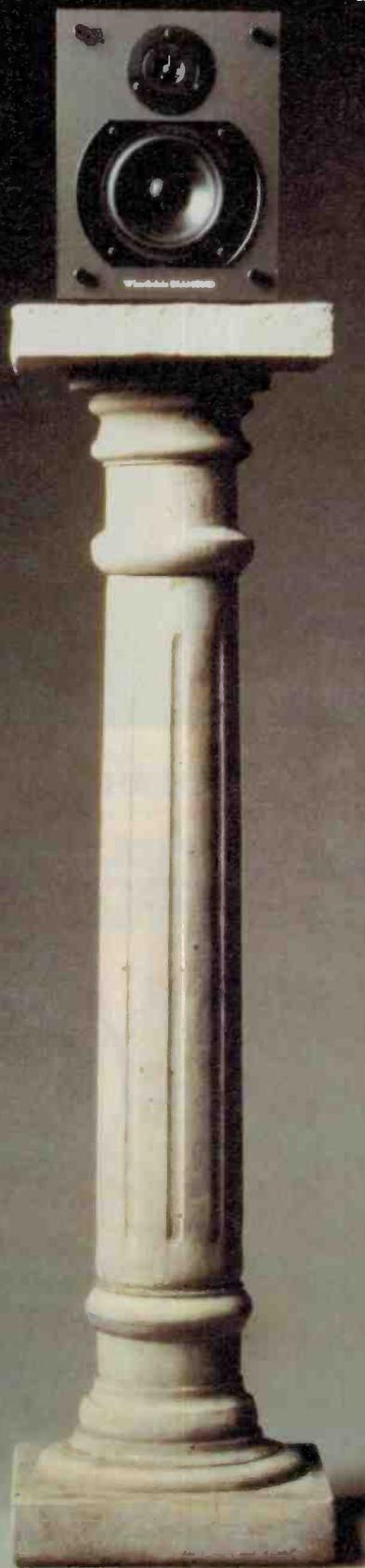
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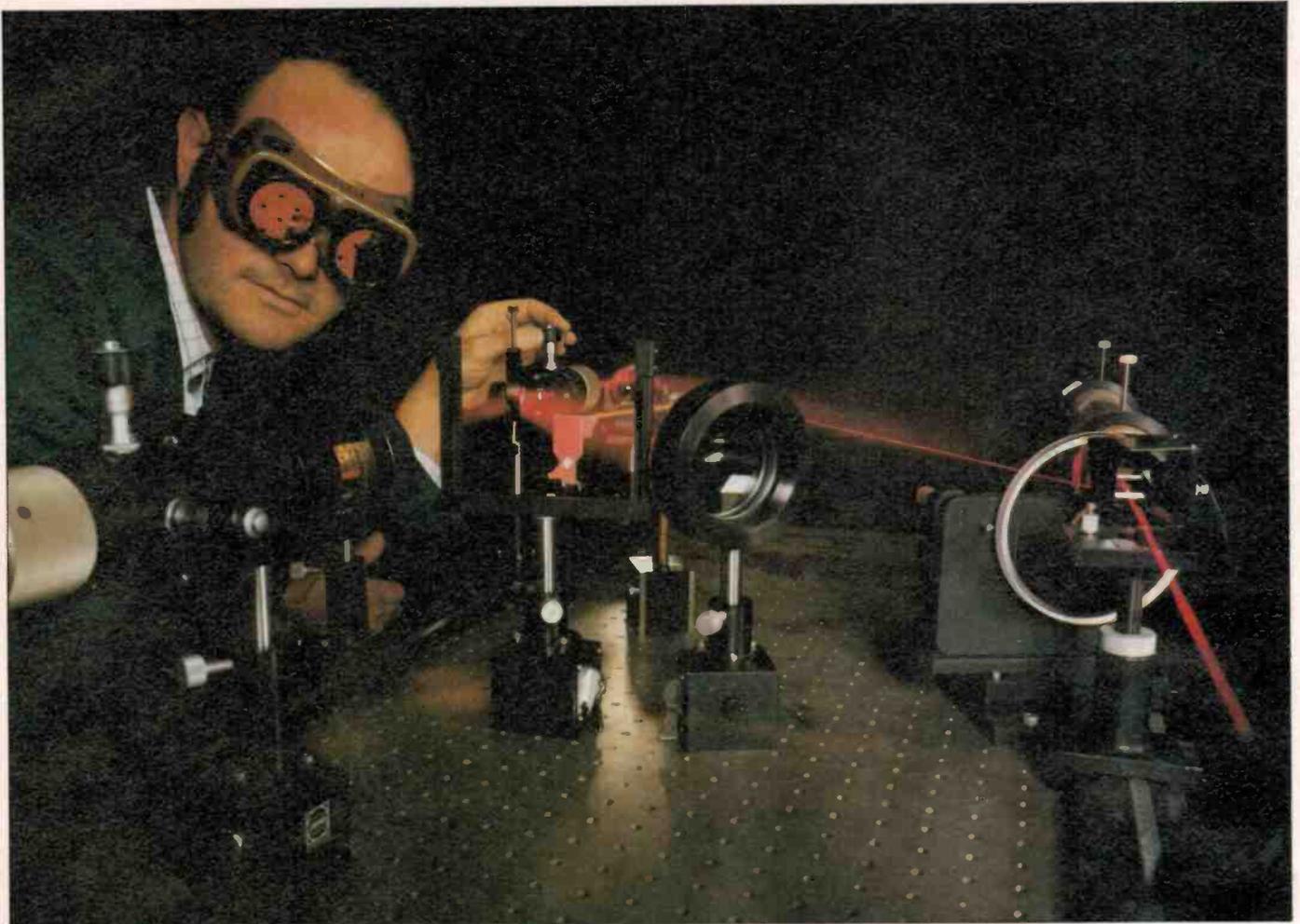


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## DIFFERENT TYPES OF FIBRE

Fibre consists of a central core surrounded by a cladding. Light propagates down the core. Unless it is launched into the fibre precisely along the axis of the cable, sooner or later it will hit the edge of the core. When it does so, it will be refracted by an amount depending on the difference between the refractive indices of the core and the cladding, and also by the angle at which it hits the interface.

The idea of an optical fibre is that it is possible to arrange things so that the light is always refracted back into the core. If this is done, the light ray will be guided down the fibre for any distance.

Fibres can be divided up depending on how they treat the interface between core and cladding. Single or monomode fibre consists of a very narrow core, of the order of a micron across. Only one ray of light can propagate, hence the name, but its frequency is very high.

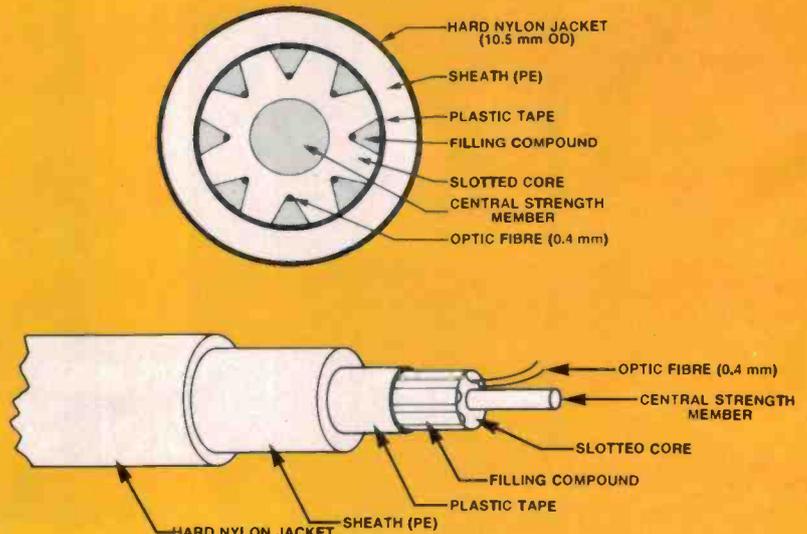
Multimode fibre, on the other hand, has a much bigger core, which supports many different routes through the fibre. The frequency has to be lower than with single mode, because of the phase errors in the multipath cable.

Clearly, both cables have advantages. Monomode is good at bandwidth and distance, and so is used by all communications authorities. Multimode has a bigger core, and is therefore handled a lot more easily. It is also cheaper to manufacture. It tends to be used where bandwidth and distance are not problems.

## STRUCTURE OF CABLE

A typical cable used in communications work consists of a number of individual fibres. As shown in the diagram, individual fibres are laid in grooves cut into a plastic central core which

is supposed to take any strain imposed on the cable during storage or laying. Wrapping around the outside prevents the ingress of moisture.



# OPTICAL FIBRES ARRIVE IN THE MARKETPLACE

Optical fibre cables are catching on — though not at the speed of light! Still things are happening fast enough to make one sit up and take note. And Australia can't be accused of lagging behind, as Telecom plans and other companies' uses indicate.

Jon Fairall

AT LONG LAST optical fibre has finally arrived. Between Sydney and Melbourne, giant Telecom tractors are plowing four kilometres into the ground every day. OTC is busy planning its first undersea fibre cable to New Zealand. All over the country, mining and industrial companies are using fibre to control pipelines and conveyor belts. And in the cities, buildings are being wired and rewired to carry light. Everywhere, companies are springing up offering modems, connectors and test gear, service and advice, in fact, all the bits and pieces that go to make up a practical communications network.

The electro-optics industry is expanding at a rate of about 100% per annum, and expansion is predicted to continue at this rate for at least the next few years. Optical fibres have arrived. According to John Wise, of Integral Fibre Systems, a 'tidal wave' of optical fibres is hitting our shores, and today we are only seeing the first swell.

Optical fibres have been around for a long time. The seminal paper on the topic was delivered by Hopkins and Kapay back in 1954. Even further back, Sir Isaac Newton is supposed to have remarked in passing that a beam of light could get 'stuck' in a column of water if the geometry of the situation was correctly arranged.

During the late 50s and 60s scientists and engineers worked on developing the basic parameters of light communications. By the mid 70s, the first experimental routes were being installed, often in third world countries without any existing telecommunications infrastructure. For instance, since about 1980, Brazil has connected all its main cities by fibre.

Today, worldwide, fibre is the glamour connector. In Europe, most of the capital cities have internal fibre routes, and many cities will soon be connected together. In the US, after a slow start, current plans call for a six fold increase in the capability of the network.

In Australia the CSIRO first started playing around with fibre in 1971, and AWA set up a pilot plant to produce fibre on an experimental basis shortly after. Since then the pace of the development has slowly increased and today Australia has a commitment to optical fibre unparalleled in the world.

## Bits and pieces

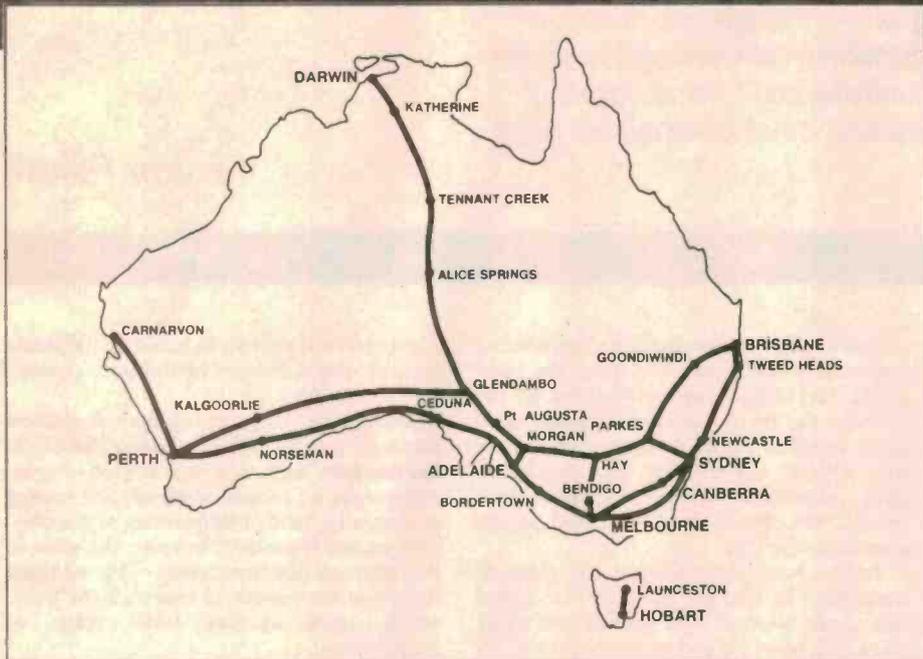
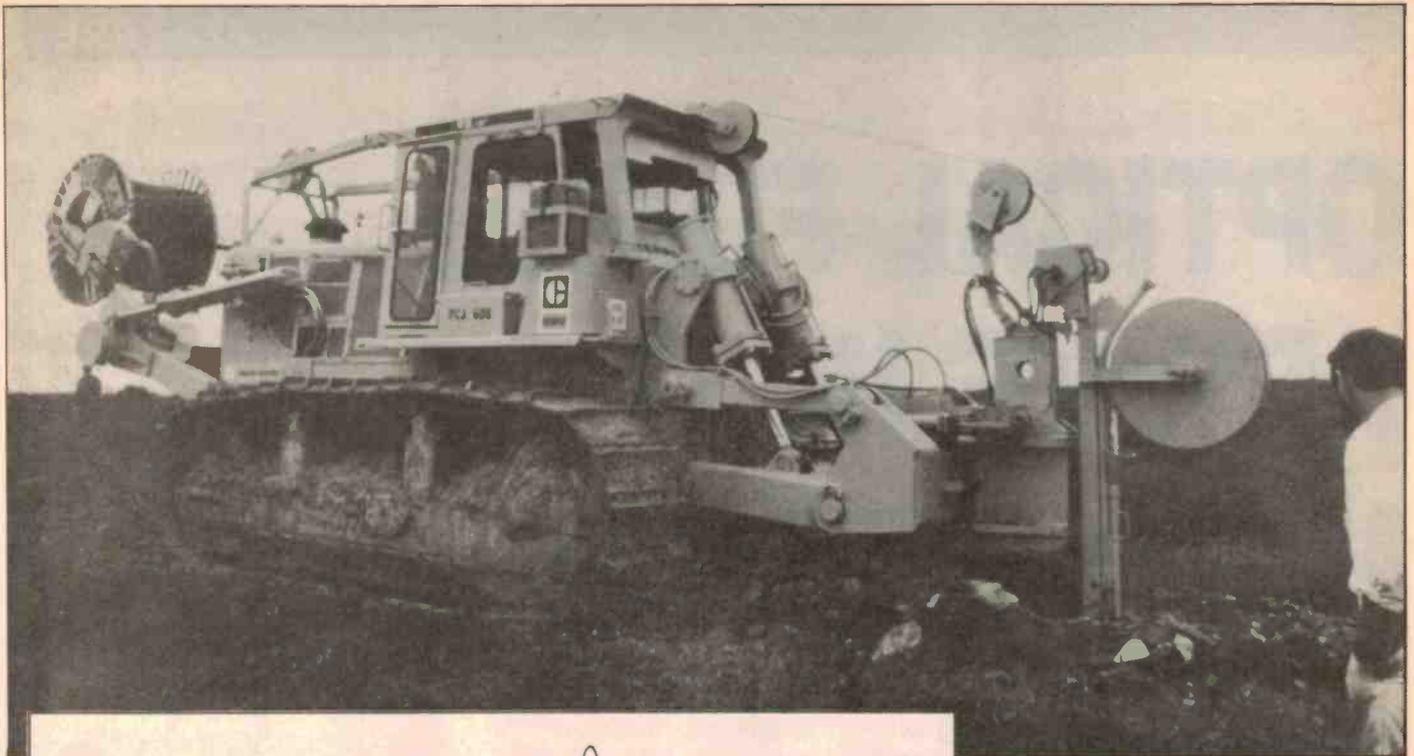
As fibre optics moves out of the lab into the market place it has spawned peripherals that do all the jobs necessary to turn the medium into a viable transmission network. To make it work, users need transmitters

and receivers, devices to quantify the transmission characteristics of the line, connectors and so on.

**Transmitters:** In practical optical systems these are usually LEDs or lasers. The LEDs are designed to have a high degree of spectral purity, ie, to emit most of their energy in as small a band of frequencies as possible. This makes it possible to tailor the glass in the fibre to the frequency. The ultimate device in this respect, of course, is the laser, which emits a very small range of frequencies.

**Receivers:** Usually some form of photodiode. Photons fall on to semiconductor material and produce hole electron pairs, and so a voltage. Even greater sensitivity can be produced with an avalanche photodiode, in which the reverse voltage is increased until internal gain takes place due to electron avalanche multiplication.

For the most part, the consumer doesn't buy these devices across the counter. It seems that the most common package for sale is a plastic pack called a transmitter or receiver, consisting usually of pins for electrical connection and a fibre optic 'tail' for optical connection. The package contains the transducer, whatever other electronic interface circuitry is required, and the optical interface that leads into the fibre. ▶



Telecom's proposed optical fibre system.  
Top: The cable laying D9 tractor at work.

**Test gear:** Fundamental to the use of optical fibre is the optical time domain reflectometer. The OTDR maps the way in which light intensity decays in a cable by looking at back-scatter in the cable. It is the OTDR that tells you if signal levels are correct, measures losses across joints and gain in amplifiers.

Another important instrument is the optical power meter. This is connected into the end of the fibre and reveals the incident power level. Usually the machine is calibrated in dB in the conventional way. There is often a filtering provision, to allow the

user to specify the wavelength being received.

**Splicers:** Joining fibre entails special problems. Firstly, the fibre is extremely small and must be connected with an accuracy approaching a micron. At the same time, special techniques have to be developed to make one bit of glass stick to another. The former problem is being solved with the aid of micromanipulators that allow very precise positioning, usually with the aid of a microscope. The answer to the second problem turned out to be very simple. Heat it and it melts. During a demonstration run

for me by Dr Bob Ayre at Telecom's research laboratories in Melbourne, I saw heat welds being created with losses of less than 0.1 dB.

**Connectors:** Connectors also need to be positioned with considerable accuracy, although here the acceptable losses are much higher, of the order of a dB or so. In general, connectors are attached to a fibre optic 'tail' in the factory, and joined to the existing cable in the field. Connectors are available from most of the companies that produce or supply conventional connectors. They are even available in Belling Lee and BNC type cases. Some manufacturers are beginning manufacture of large assemblies with multi fibre connectors. Amphenol, for instance, has just released a range of connectors having up to eight cables at once, with a claimed loss of less than a dB. It is also possible to buy do it yourself kits for joining the fibre to the connector. These have higher losses than the factory ones and take time to do, but are often a good temporary solution when one is needed.

## Manufacturing

Until this year, the only Australian made fibre was that from AWA. Overseas interests benefitted mostly from the growing use of optical fibres in this country, especially NEC, which won some notable Telecom contracts. In 1985 the AWA pilot plant closed down, pending a reorganisation of the manufacturing industry.

Now two large conglomerates have set up in Melbourne to produce fibre for the Australian market. One of these is Optical Waveguides of Australia, a conglomerate consisting of Corning Glass, Metal Manufacturers and AWA. The other company is Optrix Australia, consisting of Dunlop,



Important test gear: the optical time domain reflectometer.

Sumitomo and Pirelli Ericsson. Between the two of them they should provide more than sufficient manufacturing capacity for Australia.

The break up of the suppliers into two conglomerates reflects events overseas, where the Japanese Sumitomo and the American Corning Glass have emerged as the two giants of the market. It also reflects local conditions, where the current marketplace for coaxial cables is dominated by Pirelli Ericsson and Austral Standard Cable, itself part owned by Metal Manufacturers.

### Telecom

The biggest user of optical fibre in Australia is Telecom. A glance at the map gives the picture. By 1988 the first route to Melbourne will be finished, as will the Katherine to Darwin section. By the end of the decade, all the capital cities will be connected, and by the end of the century, connected again to provide a doubling of capacity.

This isn't Telecom's first foray into optical fibre. Field trials were conducted at the research labs in Clayton in the late 70s, and the first working route was installed between Darlington Road and Sydney University's computer centre in 1981. Since then, a number of junction routes have been laid between busy inner city exchanges in Sydney, Melbourne and Brisbane.

With the success of these field trials, the confidence of engineers has increased to the point where, in 1982, a decision was made to lay the first really long fibre link, the 975 km route between Sydney and Melbourne. At the same time, fibres are now being considered on all the shorter hauls, to the extent that Telecom is moving to phase

out the laying of copper coaxial cables completely.

The Sydney to Melbourne bearer is something of a show piece for Telecom at its best. It's the phone commission's contribution to the 1988 bicentennial. Ground was broken on the project in Canberra in July 1985, and it is expected to be finished mid 1987.

Engineers are planning on laying four kilometres a day to meet their schedule. The secret of success is a couple of customised D9 tractors, one equipped with a giant spike on the back, the other with a roll of fibre up the front. The spike opens up a slit in the earth as it is pulled forward while the cable-carrying tractor comes behind, dropping cable as it goes.

One of the most difficult problems with laying an optical fibre cable is checking that the cable is not under tension. If it is, microcracks in the cable open up over time so that the cable gradually fails. This is avoided in the cable-carrying D9 by having the cable drum mounted on a motor driven shaft. Cable tension is sensed by a lever and the drum drive speeded up or slowed down appropriately.

When the fibre link is completed, it will extend the number of telephone channels to 92,000, versus the 9000 that exist today. Critics of the optical fibre project have contended that this represents a tremendous excess in supply, which might have implications for cost, and thus the profitability of the organisation. However, experience with the introduction of other services suggests that demand quickly increases to fill the extra capacity.

In this case it is suggested that most of the excess supply will be taken up by business users wishing to link computers in Sydney

and Melbourne. Certainly, the prices will be designed to attract new custom. People in the industry do not forecast a price drop; merely that Telecom long distance charges will rise more slowly than the CPI.

### OTC

In the international arena the development of optical fibre technology is also having an effect on route planning. After a twenty year dalliance with satellites, the international routes are once again going under the sea. The first major submarine fibre is the trans Atlantic TAT 8, which will be up and running by 1988. Australia will be linked to New Zealand by 1991 and carry on to North America by 1993. The trans Tasman link is likely to consist of six fibre cable operating at 280 Mbs with repeaters every 150 km.

To support its increasing involvement in optical fibres, OTC has set up a research and development division specifically to look into undersea operations. Some of the topics under investigation include laser/fibre combinations at 1550 nm, and the effect of various components in a communications system. This latter project involves a computer model of a bearer, and allows engineers to evaluate the effect of changing individual components on the entire system.

One of the more interesting concepts under investigation is the idea of submarine branching units, which make it possible to join several cables together on the sea bottom. Up to now, all submarine cables have been point-to-point systems. The suggestion is that it should be possible to create branching units and insert them into the cable on the sea bottom. Although the first one has been deployed experimentally in TAT 8, its most obvious application would be in the Pacific Ocean, which has a large number of widely separated population centres around its periphery.

### Design questions

So the question is: why is all this work going on, especially when one considers the amount of money being spent on radio systems and satellites at the same time. The answer, of course, is the simplest one of all: it's cheaper.

At first sight it seems incredible that it can be cheaper to plow in a cable right across the country than send the signal up by satellite, or between a few microwave stations. However, as Merve Lette, chief engineer on the Sydney-Melbourne route points out, we are not talking about a few repeater stations, but a large number, and each and every one of them needs power, access roads and so on, all of which cost money.

In satellite systems, the cost of the satellite itself, plus the launch expense and insur- ▶

ance, are also massive constraints. Further, the economics of satellites are made worse by their short lifespan. The first generation of Aussat satellites, not yet completely installed, will begin to expire about 1991. In fact, Aussat has already set up a working party to begin studying the next generation.

None of these costs is going to get better as time passes. However the price of optical fibre is still going down as technology and techniques improve. Telecom's cable laying methods are also becoming more streamlined, with a combination of big tractors and small working parties providing a very cost effective solution.

Another consideration is that, in both cases, satellites and microwave, a comparison must be made on the basis of equivalent information transfer ability. The small 30 fibre cable currently being installed will have half its fibres running 140 Mbits and half running 565, leading to a total of 10,575 Mbits. In the near future this could be increased to 1.6 Gbits per fibre, leading to a total of  $48 \times 10^9$  Gbits every second, or the equivalent of about 300,000 telephone circuits. Practical microwaves or satellite systems could not approach within orders of magnitude of this figure.

It hardly needs to be said that implementing such a system in copper would need a ridiculous amount of material.

None of this particularly concerns Wayne Knowland, who is heading the Aussat team specifying the next generation of Australian satellites. He sees a communications regime during the 1990s in which the various components of the communications system provide only the services they are good at.

For instance, point-to-point transmission will almost always be done via optical fibre. The exception might be routes where the terrain is so difficult that microwave radio is a better bet. Services into remote areas, and broadcast services from one transmitter to many receivers will almost always be carried by satellite. This implies that many of the broadband applications of Aussat, studio-to-studio TV for instance, or Sydney-Melbourne computer traffic, will run on fibre, while telephone and broadcast traffic into remote areas will go on the satellite.

## Other users

The telecommunications organisations are the spectacular users of fibres, and according to some studies, soak up to 80% of all investment dollars in the country, but they are not by any means the only ones, or even the most important when considered in terms of their effect on employment or research. Other companies concerned with smaller applications are beginning to employ many people, and a large amount of engineering expertise is going into some of them.

For instance, in Adelaide, an opto-electronics company called Quentronics is getting together with the Queen Elizabeth hospital to produce a machine that can excise tumours from internal body organs without surgery. It employs a high powered laser and an optical fibre which can be fed into the body through one of the standard orifices. The fibre is then guided to the site of the problem and the excision made by burning through the tissue. Using such techniques, major surgery can be turned into fairly trivial procedures that can be done without anaesthetic.

A similar idea is used in remote probes that use fibre to retrieve images from normally inaccessible places like cable ducts, or the interiors of pipes, pumps and tubes. One such instrument, called Videoprobe 2000 and available from Panametrics, displays its image on a TV screen for ease of viewing.

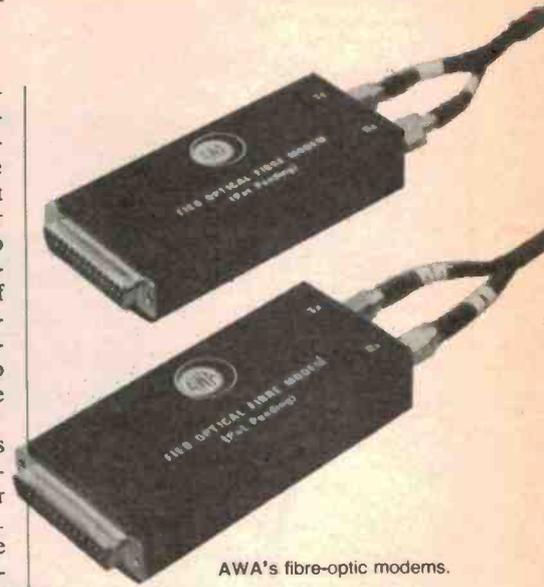
In Queensland the railways are using optical fibres to run down the side of 1190 km of electrified tracks to provide communications. Previous attempts to provide a communications network have been thwarted by interference from the electrical supplies to the locomotives.

In Sydney, Integral Fibre Systems has been developing a tidy little business finding optical fibre solutions to complex communications problems. Generally, fibre is used in circumstances where its peculiar mixture of characteristics can be taken advantage of. Electrically noisy environments are a natural, so are environments where there are earthing problems. Common applications are for controlling remote motors on conveyor belts in mines, or remote monitoring of programmable logic controllers.

Another increasingly common trend is in providing secure communications routes. Since fibre emits no electromagnetic radiation it cannot be tapped without physically intercepting the cable. Major banks in Australia have been looking at fibre for precisely that reason. Likewise fibre communications cannot be jammed by electronic means, a fact that has not escaped the notice of military aircraft makers. Latest generation aeroplanes routinely use fibres to control the flight surfaces.

For computer users, many companies are now putting together optical modems. A common pattern is to power the modem from an RS232 interface, send the serial information down a fibre and then reconstruct it back to RS232 standard at the other end. This forms a very cost effective solution where the computers are widely separated. It is also used where the small physical size of the fibre is an advantage when compared to an equivalent copper cable. This happens in heavily populated city buildings where duct space is often at a premium.

A typical system is being sold by Mayer



AWA's fibre-optic modems.

Krieg in Adelaide, sourced from the German company Hirschmann. It implements a perfectly standard Ethernet LAN in optical fibre. Without doubt it is more expensive than a copper system, but it allows the system to be spread over a very large geographical distance. If a standard Ethernet system extends over 500 m it requires repeaters. This is extended to 5 km with fibre. Also, annoying problems with ground loops and electronic interference are taken care of.

## Future

The future for optical fibre looks extremely bright. Costs continue to drop, both for the manufacturing associated with the cable itself, and for the techniques associated with it. Applications engineers are exploring new ways of using fibres in a variety of settings. Medical uses are possibly the most exciting. One imagines fibre in the future making the surgeon's knife close to redundant.

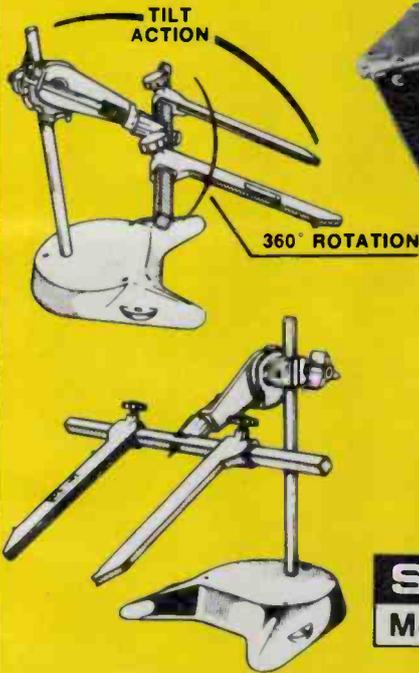
At the same time, advances in transmission technology will increase its capacity by orders of magnitude without any noticeable increase in complexity. Other things being equal, this should make it even more economically attractive.

Another trend worthy of consideration is the move to light speed information processing. The field of optical integration, in which light is treated just like electrical current and ANDed, ORed and NOTed in physically tiny integrated circuits opens up all sorts of applications which will further boost the importance of light as a communications medium.

In fact, it is probably not putting the case too strongly to say that optics represents the next stage of the electronics revolution. In this context it is a cause for concern that so little thought is being given to it by educators. Like it or not, we are all going to be seeing more of electro-optics in the future. ●

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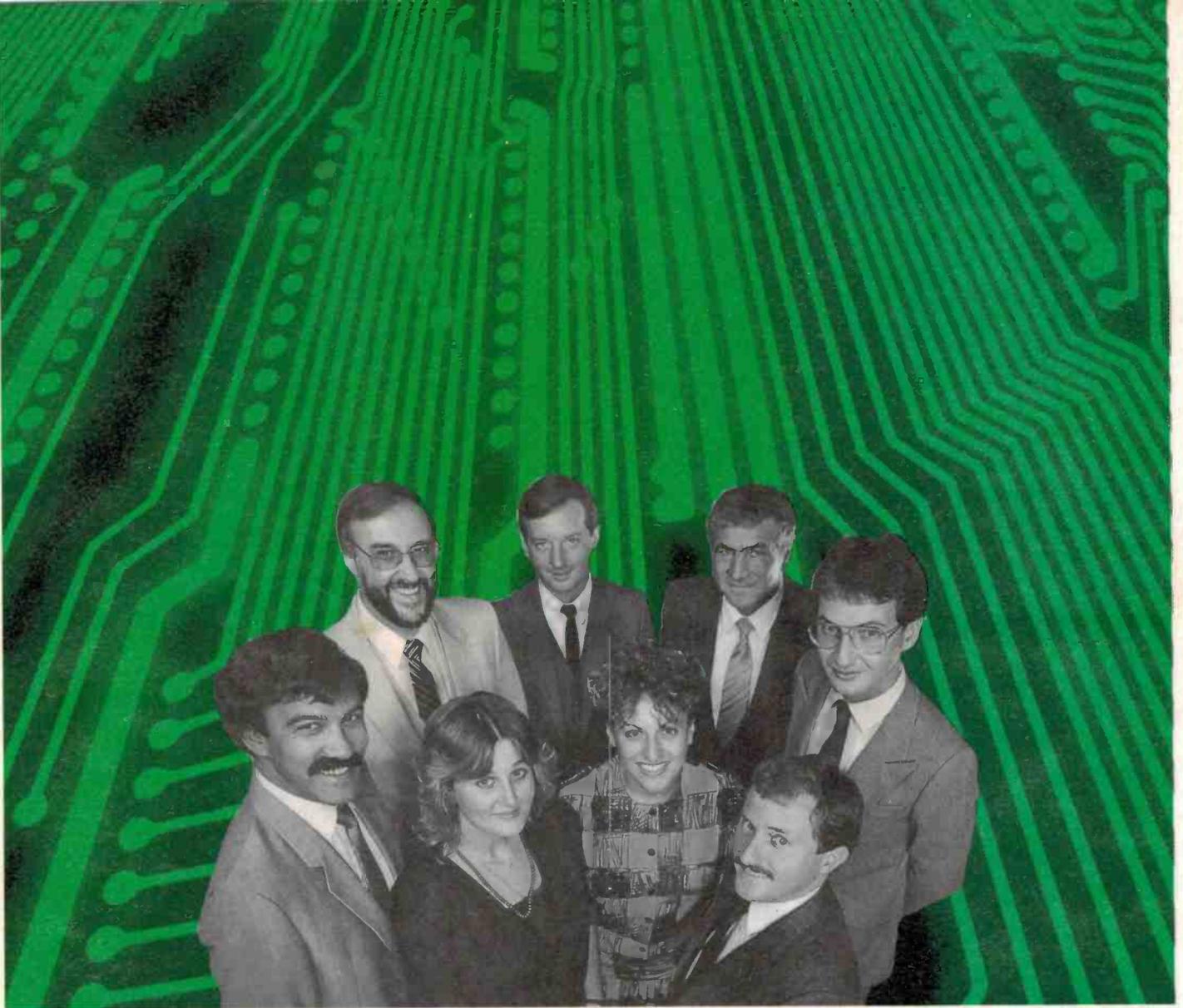


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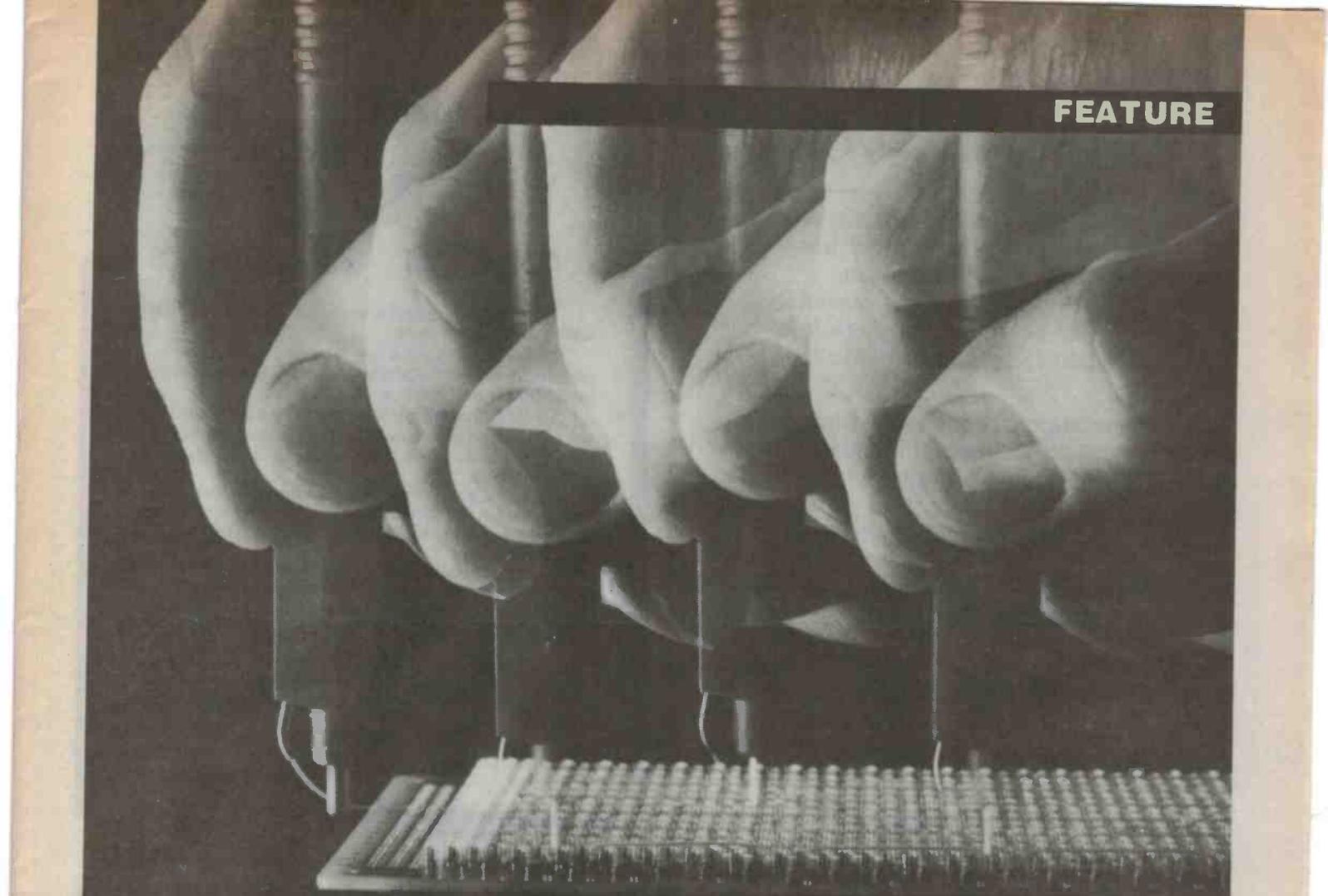
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# INSIDE THE BOARD SHOPS

Like everything else, printed circuit board manufacture marches forward, dragged by the demands of the industry it serves, lured by advances in its own techniques.

**Jon Fairall**

**SLOWLY, MORE SLOWLY** than many would have liked and most would have predicted, the future is catching up with electronic manufacturing in Australia. A whole swag of techniques and equipment is now lurching into place on assembly lines. In factories big and small, the dirt and the fumes and the noise are being replaced by computers and automatic machines. In the electronics industry at least, the day of the process worker is drawing to a close.

At the centre of the changes is the circuit board. Its manufacture used to be the seamy side of the industry, a hot house of bad smells and funny rashes for the careless. That's all going. Also changing is the way manufacturers put components into the boards. It used to be a job prized by migrant women, (the 'girls' in factory managers' lexicon). Now the machines beat fingers no matter how deft, and they don't make mistakes. Even the type of circuit boards are

changing, as surface mounting comes into view. Finally, the technician who used to sit at the end of the line testing everything is disappearing; replaced by automatic test gear.

### **Economics**

Why? As with all social processes the answer is a complex amalgum of political, economic and technological answers. Manufac-

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turing industry in this country has been through hard times. Since the Whitlam government lifted the tariff barriers in the mid 70s it's been out of fashion. Perhaps the nadir was reached when Barry Jones, Labor's mercurial Science Minister, published his influential *Sleepers Awake*, in which he argued that the future of Australia lay not in manufacturing, but in service industries.

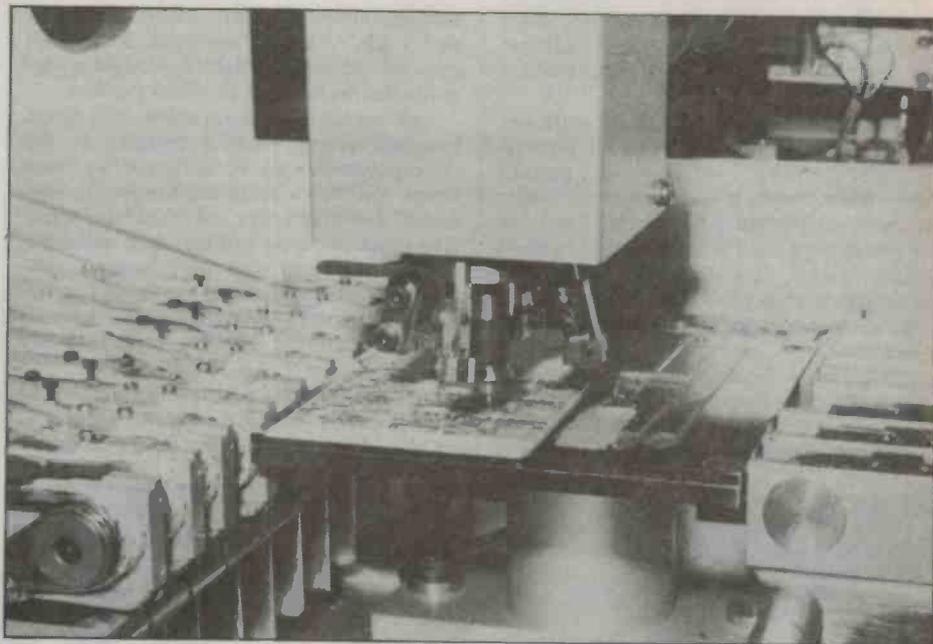
The wheel turns. The current economic wisdom is increasingly that the future belongs indeed to manufacturing. Not in the old way though. Not hidden behind trade barriers, not relying on 20 year old processes, but efficient, lean and hungry: competitive with anyone in the world. Interestingly, Jones and Trade, Industry and Commerce Minister Button have been two of the strongest converts to the new economic religion.

Daily we see the steady debunking of the twin pillars of the Australian economic system: mining and farming. In the early 80s the mining boom went bust; today good hearted ladies in the cities are making up food parcels to send out to farmers who can't make enough to pay their own food bill. It's rather reminiscent of the days when Australians, with infinite condescension, sent food parcels to Britain. It's a far cry from the days when the farmers carted swill to the pigs in the boot of a Mercedes Benz.

### New techniques

So the new saviour is sophisticated manufacturing. Not salt of the earth stuff, grubbing around in the bowels of Dante's inferno, but computer aided, clean room, anti-static, high quality, very clever manufacturing. New technologies are making it possible to make fundamental changes to both the structure and the competitiveness of Australian electronic manufacturing.

From the beginning to the end of the manufacturing process, processor-based equipment is aiding workers and adding to the value of the final product. At the front end, computer aided design equipment is helping workers to design boards (a follow up article next month will look at computer aided design in some detail). The output from CAD machines is used to control



A pick 'n place machine used for surface mounting components (courtesy Philips).

other machines further down the line in a way that can make it possible to build a complete board almost without human intervention.

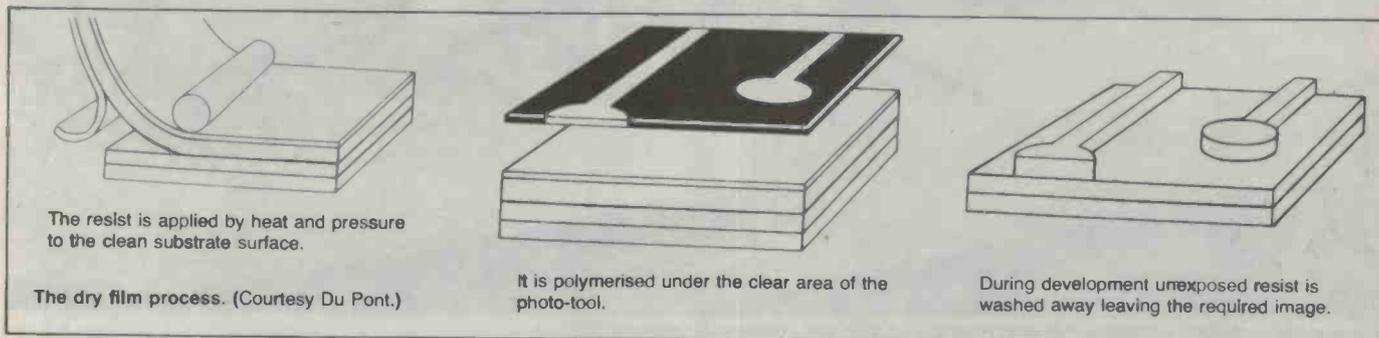
For instance, numerically controlled drilling machines are now almost standard equipment in board shops around the country. They have one or more drill heads controlled on two axes by computer-guided stepper motors. The computer divides the board up into a grid with 0.1 inch centres, then positions the head over any intersection on the grid with an accuracy measured in tens of thousandths of an inch.

Meanwhile, increasing board packing density (the number of components per square centimetre) is prompting designers to demand narrower tracks. Narrow tracks can be laid more easily between pins, making it possible to route them more efficiently. At the same time, the components themselves are needing less and less current to perform their functions. As a result, the current carrying capacity of the tracks (proportional to their cross sectional area) is less critical.

Until fairly recently, track sizes varied between a millimetre and perhaps 0.5mm, using screen printing techniques. Today, sophisticated shops are using dry film techniques, in which the board to be etched is laminated to a layer of organic polymer which acts as a resist. According to Michael Brinsden, Managing Director of Printronics, a Sydney based board shop, these techniques allow track widths of 0.18mm. This allows two tracks between pins routinely, and three with special care.

To go beyond this level of precision, however, is very difficult. According to the Du Pont company, which makes many of the photographic polymers used in imaging circuit boards, the practical limit of photographic techniques is about 0.1mm. Most manufacturers would be less optimistic.

Problems start to manifest themselves in the material used and the manufacturing environment. For a start, the board material itself must be built to a fine degree of tolerance. A 0.25mm hole in the copper, for instance, is insignificant at millimetre technology but will cut narrow tracks. Cleanli-



## FEATURE

ness becomes extremely important, since dust mites will destroy the board. All this has implications for the economics of board production.

Another factor is that a solder mask becomes essential. A solder mask is a layer of polymer applied all over the board except in areas where solder is required. Since solder does not stick to the polymer the board can be pre-wetted, and solder reliably applied where desired, thus eliminating, or at least reducing, bridging between the tracks. It also serves as a protective layer for fine trackwork.

Even more fundamental problems are caused by the physics of the situation. For instance, in the imaging process, it is necessary to shine light on to the board, passing

through, at the very least, a layer of artwork and a layer of resist material. Refraction and distortion of the light rays begin to degrade the accuracy of the final product.

One solution to the problem is a direct imaging system whereby imaging of the photopolymers can be achieved by laser beam. Du Pont's Technical Marketing Specialist, Ted Messenger, says that laser sensitive products, now commercially available can be interfaced with laser imaging technologies, thus alleviating the need for artwork. Extremely fine tracks can be defined, limited only by the chemical action of resists and so on.

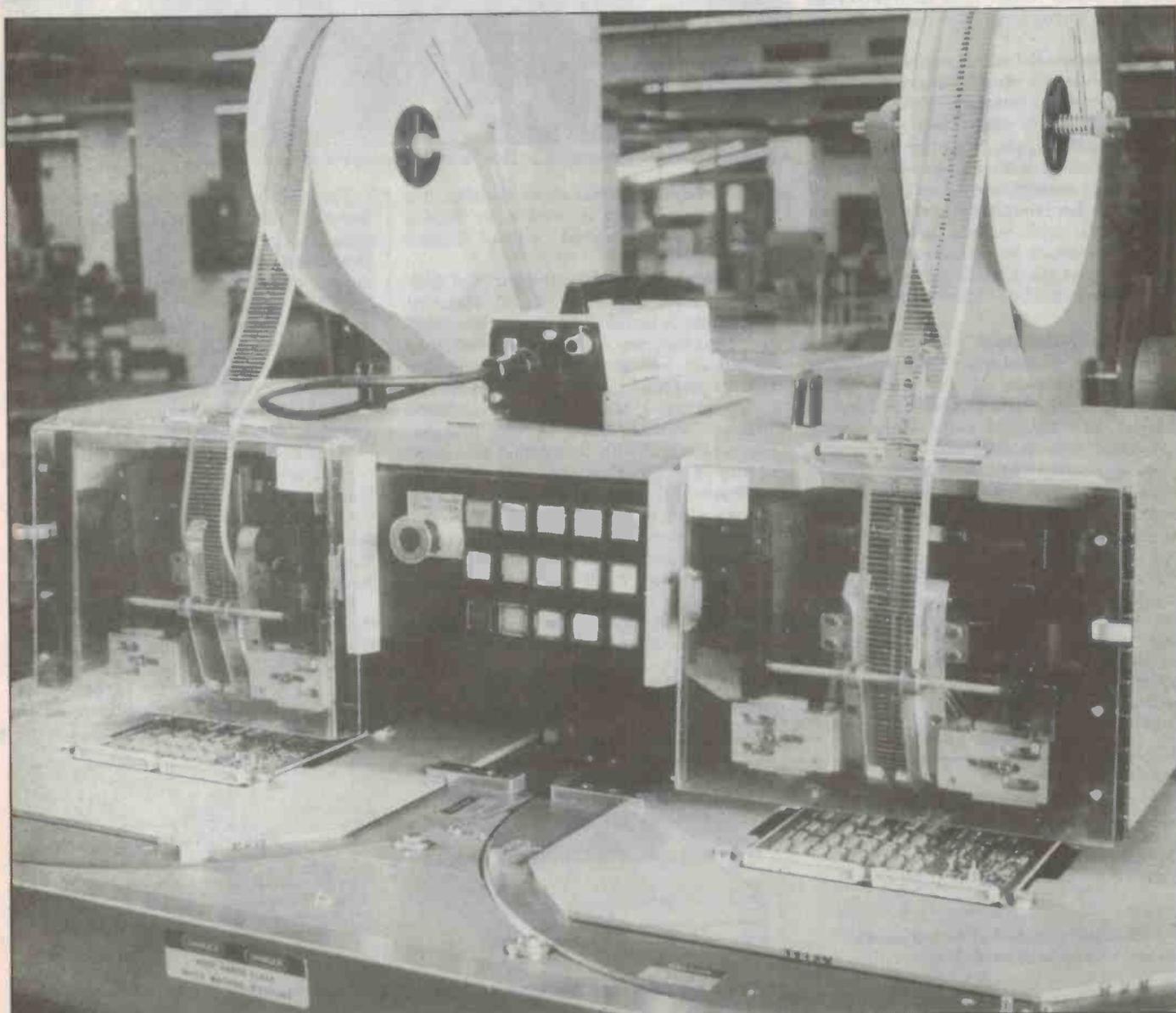
Beyond this, the next level of sophistication is called multiwire technology and is produced under licence by the Perth based

Circuit Technology. Multiwire involves burying fine threads of copper in the molten epoxy of the board during the curing process. It has obvious problems in terms of flexibility of use, but it does have the tremendous advantage of allowing extremely high board density.

The other way to achieve great density is through multilayer boards. Current state of the art is probably at Morris Productions in Sydney, where 14-layer boards for the FA-18 radar are being produced under an offset agreement for Hughes Aircraft.

### Stuffing

Probably nowhere are changes occurring at a greater rate than in the board stuffing part of the industry. Here automation is



A computer controlled automatic insertion machine for axial lead components (courtesy STC).

taking the sweat out of virtually every process in the shop. At centre stage are the automatic insertion machines, most notably from Dynapert, a US manufacturer.

Insertion machines for boards come in three types: axial, radial and DIP, depending on the type of component to be assembled. Axial components require a machine to bend the leads so they are parallel to each other. They need a different type of machine from radial components. DIP insertion is usually done using a vacuum to lift the chip and place it in the correct position.

It goes without saying that all these machines must work to a remarkable degree of accuracy. This is provided in the first place by computer control. Usually, the same program as that used to control the drilling machine is used in the insertion machine as well.

There are large numbers of these machines already in service in Australia. Indeed, most board shops seem to have made some concession to this level of technology. However, even before it is fully in place, it is being overtaken by surface mounting.

### Surface mounting

Surface mounted devices (SMDs) do not have leads. Instead they are glued to a circuit board and then pins are soldered to the tracks. The process of mounting the boards has to be done automatically by so called 'pick 'n place' machines because of the extremely small size of the components and the difficulty of identifying them.

There are a number of advantages to surface mounting: small board size, and thus improved economic and electrical characteristics for instance. Also, all SMDs can be mounted by one machine, thus reducing the capital costs involved in setting up shop.

This saving can be considerable. While Dynapert sells inserters of one type or another for upwards of \$100,000, the same company sells pick 'n place machines for \$55,000. Since three inserters are needed to fully automate a line, the real saving is considerable.

However, manufacturers are only slowly coming to the party. Mark Riley of Penn Central, which sells Dynapert machines in Australia, sees the problem lying with many manufacturers questioning whether the possible market in Australia justifies the capital outlay. Says Michael Brinsden of Printronics: "We must be careful of climbing on to a technical bandwagon," and points to the high price of surface mount components compounded by supply problems.

Others attribute the slow start of SMDs to simple conservatism rather than any rational consideration of the economics of the situation. Colin Casey of Royston Engineering says "the full impact of SM technology is still two years away". This reflects the situation in the US where it is still drag-

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## FEATURE

ging its heels. He argues that supply and cost will take care of themselves as demand in Japan continues to increase.

One rather interesting variation on this theme is offered by the German company Schlup, represented here by Meltec, which offers a semi-automatic facility. The dispensing of glue and components is done under operator control. According to Meltec's Ian Mathieson, this saves considerably on initial capital costs, and makes it possible to change rapidly from one board to another.

There is another reason for hesitancy by some manufacturers, and that is the impermanency of the SMD technology. Many see SMD as a transitional technology on the way to a further level of integration called chip-on-board. With chip-on-board, the silicon substrate is actually bonded directly to the board itself, connections are made with gold-thread, and the whole unit covered in protective plastic. This type of technique is already tried and proven in hybrid manufacture, however, the economics of automatic insertion technology will have to improve considerably before it becomes viable in most areas.

### Soldering

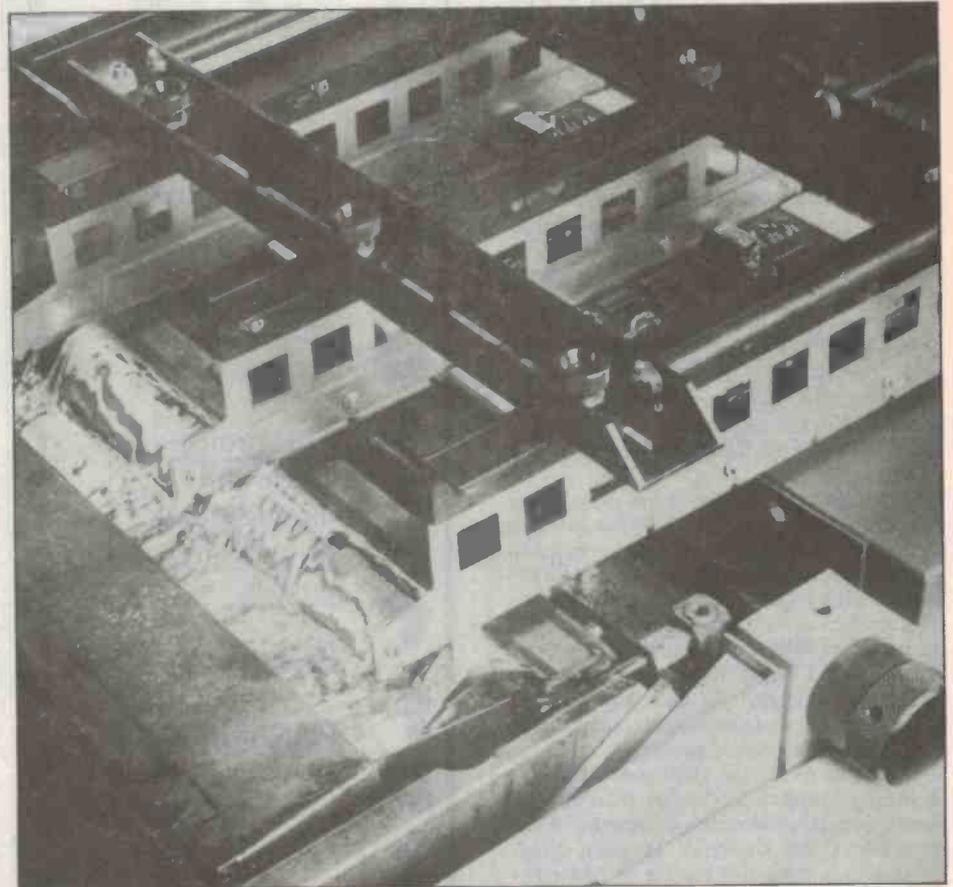
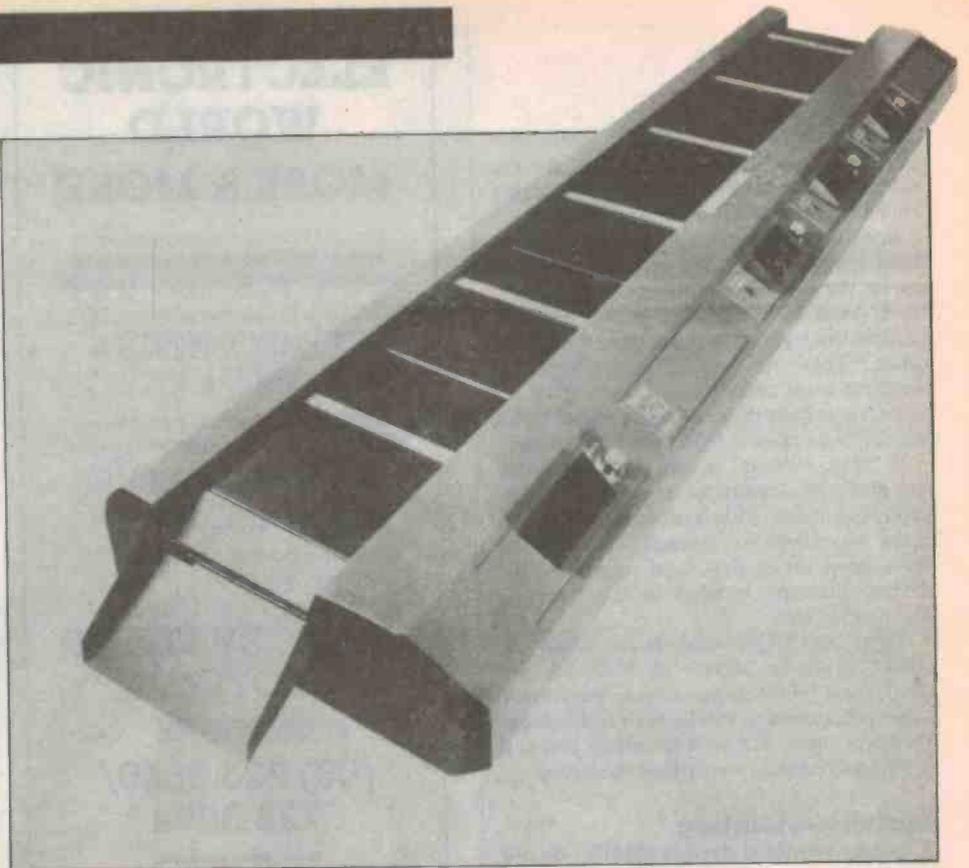
Accompanying the move to automatic insertion is a parallel move to more efficient and economical soldering techniques. Irrespective of technique, all soldering machines on the market, and there are many, come as a 'black box' in which you put the boards in one end, and they come out the other end with components correctly soldered.

The first and still the most common technique is wave soldering. In this system the board is pulled over a bath of solder by a conveyor belt. In the centre of the bath is a wave, created by pumping solder up from the bottom of the bath. The solder in the wave washes over the bottom of the board and sticks the components down.

Over the years an enormous amount of research has gone into examining the exact geometry and number of waves in the bath, with a view to increasing the reliability of the joints and reducing bridging problems. The latest development from Hollis in the US is the hot air knife. This directs a blast of hot air at the bottom of the board as it emerges from the wave, hopefully blowing away any solder that might form icicles or bridges.

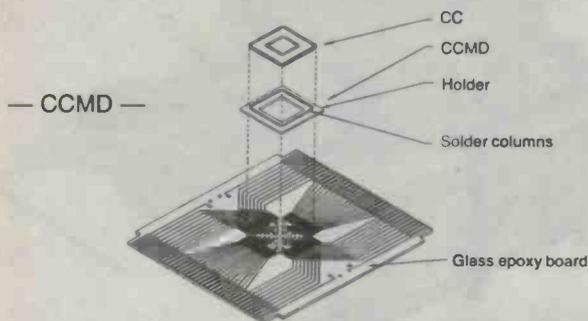
Typically, computerisation is also at work on the solder wave machine, controlling all the important parameters in the process, such as the solder temperature, flow rate, board speed and so on. The beauty of this process is that it is now possible to guarantee a consistent result right through the job.

But now the solder wave type machine is under threat. The new challenger is reflow



Wave soldering. A board carrier finishes its run over the wave of solder. Above: The alternative to wave soldering is the belt reflow machine.

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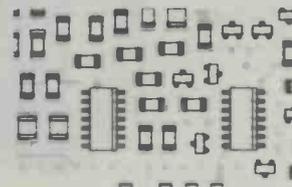
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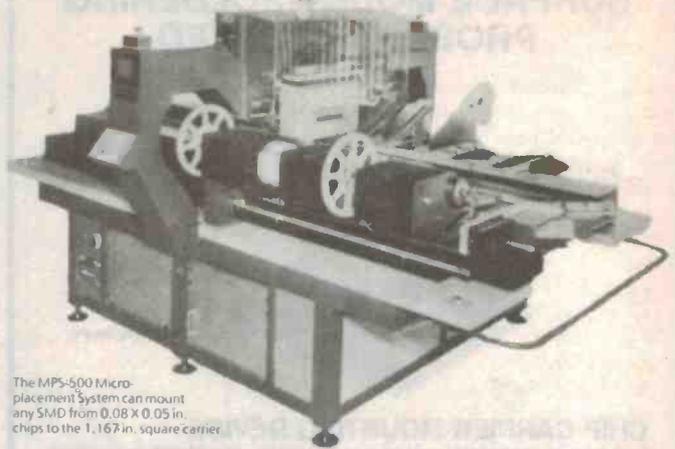
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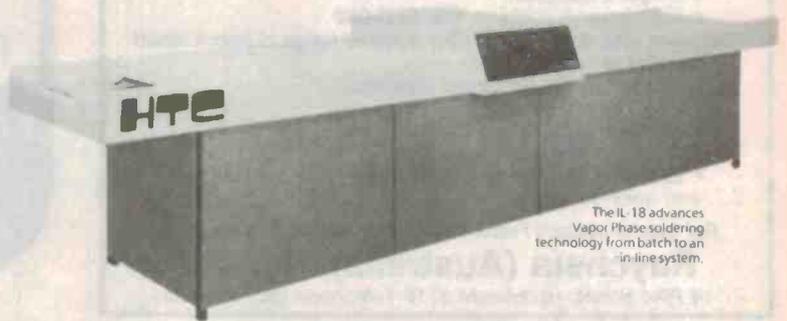
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soldering. Although it's been around since the late 60s, reflow is now starting to make an impact, if only because of the introduction of computer control and SMD techniques at more or less the same time.

In a reflow system, the solder is first added to the board, usually in the form of a paste. Often this is part of the original etching process. However it's done, when all the components have been loaded, the assembly is heated, the solder melts (reflows), and components are joined to the tracks.

The major controversy is over the method of heating. Vapour phase and infrared appear to be front runners at the moment, with claimed advantages of reliability and lack of thermal shock. In the vapour phase system the board is plunged into a hot but inert gas. In infrared systems, heating is achieved by exposing the board to infrared radiation.

Hedinair is an English company with extensive experience in both technologies. It claims advantages of tremendous flexibility for the vapour phase system, since all the important set-up parameters of the soldering station are virtually independent of the devices to be soldered. Double-sided, SM or plated-through technologies can all be handled at the same time.

Infrared, on the other hand, is vitally affected by the size and shape of the components on the board, since one component can easily shadow another one. However, infrared is very accurately controllable, so this may not be as much of an operational problem as it sounds. Its advantage is size. Fully professional units will sit on a bench top, or can be integrated into an assembly machine.

## Testing

At the testing stage, computers have made massive inroads to the production scene. There are two types, both produced with varying degrees of intelligence and thus user friendliness: static and dynamic testers. A static tester injects a potential on to certain pins and measures current into the others. It's very useful for testing the efficiency of the soldering process and the integrity of tracks and so on. In fact, static testing is often carried out by the board manufacturer to ensure the quality of its product before it's soldered.

However, for testing boards full of components its use is rather limited. For in-circuit testing, especially when complex ICs are involved, the best testers are dynamic. They input a signal similar to those that will be experienced in actual operation and watch the outputs.

Most modern systems have learning functions. These will look at a known good board and learn the expected results. The operator must then go through and specify tolerances but once that is done, the



At STC components are checked against the specification documents (courtesy STC).

machine will reject any board that does not measure up.

One of the largest problem areas is the actual physical connection of the test equipment to the board. Usually, the board is tested using a 'bed of nails'. This consists of a stand of vertical pins, each spring loaded and located in line with every pad on the board. The board is then sucked down by a vacuum on to the bed, and appropriate measurements taken.

The problem is that in some manufacturing plants the probability of a fault developing in the mechanical connection between the bed and the pads is at least as great as an actual problem on the board. In an attempt to solve this, provision is made in the design of the board for pads that are specifically tailored to the needs of the nails and the test routine. But according to Bruce Stephens, Director of Manufacturing at STC, even this has not been completely successful and there is a move towards testing via purpose built circuits on the board, or via edge connectors.

A typical modern piece of automatic test equipment (ATE) is being developed by Tony Richardson of Binary Engineering in Sydney. It's a rack mounted device containing a central processing unit. On one side the board is connected into the ATE via a bed of nails or edge connector, or indeed any arbitrary connection device, and on the other side a set of test instruments: signal generators, counters, oscilloscopes and whatever, connected via standard control buses. This set-up allows the user to define with absolute freedom whatever tests s/he requires, and to make any sort of measurement. At the moment Richardson is work-

ing on learning software for his device, which he hopes will sell for about \$30,000.

## Quality control

The implications of all this for quality control are major. In the big companies: STC, Ericsson and AWA, there has been a long and on-going procedure for checking the quality of product going out the door. In the past it tended to be a one stop arrangement. When the product was finished, it was inspected. If it failed, it was sent to a technician who fixed it by hand. It was an overhead on the whole manufacturing process born of necessity.

The existence of cheap, computerised test facilities has made it possible to check at much lower levels within the factory.

At STC for instance, they have done away with the whole idea of the assembly line and instead introduced cells in which a small number of workers carry out a sizable proportion of the manufacturing task. It's an arrangement that not only alleviates the boredom of assembly line work, but it also makes it possible to check the work as it's done. This means that product coming out of a given cell is theoretically always perfect, thus preventing any wasted effort further down the line.

At small companies which includes the majority of board stuffers, the same idea of checking as soon as practical has also taken off. At General Power Tools in Penrith NSW, Fred Morris has divided his factory into sections such that each product batch is tested at every stage of manufacture before it goes any further. There are extra problems in an operation like his though, because of the small size of individual runs.

## Imports

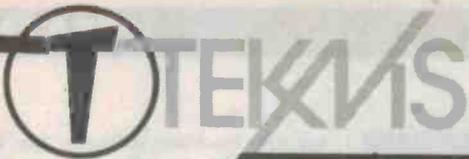
Nevertheless, the overheads involved in quality control seem to be welcomed by most manufacturers. This is not as paradoxical as it seems because it allows the local manufacturers to compete with the sweatshops of Asia on their own terms.

For a long time local shops have sat and watched engineers fly their designs out to Hong Kong or Singapore, secure in the belief that both price and reliability was better in Asia than here. For the first time, they have a means of fighting back. Automation means quality control as a matter of course.

The cost of labour, once the albatross around our necks, is becoming irrelevant.

Not that we are having it all our own way. In many respects the Asians are a moving target, at least in price terms. Prices for board and assembly have been driven down by excess capacity following the downturn in the US market. But it's not a situation that is likely to continue.

What will continue is the reliability and quality of the local product, and hopefully an even more competitive pricing structure. ●



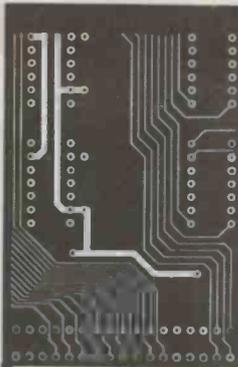
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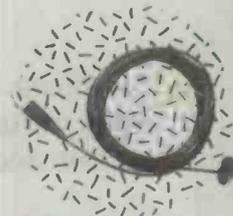
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# THE ALPINE VIEW

## — Alpine 5900 car CD player

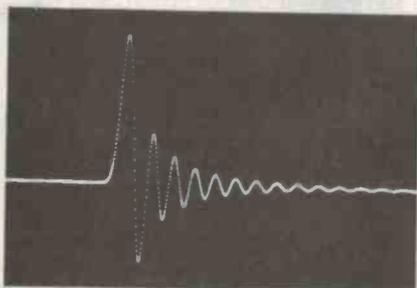
Louis Challis

## ALPINE 5900 CD PLAYER

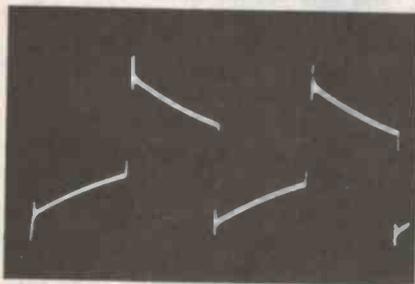
Dimensions: 178mm (wide) x 50mm (high) x  
155mm (deep)  
Weight: 1.8kg  
Manufacturer: Alpine Electronics Inc, Japan  
RRP: \$1546

The Alpine 5900 sits loftily as the most expensive CD player selling in Australia. For your extravagance you get some fresh features and a top performance.

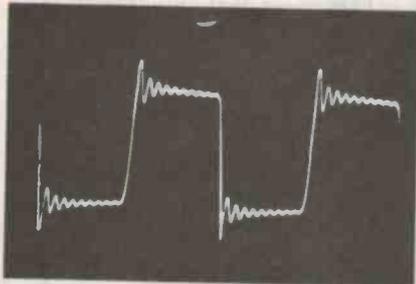
## Response curves



Impulse wave



Square wave at 100Hz



Square wave at 1kHz

VARIOUS PIECES OF electronic equipment have their devotees and it seems that the latest Alpine AM/FM car cassette players have a somewhat unusual 'fan club'. Members will stop at almost nothing to get their hands on one or more of these pieces of equipment. That the equipment in question is someone else's property is really of little interest because this fan club works at night with bricks, hammers, jemmys, screwdrivers and other assorted tools to remove the latest versions of Alpine 7155E and 7273E units, which they know are fitted as standard equipment to recent SAABs (amongst other cars). You might ask how I happen to be aware of such trivia? Well, a member of staff and I have new SAABs, and both of us have had our Alpine units stolen.

With such nefarious admirers, it is questionable whether you need friends to admire your equipment, and it was with some misgivings that I proceeded to evaluate the Alpine 5900 compact disc player.

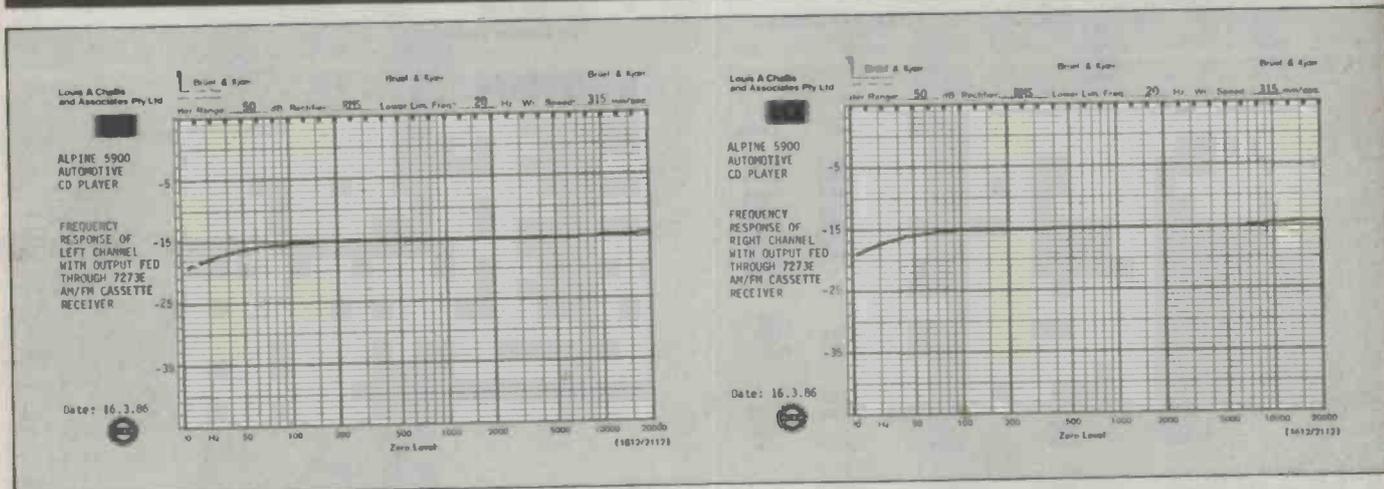
The 5900 automotive CD player requires an appropriate FM/AM cassette player or external amplifier to provide the amplification and interconnection facilities to utilise the unit. The Australian importers provided us with a top of the line 7273E unit with a base power level of 2 x 20W output and appropriate PRE OUT/IN interconnecting cable facilities. Before I realised that the 7273E was not intended to be reviewed, I had evaluated its objective performance characteristics as well. It was only after I finished the testing and subjective reviewing that Alpine provided a DIN-to-RCA adaptor (part no 4308) to connect this unit to other brands of amplifier and more specifically to facilitate direct testing without introducing the problems created as a result of performance limitations in the FM/AM cassette player.

## Design and appearance

The front panel of the CD player is sized to match the standard DIN dimensions to which most manufacturers' units now conform. On the left hand side of the black moulded plastic escutcheon is a large concentric VOLUME and BALANCE control. The volume control is provided with a series of indents so that once a level setting is selected, it will not be easily knocked or displaced to a different level. Immediately below these controls are recessed spring loaded BASS and TREBLE volume controls which pop out on touch and similarly return to provide a neat and uncluttered access to VOLUME and BALANCE controls with which they would otherwise interfere.

At the top of the panel is a recessed slot into which you partially push a CD disc before the power loading capabilities take over. This facility literally draws the disc from your fingers and digests it within the internal workings of the unit before dropping down a dust cover. Immediately below the left hand end of the slot is an elongated REPEAT button. To the right of this is the display module which looks very much like the 7273E unit provided with it. It displays the repeat mode (ONE or ALL), as well as elapsed time (in minutes and seconds) and track number by means of a large blue plasma display. It also displays the PLAY and PAUSE functions at the right hand end.

At the lower right hand corner of the panel are eight pushbuttons with soft rear illumination. These buttons are arranged in two rows. The first two buttons, labelled M SENSOR, allow you to move progressively forwards or backwards track by track. Adjacent to these are the buttons providing conventional FAST FORWARD and BACKWARD capabilities. The next but-



ton is labelled ADI (auto disc initialiser) which returns the laser tracking system to the beginning of the disc and also functions as a partial reset button, whilst immediately below is the DISPLAY button, which flips the display between elapsed time and the remaining time and track number.

The last two buttons are the EJECT button (at the top) and the PLAY/PAUSE button at the right hand corner. These controls are accompanied by the same "bleep" when pressed, regrettably irrespective of function. A better approach would have been a different tone for each function so that you could identify the accuracy of your probing (without looking) as you drive.

One additional control which is not labelled is provided at the extreme right hand end of the power loading socket. This takes the form of a small hole which requires a sharp needle or probe tip and is the total function RESET button. This should only need to be activated in the event of a total functional failure.

The rear of the unit is provided with a number of special cables. One of these has the high voltage supply (with its noisy components) terminating its end so that the electronic interference that would otherwise be produced is sensibly located outside the main cabinet. The rear panel also incorporates a pair of multi-core cables fitted with specially moulded and unusually large DIN sockets. These have locking facilities into which a matching pair of normally intercon-

nected plugs and sockets (on the 7273E unit) are then plugged. These cable harnesses simplify the interconnection and powering of the unit for minimal problems when fitting the unit into the dashboard.

Inside of the unit space limitations are, it would appear, primarily the result of the power loading facilities which not only require considerable space but, I believe, considerable ingenuity as well. The result is that the base of the unit incorporates a large mother board over which a number of supplementary printed circuit boards are installed. These are supplemented by additional printed circuit boards at the rear of the unit and at the top of the chassis immediately behind the volume control. Although beautifully executed and supplemented by appropriate ribbon cables with plugs and sockets, the unit would present some 'exciting' problems for the serviceman, if and when he has to work on it. Even so, the unit is very solidly constructed with good commercial components although, it should be noted, the resistors and a large number of other components are positively miniscule!

The main chassis and cabinet of the unit, together with the chassis frame for the laser power loading system, are well made from heavy folded steel. A closer inspection inside the chassis reveals that the laser tracking system is the well-proven Sony system, apparently as are many of the other critical components used in the system design.

## Objective performance

With the 5900 CD player interconnected with the 7273E FM/AM cassette player, we were able to undertake a slightly less than critical evaluation of the CD player's performance. As it transpires, far too many of the performance parameters are dominated by the FM/AM cassette player, rather than by the characteristics of the CD player. The frequency response is a good example of this, being controlled by the cassette player's amplifier circuitry. The performance is +1 -3dB from 30Hz to 20kHz. By referencing the measured performance of the FM/AM cassette player, it is apparent that the low frequency response of the CD player is virtually flat.

One parameter that was not affected by the interconnection was the linearity performance of the player. This is within 0.1dB to -60dB, within 0.2dB to -70dB, within 0.4dB at -80dB, and is 2.4dB high at -90dB. This linearity performance is excellent and far better than that provided by many 'domestic' CD players.

The channel separation is in no way comparable with that provided by most domestic CD players because of the feedthrough within the amplifier section of the car cassette player as well as by the interconnection cables. The separation is a modest -56dB at 100Hz, -58dB at 1kHz, -45dB at 10kHz and -40dB at 20kHz. These figures are, however, far better than you would

**MEASURED PERFORMANCE OF ALPINE CAR COMPACT DISC PLAYER**

MODEL NO. 5900

SERIAL NO. 51124134 C/22708

1. **FREQUENCY RESPONSE** 20 Hz to 20 kHz +1 -3 dB

LINEARITY @ 1kHz NOMINAL LEVEL	LEFT OUTPUT	RIGHT OUTPUT
0 dB	0.0	0.0
-1.0	-1.0	-1.0
-3.0	-3.0	-3.0
-6.0	-6.0	-6.0
-10.0	-10.0	-10.0
-20.0	-20.1	-20.1
-30.0	-30.0	-30.0
-40.0	-40.0	-40.0
-50.0	-50.0	-50.0
-60.0	-59.9	-60.0
-70.0	-69.8	-69.9
-80.0	-79.7	-79.6
-90.0	-87.6	-87.6

3. CHANNEL SEPARATION FREQUENCY	RIGHT IN TO LEFT dB	LEFT IN TO RIGHT dB
100Hz	-57.2	-56.1
1kHz	-58.8	-59.0
10kHz	-45.2	-49.8
20kHz	-40.6	-47.2

4. DISTORTION (@ 1kHz)	2nd	3rd	4th	5th	THD%
Level 0	-68.8	-73.9	-79.2	-80.1	0.044
-1.0	-68.5	-73.1	-80.2	-80.4	0.046
-3.0	-68.6	-73.5	-82.3	-80.5	0.044
-6.0	-69.1	-73.4	-80.3	-79.3	0.042
-10	-69.2	-73.8	-79.9	-79.6	0.043
-20	-69.3	-74.5	-78.5	-79.6	0.042
-30	-69.2	-74.7	-79.4	-81.5	0.041
-40	-79.7	-73.2			0.024
-50		-57.7			0.013
-60					
-70		-35.7			1.64
-80	-34.9	-27.0	-35.9	-33.6	5.40
-90	-22.1		-27.8	-13.0	19.9
(@ 100 Hz)					
0	-59.5	-73.4	-80.6	-83.3	0.11
-20	-66.4	-74.6	-83.8	-83.0	0.052
-40	-51.9	-67.9			0.26
-60	-31.7	-47.4	-54.8	-50.4	2.66
(@ 6.3 kHz)					
0	-59.2	-60.6	-76.1		0.14

5. EMPHASIS	Frequency	Recorded Level	Output Level (L)	Output Level (R)
	1 kHz	-0.37 dB	-0.4	-0.4
	5 kHz	-4.53 dB	-4.8	-4.8
	16 kHz	-9.04 dB	-9.4	-9.4

6. SIGNAL TO NOISE RATIO	Without Emphasis	With Emphasis
	56.6 (Lin)	56.6 (Lin)
	73.2 dB(A)	73.2 dB(A)

7. **FREQUENCY ACCURACY**  
(19,999 kHz) ± 2 Hz for 20kHz test signal

8. **SQUARE WAVE RESPONSE**  
(See attached photos)

9. **IMPULSE TEST**  
(See attached photo)

**DIRTY RECORD TEST**  
Using Phillips NR4A (410-056-2)

**Interruption in Information Layer**  
400 micrometer ; Passed  
500 micrometer ; Passed  
600 micrometer ; Passed  
700 micrometer ; Passed  
800 micrometer ; Passed  
900 micrometer ; Passed

**Black Dot at Read out Side**  
300 micrometer ; glitches  
500 micrometer ; Passed  
600 micrometer ; Passed  
800 micrometer ; Passed

**BLACK STRIPE TEST** (passed)

**VIBRATION OR DISPLACEMENT TEST**  
Acceleration level 16g'rms failed

reasonably require in an automotive environment.

The distortion characteristics of the CD player are almost completely dominated by the performance of the amplifier. They were measured at 0.8 volts output from the amplifier so as to limit the effects that this unit has on the figures. Between 0dB and -30dB, the distortion is typically 0.4% rising to 0.13% at the -50dB level. It is not until the signal drops to -70dB that we see any significant rise in the distortion, and by -80dB the distortion rises to more than 5%. At -90dB (where it would be impossible to hear the distortion above the road noise), it rises to 20%. The distortion figures at 100Hz and 6.3kHz are also dominated by the car cassette player amplifier distortion but it is clear that the basic CD player has particularly low distortion characteristics.

The 'emphasis' circuit characteristics of the player are reasonably accurate while the signal-to-noise ratio (relative to 0dB signal level) is still a healthy 73dB(A) even with the added burden of the cassette player amplifier. It is questionable whether you will ever be able to use that performance capability except in a boat, caravan or with the car's engine switched off.

The frequency accuracy is excellent at 2% but the square wave performance is also

dominated by the characteristics of the car cassette player, particularly at low frequencies. The impulse response is clean although it shows the signs of the analogue filter's steep 'skirt selectivity'. This characteristic also shows through in the square wave response.

The laser tracking circuitry is able to track all the nasty sections of the Philips tracking disc including interruptions in the information level of up to 900 micrometres without any sign of a problem. When it comes to the Black Dot readout test, the laser tracking system is only able to cope with surface dust and imperfections of up to 1mm (which is extremely commendable).

The player cannot cope with eccentric discs but is able to operate when vibration levels in the critical 2-10Hz region are as high as 15g'rms. This would correspond to the road conditions of many bush tracks and means that most suburban roads with pot holes would be handled adequately.

**Subjective performance**

Although I requested that the agents find a car with the CD player installed, I was unsuccessful and had to be 'happy' with a laboratory evaluation because of the complexity of interconnections. This was performed with a pair of JBL L4301 monitors interconnected to the output of the 7273E. With this

set-up in operation, the performance of the 5900 CD player proved to be exciting and I was hard pressed to detect any subjective difference in comparison with a Sony CDP-101 player interconnected with a Yamaha 101M amplifier.

Even though the performance of this unit is extremely good, I am still apprehensive at the thought of a potential user gingerly loading an unprotected disc into the loading port whilst driving. Although many users may develop the necessary skills of holding the disc by its edges, I feel they will be the minority.

The Alpine 5900 CD player has been designed to cope with disc 'grabbing' and even re-ingests the disc if it is not withdrawn from the slot within 15 seconds. Even so, the laser tracking system has to cope with many other problems including dust, grime, and dirty fingers, all of which will ultimately take their toll.

At this early point, our testing indicates a performance coping with most of these problems.

The Alpine 5900 automotive CD player is an excellent unit and certainly provides overall advances in automotive music listening potential when compared to an AM/FM cassette player. However, with its recommended retail price at \$1546 the importers may have limited the size of their market. ●

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Ref. EA June 1986  
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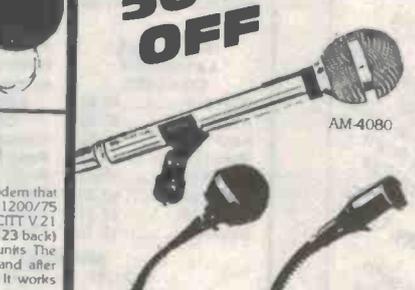
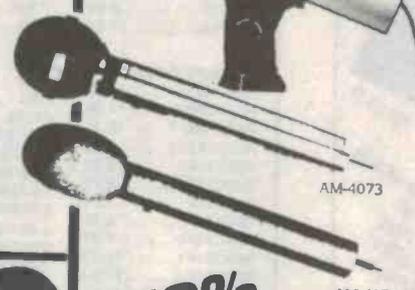
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# GLITTERING GOLD

## — Tannoy M20 loudspeakers

Louis Challis



Tannoy has emerged out of the shadows of the giants of speaker manufacture, glittering. The new M20 "Gold" Loudspeakers reflect some design innovation and pride.

### TANNOY M20 "GOLD" LOUDSPEAKERS

*Dimensions:* 530mm (wide) x 570mm (high)  
x 315mm (deep)  
*Weight:* 5.5kg (each speaker)  
*Manufacturer:* Tannoy Ltd, United Kingdom  
*RRP:* \$799 (per pair)

TANNOY IS ONE of Britain's oldest and probably its best known manufacturer of loudspeakers. Until the mid 50s, Tannoy had a virtual strangle-hold on the supply of studio monitors in the UK and provided the BBC with nearly all its critical loudspeakers. In the late 60s and early 70s, the company was eclipsed by a number of other notable English, European and American speaker manufacturers which devoted much more money to research and were thus able to produce more exciting speaker systems.

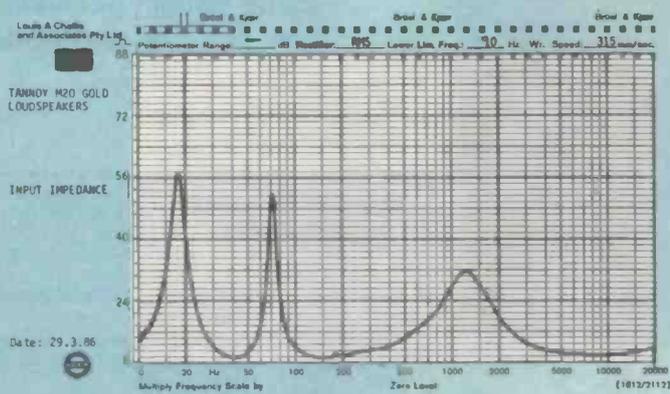
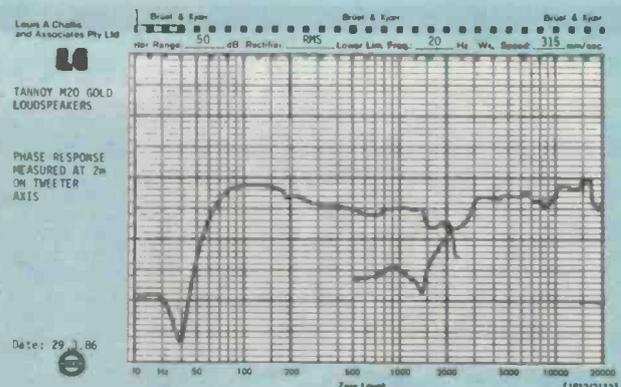
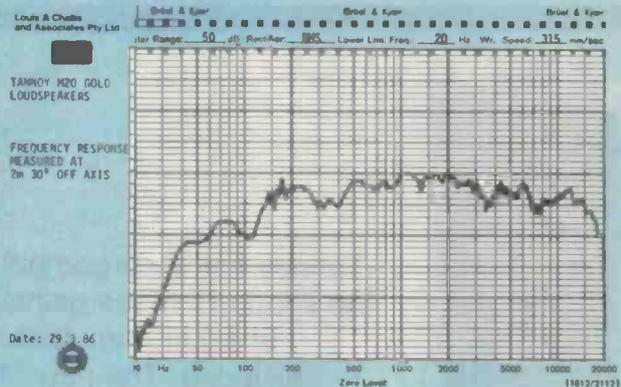
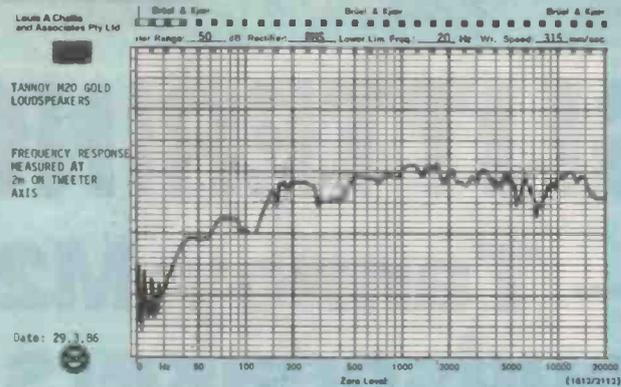
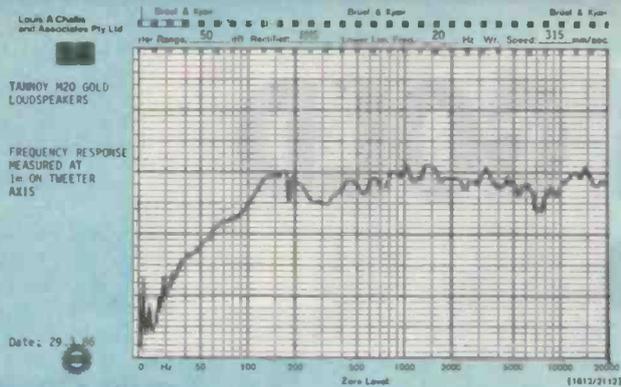
At this time, Tannoy placed its 'blind faith' in the attributes of its coaxial loud-speaker systems and this, to a large measure, proved to be its undoing. A coaxial

loudspeaker with the supplementary tweeter cone directly coupled to the woofer cone at the edge of the voice coil is just too much of a compromise to work efficiently and effectively at both ends of the audible spectrum. Whilst the low frequency end works out reasonably well, the mid and high frequency ends exhibit various objective and subjective deficiencies that 'not all the blarney' in the world can hide.

It took the management at Tannoy far too long to realise that they were thrashing a dead horse, but when they did, they reapplied their research effort to more conventional tried and proven recipes for loud-speaker configurations.

A number of Tannoy's late 70s designs and even early 80s designs still lacked the refinements and performance that the market place demands (see ETI June 1983) and Tannoy went back to the drawing boards yet again.

The recent M20 "Gold" system is one of the smallest bookshelf speaker systems that Tannoy has marketed to date, yet it contains a number of well-chosen refinements and unusual design features which go a long way towards achieving the superlative performance that most intending purchasers are seeking.



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## Design and appearance

The M20 has an overall volume of approximately 90 litres, which means that the cabinets have a particularly small volume especially as the designers have opted to use a conventional venting port to extend the low frequency performance. Most manufacturers use a sealed air-loaded enclosure for such a miniscule volume as this tends to result in a smaller number of resonances and fewer overall design problems. The venting port, which has a diameter of 47mm and a length of 80mm, is located immediately below the 200mm diameter woofer, which is itself of a rather unusual design.

The effective diameter of the woofer is less than 150mm and the cone is constructed

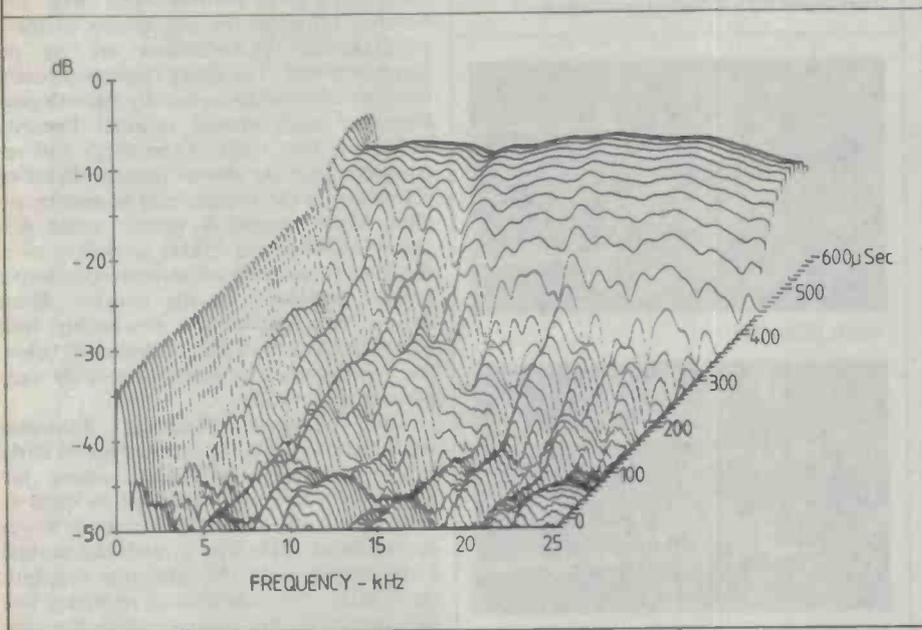
from an unusual translucent polyolefin copolymer, which allows you to view the speaker bracket and voice coil connection leads through the diaphragm. Although the visual effect is not exciting, the polyolefin copolymer is a mighty tough material, appropriate for this demanding service.

The outer edges of the speaker diaphragm are flexibly connected to the inner ring of the speaker basket frame by means of a rolled-EPDM rubber surround, about which I will have more to say later. The active portion of the speaker diaphragm has a far smaller area than appears at first sight and consequently, the acoustical output of the woofer is remarkably efficient when the real area of the speaker is considered. The

woofer's voice coil diameter is 25mm and the speaker magnet appears to be a fairly conventional high energy ferrite assembly designed for reasonably high amplitude (long throw) movement of the speaker.

The tweeter is also of unusual design and, like the woofer, uses a fairly esoteric diaphragm material. In this case, the diaphragm is a soft dome, plastic impregnated, woven material carefully selected to achieve a wider polar dispersion or radiation pattern than most of the comparable units on the market. This diaphragm is directly connected to a 25mm diameter voice coil, which ensures that its power handling capacity and peak output are way above average.

Decay response spectra.



The tweeter diaphragm has been supplemented by an "acoustic matching plate" which Tannoy claims ensures improved acoustical output to the surrounding air mass. It is also to provide an enhanced wide listening window with simultaneous improvements in the frequency linearity at high frequencies (2kHz to 20kHz). This matching plate uses a simple tapered inner edge profile, extended radially into a flush face plate element. The tweeter arrangement sits flush with the face of the speaker cabinet to provide optimal propagation over the primary frequency range. This seemingly obvious approach has been overlooked by most other speaker designers and, when correctly implemented, can readily tailor a specific portion of the frequency response to modify its characteristics. A little more thought leads one to the obvious conclusion that by introducing extended contouring of the taper, wider and more significant enhancement could be achieved over a greater range of frequencies.

All the primary exposed surfaces of the cabinet, as well as all the front surfaces which are not normally exposed, are well finished with genuine walnut veneer. With the cloth-covered, tapered face speaker grille attached (by means of plastic plug-in clips), the unit presents an extremely neat and particularly attractive appearance. The cabinet is constructed from moderately heavy medium density particleboard, the surfaces of which are reasonably well damped on the top and bottom panels, but not as well damped on the two sides or rear.

The inside of the cabinet uses a glue bonded open cellular urethane foam on all secondary surfaces and the speaker cross-

over uses hard-wired second order low pass and high pass filter sections, which are screw fixed on the inside of the back panel. The recessed speaker terminals use a pair of gold-flashed screw terminals of unusual design, which will accept both spade lugs or bared wires up to 4mm in diameter.

### Objective testing

I was a little apprehensive before the first stage of the objective testing, as I had previously been very critical of the Tannoy "Little Red" monitors. The first series of tests to determine frequency response in my anechoic room, revealed a rather unusual phenomenon, namely a strange notch in the response at 180Hz which the second speaker also showed. A closer examination of the speaker revealed something that neither my staff nor I had seen for quite a while. The design of the speaker's rolled flexible edge gives rise to a 'rim resonance' effect where the flexible surround interacts with the oscillating section of the diaphragm to produce an effective null at one specific frequency. This cancellation phenomenon is both frequency and position dependent, so that the interference frequency drops with increasing distance from the speaker cabinet. The interference is more significant when measuring on the direct axis of the speaker and is relatively insignificant at 30° off-axis. You would be hard pressed to easily hear or even detect this interference phenomenon during normal programme content because of the selectivity of the interference pattern, but it did disturb me for more than a few minutes until I worked out what was happening.

When I had overcome my initial distract-

tion, I was able to observe that the frequency linearity of the M20s from 100Hz to beyond 20kHz was remarkably good and, although the output dropped off fairly quickly below 100Hz, it was still reasonably good all the way down to 60Hz. With increased measurement distance from the face of the speaker (on-axis measurements at 2m), the picture did not change markedly although the interference between the venting port and the woofer does affect the shape of the low frequency response in the 80Hz to 140Hz region.

The response at 30° to the main axis is still exceptionally good and the output at 20kHz is only 6dB down from the on-axis response, which is more a credit to the designers of the tweeter than it is to the designers of the system. The near-field measurements at 5cm from the face of the woofer and tweeter revealed that the cross-over frequency is approximately 2.2kHz, rather than the 3kHz frequency specified in the technical literature. The woofer response is particularly smooth and when measured at such close proximity, the problems of interaction with the venting port are insignificant.

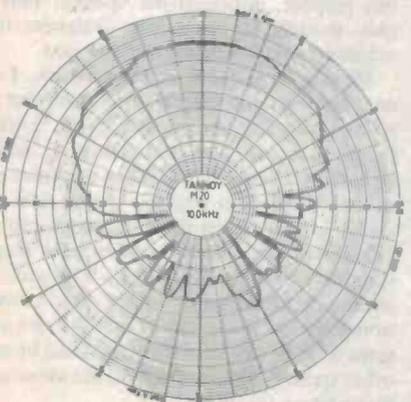
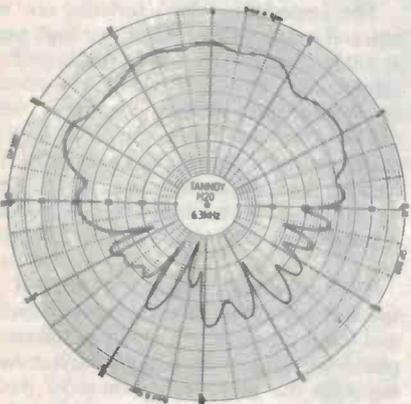
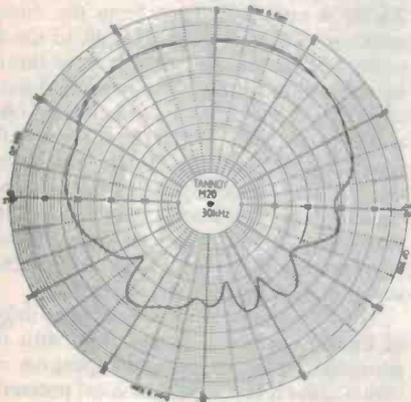
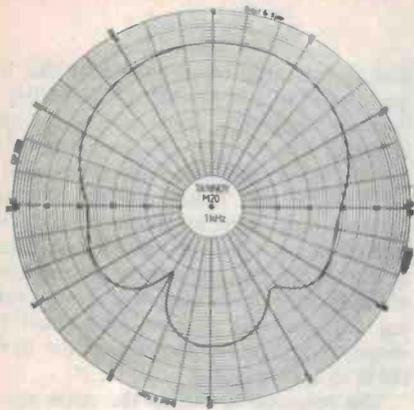
The frequency response exhibits a degree of linearity which is comparable with that provided by many monitor speakers and which quite a few would be hard pressed to match.

The impedance characteristics are very unusual in that they exhibit two high peaks at 18Hz and at 71Hz where the impedance values are 57 and 51 ohms, respectively. Whilst most modern amplifiers would not be disturbed by such unusually high impedances, there is always a possibility that cheaper amplifiers or even low-powered amplifiers would be driven into overload or instability as a result of these characteristics.

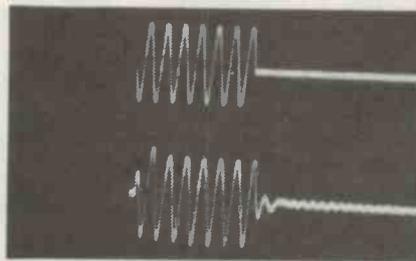
The measured phase response of the speaker proved to be exceptionally smooth and the level recording exhibits a degree of phase linearity which is very much in keeping with the more comprehensive picture provided by the decay response spectra. In this respect, although the speaker may be only modest in price, the designers have achieved very commendable results.

Having seen these characteristics, I was not the least bit surprised to find that the polar responses are equally good. Each of the plots recorded at 1kHz, 3kHz, 6.3kHz is clearly excellent. The 6.3kHz response provides a bandwidth which is within 6dB over an arc of 150° whilst the bandwidth and uniformity of the response at 10kHz is outstanding at within 6dB over a 110° arc. The overall performance within the conventional specification arc of 60° is more than somewhat better than that provided by most other quality speakers selling at two or even three times the price.

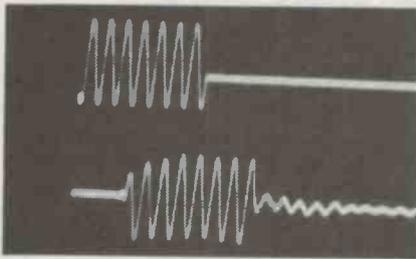
**Polar response plots.**



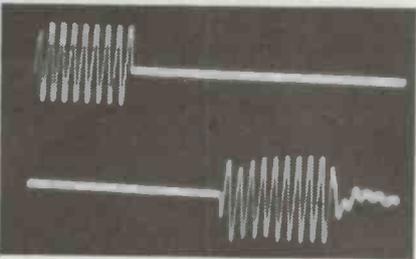
**Tone burst response.** Upper trace is electrical input; lower trace is loudspeaker output.



100Hz (20ms/div)



1kHz (2ms/div)



6.3kHz (0.5ms/div)

The tone burst evaluation revealed some traces of ringing, particularly at 1kHz and 6.3kHz, although the magnitudes of these post-transient perturbations are by no means unusual. The decay response spectra however showed an unusually smooth performance with almost optimal linearity within the first 15dB of the decay and remarkably little by way of ringing effects or resonance in the normal mid-frequency region. What ringing is visible occurs primarily at 6kHz and 11kHz as well as over the 9 to 11kHz range which corresponds to a natural resonance in the tweeter. Even these characteristics are reasonably well controlled and sufficiently attenuated below the fundamental to give rise to only very modest colouration.

The measured harmonic distortion characteristics of the speaker revealed fairly healthy distortion at 100Hz where the power level had to be reduced to 90dB to achieve a 4.2% distortion and much lower distortion at 1kHz where, with the normal 96dB output, only 1% distortion resulted. At 6.3kHz, the distortion is relatively low with only 0.5% distortion resulting from the 96dB output at 1m.

The sensitivity is moderately low as the speaker requires an indicated 10 watts of power to provide 96dB at 1m. My overall impression of the objective performance of the Tannoy M20s is that they provide an above average performance which is essentially very good.

**Subjective testing**

The initial subjective impressions of the M20s was derived using the Swedish Hi-Fi Institute test record "LJUD och hur det ska

**MEASURED PERFORMANCE OF :** TANNoy M20 GOLD LOUDSPEAKERS  
**SERIAL NO :** 885811

**FREQUENCY RESPONSE :** On-axis 60 Hz to 20 kHz -10dB  
 30° Off-axis 60 Hz to 20 kHz -10dB

**CROSSOVER FREQUENCIES :** 2.7 kHz

**SENSITIVITY :**  
 (for 96dB average at 1m) 9.0 V r.m.s. = 10.1 Watts (nominal into 8 Ohms)

HARMONIC DISTORTION: (for levels indicated)	90 dB			96 dB		
	100Hz	1kHz	6.3kHz	100Hz	1kHz	6.3kHz
2nd	-27.8	-40.5	-47.3			
3rd	-41.0	-49.6	-52.5			
4th	-56.1	-67.5	-			
5th	-51.3	-69.6	-			
THD	4.2	1.0	0.49			
						%

**INPUT IMPEDANCE** 100Hz/7kHz 4:1

100 Hz	11.6 ohms
1 kHz	31.2 ohms
6.3 kHz	9.6 ohms
Min at 150 Hz	9.2 ohms

**PEAK IMPEDANCES** at 18 Hz, 71 Hz and 1200 Hz.

lata". The results of this were to confirm that the speaker provides a crisp, relatively clean output with modest colouration and extremely neutral performance on most orchestral music. The last and most difficult test track on the record surprisingly revealed that the speaker had no difficulty handling its nasty low frequency content with input peak power levels of up to 300 watts and outputs in excess of 105dB at my normal monitoring position.

With the test 'speech and singing' reference content, the immediate impression gained was of a speaker with a degree of natural reproduction, which is above average and both male and female voices sound as they should. With Virgil Fox's "The Digital Fox" (Ultragroove UG9001), the speakers happily replayed the strident and persuasive power of the Garden Grove Community Church pipe organ with a realism and fidelity which I found positively surprising. My B&W 801F monitors provided a cleaner low frequency on the lowest organ notes, but considering the price difference, I was nonetheless impressed.

With the Sheffield Tract Record, the immediate impression I gained was of a speaker which provides superlative re-

sponse for percussive instruments, remarkable stereo imaging, crisp rise times, clean decay times and acceptable colouration with peak power levels ranging up to 600 watts. Had I a more powerful amplifier than the Yamaha M80 that I was using, I think I would have been scared to apply it for fear of destroying the drivers as this speaker system does not incorporate a protection circuit. Even so, I really belted the speakers with continuous average listening levels of over 60 watts input and peak levels repeatedly pushing the stops on the amplifier, and failed to destroy the speakers.

The next series of test material came from CD discs, including Sheffield Lab's "Crème de la Crème", track 2 "The Higher You Rise", track 4 "Gone Buttlefishin" and track 5 "Cripple Creek Breakdown" which provided superb examples of snare and kick drum, organ and xylophone in which the Tannoys absolutely revelled.

With the first track of Elton John's "Ice on Fire" (Rocket 826-213-2), I pushed the peak input levels again to beyond 600 watts, whilst with track 3 "Soul Glove" I pushed as hard as I dared with the amplifier's input line attenuators set to minimum. The peak signal levels were by this stage topping

110dB and the distortion, although clearly audible was still acceptable

The last disc I used was Don Dorsey's "Bachbusters" (Telarc CD 80123) which is a remarkable moog synthesiser-based disc of some of Bach's finest organ and orchestral works. The subsequent discs that I used were all classical, and I must acknowledge played at lower, more acceptable levels.

My overall impression of the Tannoy M20 "Golds" is of a well designed speaker which achieves a surprisingly good subjective performance for most recorded classical music, good performance on popular music and more than acceptable performance when pushed hard to reproduce rock music.

Considering the miniscule size of their enclosures, the M20s provide a healthy performance with truly exceptional stereo imaging over an unusually broad arc. This is matched by a superlative high frequency response over the critical 10kHz to 20kHz region where most other speakers in their price range do not perform nearly as well.

Whilst I have previously been critical of Tannoy loudspeakers, I believe that their designers have achieved an unusually noteworthy result with the M20 "Gold" speakers which justly deserve the *gold* title. ●

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17	42	67	92	117	142	167	192	217	242	267	292	317	342
18	43	68	93	118	143	168	193	218	243	268	293	318	343
19	44	69	94	119	144	169	194	219	244	269	294	319	344
20	45	70	95	120	145	170	195	220	245	270	295	320	345
21	46	71	96	121	146	171	196	221	246	271	296	321	346
22	47	72	97	122	147	172	197	222	247	272	297	322	347
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  - All ranges fully protected plus Automatic "ZERO" of all ranges without short circuit except 200 ohm Range which shows "000 or 001"
  - High Surge Voltage protection 1.5 KV-3 KV
  - Diode testing with 1 mA fixed current
  - Audible Continuity Test
  - Transistor hFE Test

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3 1/2 digit type with automatic polarity indication.  
Indication Method: LCD display.  
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  - Single 30 position easy to use rotary switch for FUNCTION and RANGE selection
  - 1/2" high contrast LCD
  - Automatic over-range indication with the "1" displayed
  - Automatic polarity indication on DC ranges
  - All ranges fully protected plus Automatic "ZERO" of all ranges without short circuit except 200 ohm Range which shows "000 or 001"
  - High Surge Voltage protection 1.5 KV-3 KV
  - Capacitance measurements to 1pF
  - Diode testing with 1 mA fixed current
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Dual 8" Slimline Drive Case	\$99
X11025 Bare Case	
X11026 Case & Pwr Supply	\$275

### GREY FLAT RIBBON CABLE

Cat. No.	Description	\$ Mtr
W12614	14 Way	\$1.90
W12618	16 Way	\$2.20
W12622	20 Way	\$2.50
W12624	24 Way	\$2.80
W12625	25 Way	\$2.90
W12626	26 Way	\$3.00
W12634	34 Way	\$3.60
W12636	36 Way	\$3.80
W12640	40 Way	\$4.00
W12650	50 Way	\$5.00
W12660	60 Way	\$6.90



### WIPER DELAY CONTROLLER AND LIGHT ON REMINDER

- Triggers if lights are left on and ignition is turned off.
  - Has both an audible and visible alarm.
  - Allows windshield wipers to be delayed for up to 20 seconds.
  - Undershoot or on dash mounting.
  - Designed for 12 volt negative earth electrical systems.
  - Complete with mounting hardware.
- Cat. A15070 \$24.95



### MICROWAVE LEAKAGE MONITOR

Simple to use, this microwave leakage detector can be used to protect you and your family by periodically checking around the hinges, door seals, etc. of your microwave for hazardous excessive leakage.  
Cat. A30001 only \$12.95



### NEW SLOPING CASES

Plastic with metal front panel, available in two sizes:  
Cat. H10450 190x120mm \$12.95  
Cat. H10455 256x185mm \$21.95 (measurements are approx. only)



### RITRON 19" RACK CASE

Tremendous Value! Dimensions 480(W) x 134(H) x 250(D)mm.  
Cat. H10415 Normally \$47.95  
**SPECIAL, ONLY \$37.95**



### RITRON KEYLESS CAR ALARM

- The first shipment sold out immediately to the trade. They don't reach our own retail stores!
- Activated and disarmed by ignition key, so you never forget to turn it on
  - Multi-function, built in siren or external siren, car signal horn output
  - Easy to install, no door switch required.
  - Automatic reset after 60 seconds (avoids noise pollution)
  - Special sensor protects Stereo or CB.
  - 12V DC
- Cat. S15054 Normally \$39.95  
**NOW \$29.95**



### OMNI-DIRECTIONAL WIRELESS MICROPHONE

Tunable: 92 - 104MHz  
Freq. Response: 50 - 15kHz  
Range: Over 300 feet in open field  
Modulation: FM  
Power Source: 9V Battery  
Type: Electrical Condenser  
Dimensions: 185 x 27 x 38mm  
Weight: 160 grams  
Cat. A10450 \$19.95



### ARLEC SUPER TORCH

- A sophisticated rechargeable torch ideal for use in and around the home, the car, the boat, etc.
- FEATURES:**
- Powerful built-in Nicad batteries
  - Reflector head swivel through 90 degrees.
  - 3 position switch gives on/off/ and dim.
  - Indicator lamp when recharging.
  - Charges from mains, electricity or from a car battery.
  - Supplied complete with (A) SEC approved battery charger (B) Plug and cord for car lighter socket.
  - (C) Handy charging bracket with timing screws.
  - 12 months guarantee
- Cat. A15055 Normally only \$44.95  
**SPECIAL, ONLY \$39.95**

# WHAT'S NEW?



### CENTRONICS GENDER CHANGER

- Female to Female.
  - Saves modifying or replacing non-mating Centronics cables.
  - All 36 pins wired straight through
- Cat. X15662 \$33.95



### ARGUS 726 ADJUSTABLE MAGNIFIER WITH LAMP

- Absolutely perfect for close up work! Intricate PCB's, projects, etc. will be a breeze under this superb, adjustable magnifying lamp.
  - Magnifies 1.75 times
  - 40 watt incandescent lamp
  - 2 spring-balanced arms, extendable to 95cm
  - Adjustable head for optimum viewing angle
  - Fantastic Value!
- Cat. X15662 only \$89



### 6 1/2" WOOFER

Cloth edge roll surround.  
**SPECIFICATIONS:**  
Sensitivity: 96dB  
Freq. Response: 55 - 7 kHz  
Impedance: 8 ohms  
Power RMS: 15 watts  
Magnet Weight: 5.4 oz  
Cat. C10208 \$15.95



### 8" WOOFER RIBBED CONE

Cloth edge roll surround.  
**SPECIFICATIONS:**  
Sensitivity: 94dB  
Freq. Response: 55 - 8 kHz  
Impedance: 8 ohms  
Power RMS: 20 watts  
Magnet Weight: 5.4 oz  
Cat. C10210 \$18.95



### 10" WOOFER RIBBED CONE

Cloth edge roll surround.  
**SPECIFICATIONS:**  
Sensitivity: 95dB  
Freq. Response: 37 - 6 kHz  
Impedance: 8 ohms  
Power RMS: 25 watts  
Magnet Weight: 10 oz  
Cat. C10212 \$29.95



### CIS 5 1/4" D/S DISKS

100% certified and error free guaranteed! Where else can you get 100% guaranteed D/S D/D disks for just \$24.95/7!!  
Cat. C12440 ONLY \$24.95  
\*Less 10% for 10 or more!!!



### PROGRAMMABLE 24 HOUR TIME SWITCH

- 48 switching possibilities per day
  - 240V AC, 2400 watt, 10 amp
  - Suitable for turning on...  
Heaters/Coolers  
pool filter  
electric blankets  
cooking appliances  
warming you, even making the coffee! lights etc for security while you're away from home!
  - Bargain Price!
- Cat. M22002 only \$19.95



### "SNAP TOGETHER" PLASTIC CABINET

Top and bottom simply snap together (no screws required), removable front and back panels.  
Dimensions: 186(W) x 125(D) x 50(H)mm.  
Cat. H10116 \$6.95



### HI FI SPEAKERS

A comprehensive range of matched appearance speakers, all with square silver grey frames and black cones - ideal for building up low cost speaker systems that will look and sound superb.



### 1 1/2" TWEETER

**SPECIFICATIONS:**  
Sensitivity: 90dB  
Freq. Response: 1.2 - 20 kHz  
Impedance: 8 ohms  
Power RMS: 10 watts  
Magnet Weight: 2 oz  
Cat. C10200 \$4.95



### REGULATED DC-DC CONVERTER

Built on to a heavy duty aluminium heatsink with 7 amps. Ideal for trucks and boats.  
• Input 24V DC  
• Output 12V DC at 7 amps  
• Fully regulated with short circuit protection  
• Size: 180(L) x 94(W) x 33(H)mm  
Cat. A15056 \$33.95



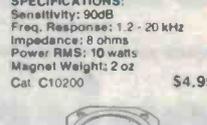
### 12" WOOFER RIBBED CONE

Cloth edge roll surround.  
**SPECIFICATIONS:**  
Sensitivity: 92dB  
Freq. Response: 32 - 4 kHz  
Power RMS: 30 watts  
Magnet Weight: 13.3oz  
Cat. C10214 \$39.95



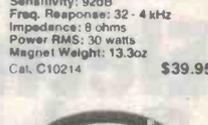
### MICRO PIEZO SIREN

- Very small and easy to install.
  - High impact plastic, (white).
  - Input 12V DC - 150mA
  - Output 110dB at 1 metre, dual tone.
- Cat. S15069 \$13.95



### 2 1/2" TWEETER

**SPECIFICATIONS:**  
Sensitivity: 94dB  
Freq. Response: 1.1 - 17 kHz  
Impedance: 8 ohms  
Power RMS: 10 watts  
Magnet Weight: 2 oz  
Cat. C10202 \$5.95



### PIEZO DIRECT RADIATING TWEETER

Requires no crossover, handles up to 100 watts.  
Sensitivity 96dB  
Maximum input: 24 volts  
Freq. Response: 3.2 - 30kHz  
Dimensions: 95mm diameter.  
Cat. C12104 \$11.95



### 4" MIDRANGE WITH SEALED BACK

**SPECIFICATIONS:**  
Sensitivity: 95dB  
Freq. Response: 650 - 15 kHz  
Impedance: 8 ohms  
Power RMS: 15 watts  
Magnet Weight: 3.6 oz  
Cat. C10204 \$9.95



### PIEZO UNITS IN HIGH IMPACT PLASTIC CABINET

- Input 12V DC - 200mA
  - Output 115dB at 1m, dual tone
  - Compact size 105 x 85 x 45mm
  - Smart design suits interior use
- Cat. S15071 \$23.95



### 12" HIGH POWER MUSICAL SPEAKER

• Aluminium die cast chassis  
• Carbon fibre impregnated cone paper  
• Foam edge  
• Light grey cone, silver dust cap  
• High temperature "NOMEX" voice coil.  
**SPECIFICATIONS:**  
Sensitivity: 97dB  
Frequency Response: 50-4kHz  
Impedance: 8 ohms  
Power RMS: 60 watt  
Magnet Weight: 30 oz.  
Cat. C10218 \$59.95



### PIEZO UNITS IN HIGH IMPACT PLASTIC CABINET

- Input 12V DC - 200mA
  - Output 115dB at 1m, dual tone
  - Compact size 105 x 85 x 45mm
  - Smart design suits interior use
- Cat. S15071 \$23.95



### 4 1/2" MIDRANGE WITH SEALED BACK

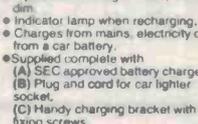
**SPECIFICATIONS:**  
Sensitivity: 97dB  
Freq. Response: 600 - 8 kHz  
Impedance: 8 ohms  
Power RMS: 20 watts  
Magnet Weight: 5.4 oz  
Cat. C10206 \$12.95

**10% OFF!!**



### ARLEC SUPER TORCH

- Powerful built-in Nicad batteries
  - Reflector head swivel through 90 degrees.
  - 3 position switch gives on/off/ and dim.
  - Indicator lamp when recharging.
  - Charges from mains, electricity or from a car battery.
  - Supplied complete with (A) SEC approved battery charger (B) Plug and cord for car lighter socket.
  - (C) Handy charging bracket with timing screws.
  - 12 months guarantee
- Cat. A15055 Normally only \$44.95  
**SPECIAL, ONLY \$39.95**



### PIEZO UNITS IN HIGH IMPACT PLASTIC CABINET

- Input 12V DC - 200mA
  - Output 115dB at 1m, dual tone
  - Compact size 105 x 85 x 45mm
  - Smart design suits interior use
- Cat. S15071 \$23.95



**10W HORN SPEAKERS**

White durable plastic, 8 ohms  
Cat. C12010 Normally \$9.95  
**SPECIAL, ONLY \$7.95**



**UV EPROM ERASER**

Erase your EPROMs quickly and safely. This unit is the cost effective solution to your problems. It will erase up to 9 x 24 pin devices in complete safety, in about 40 minutes (less for less chips).  
Features include:  
• Chip drawer has conductive foam pad  
• Mains powered  
• High UV intensity at chip surface ensures EPROMs are thoroughly erased  
• Engineered to prevent UV exposure  
• Dimensions 217 x 80 x 68mm  
Cat. X14950 **NORMALLY \$99.95**  
**SPECIAL, ONLY \$89.95**



**STANDARD DESOLDING PUMP**

Light weight, powerful suction, teflon tip. Replacement tips teflon and ceramic. Length 195mm.  
Cat. T11241 \$16.95, Now \$14.95

**MINI DESOLDERING PUMP**

Light weight, powerful suction, teflon tip. Replacement tips teflon and ceramic. Length 165mm.  
Cat. T11251 \$15.95, Now \$13.95

**DELUXE DESOLDERING PUMP**

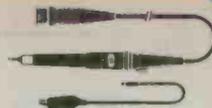
Light weight, non conductive, powerful suction, ceramic long life tip. One of the best in the business. Length 210mm, replacement tip HT3C ceramic.  
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**CORDLESS RECHARGEABLE SOLDERING IRON**

- Built in solder point illumination
- Easy replacement of solder tip
- Protective stand which also functions as charging unit
- Sponge pad attach to stand
- Plug pack power adaptor
- Includes Nicad battery
- Instruction manual
- 12 months warranty

Cat. T12480 Normally \$59.95  
**SPECIAL, ONLY \$49.95**



**BESWICK 88100 PROBE SET**

CONTAINS: Compensated probe lead with:  
• Detachable 6 inch earth lead  
• Retractable hook  
• IC test tip  
• Tip insulator  
• BNC adaptor  
• Trimming tool

**SPECIFICATIONS:**  
Bandwidth: 10:1 position 250MHz at -3dB into 20 pF  
Rise Time: 10:1 position less than 1.4ns nominal

**Switch Function:**  
(a) 10:1 attenuation +/- 1%, with oscilloscope of 1 Mohm input resistance.  
(b) 1:1 attenuation with bandwidth of 10 MHz approx.  
(c) Reference position, tip grounded via 9 Mohm, oscilloscope input grounded.

Input Capacitance: 16pF typical depending upon oscilloscope input capacitance.  
Compensation Range: oscilloscopes of 15 to 60 pF input capacitance.  
Working Voltage: 600V DC or peak AC

\$34.95



**WELLER WTCPN SOLDERING STATION**

The WTCPN Features:  
• Power Unit 240 V AC  
• Temperature controlled iron, 24 V AC  
• Flexible silicon lead for ease of use  
• Can be left on without fear of damaged tips!  
The best is always worth having.  
Cat. T12500 R.R.P. \$129  
**SPECIAL, ONLY \$99**

# SAVING BIG BONANZAS!



**AÑLEC SUPER TOOL**

A versatile 12V electric tool for:  
• Sanding  
• Engraving  
• Grinding  
• Polishing  
• Cutting  
• Drilling  
• Milling  
• Erasing, etc.

**Features:**  
Operates on safe, low 12 volts from mains electricity via AC adaptor (supplied). Light and easy to handle with touch switch and lock for continuous running. High torque motor, 10,000 R.P.M. Can drill 2mm holes in steel. 2 year guarantee

**Contents:**  
• 12V Super Tool  
• Plugpack AC adaptor  
• 1 spherical milling cutter  
• 1 wire brush  
• 1 grinding wheel  
• 4 drill bits, 0.6, 0.8, 1.0, 1.2mm  
• Set of 5 chuck collets  
• 6 eraser sticks  
• 1 instruction sheets  
Cat. T12300 **NORMALLY \$49.95**  
**SPECIAL, ONLY \$44.95**



**AA NICADS (ROCKET BRAND)**

Save up to 50% off the regular price of \$2.80!

1-9	10+	100+
\$1.75	\$1.65	\$1.40



**DIGITAL SPEEDO/DIGITAL TACHO/SPEED ALERT**

- Digital readout (LED) for both tach and speed.
- Alarm with sound at variable preset speed.
- Audible beeper and visual indicator.
- In built light indicator for night illumination.
- Designed for 12 volt negative earth electrical systems.
- Speed: 0 - 199kph
- Tachometer: 0 - 9900kph
- Speed alert: 40 - 120kph
- Complete with mounting hardware.

Cat. A15064 **NORMALLY \$69.50**  
**SPECIAL, ONLY \$59.50**



**FREE STANDING, FOLD UP MAGNIFIER**

An economically priced "hands free" magnifier, lets you take care of all those tricky fine detailed jobs so often encountered in electronics, or any of many other practical uses such as home, work, hobbies etc.  
Cat. T12083 **NORMALLY \$14.95**  
**SPECIAL, ONLY \$12.95**



**RECHARGEABLE 12V GELL BATTERIES**

Leakproof and in 3 convenient sizes, these long service life batteries are ideal for burgular systems, emergency lighting or as a computer backup power supply. Ideal for many power needs.  
Cat. S15029 12V 1.2 AH \$12.95  
Cat. S15031 12V 2.6 AH \$39.50  
Cat. S15031 12V 4.5 AH \$49.95



**LOGIC PROBE 3800A**

Features 20MHz memory. TTL/CMOS operation. Normally \$29.50  
Cat. Q11272 \$34.50  
**SPECIAL, ONLY \$29.30**

## No.1 FOR COMPONENTS!



**IC SPECIALS!**

1-9	10+	100+
4116	\$2.95	\$2.75
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2716	\$5.90	\$5.50
2732	\$6.25	\$5.95
2764	\$6.25	\$5.95
27128	\$6.95	\$6.50
6116	\$2.95	\$2.75
41256	\$6.95	\$6.50
6284	\$6.50	\$6.25
27256	\$11.50	\$10.50

**WORLD MODEM CHIP**  
Cat. U21614 **NORMALLY \$49.50**  
**Save \$20, SPECIAL \$29.50**



**IC SPECIALS! 8000 SERIES**

1-9	10+
8085	4.50
8212	1.50
8216	1.50
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8255	2.90
8257	3.50
8259	3.50
8279	3.50
2532	7.50
2764	5.50
27128	7.50
1488	.55
1489	.55



**DIODES SPECIALS**

1-9	10+	100+	1000+
IN4148	Cat. Z10135		
3e	2 1/2e	2e	1 1/2e
IN4002	Cat. Z10150		
4e	3e	2 1/2e	3e
IN4004	Cat. Z10107		
5e	4e	3e	2 1/2e

**CRAZY SPECIAL!**

**CRYSTALS SPECIALS**

We simply have too many of these prime spec. crystals in stock!

Description	Cat.No.	1-9	10+
1.8432MHz	Y11000	\$6.00	\$5.20
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4.433618MHz	Y11023	\$2.00	\$1.60
4.75MHz	Y11025	\$2.00	\$1.60
4.915200MHz	Y11026	\$2.00	\$1.60
5MHz	Y11030	\$2.00	\$1.60
6MHz	Y11040	\$2.00	\$1.60
6.144MHz	Y11042	\$2.00	\$1.60
6.670MHz	Y11045	\$2.00	\$1.60
8MHz	Y11050	\$2.00	\$1.60
8.867238MHz	Y11055	\$2.00	\$1.60
10MHz	Y11060	\$2.00	\$1.60
12MHz	Y11070	\$2.00	\$1.60
14.31818MHz	Y11072	\$2.00	\$1.60
15MHz	Y11075	\$2.00	\$1.60
18MHz	Y11082	\$2.00	\$1.60
18.432MHz	Y11085	\$2.00	\$1.60
20MHz	Y11090	\$2.00	\$1.60



**RCA GOLD PLATED PLUGS AND SOCKETS**  
For those who need the ultimate in connection. Essential for laser disc players to get that fantastic sound quality.  
Plug Cat. P10151 \$3.50  
Socket Cat. P10150 \$2.75



**RELAYS**  
Massive 3A connectors 1-9 100+  
S.P.D.T. S14060 \$1.20 \$1.00 \$0.75  
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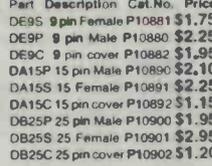


**MINIATURE BUZZER**  
5-15V White or black.  
Cat. C15062 1-9 10+  
\$0.95 \$0.75



**RS232 & 'D' TYPE SPECIALS**

Part Description	Cat.No.	Price
DE9S 9 pin Female	P10881	\$1.75
DE9P 9 pin Male	P10880	\$2.25
DE9C 9 pin cover	P10882	\$1.95
DA15P 15 pin Male	P10890	\$2.10
DA15C 15 Female	P10891	\$2.25
DA15C 15 pin cover	P10892	\$1.15
DB25P 25 pin Male	P10900	\$1.95
DB25S 25 Female	P10901	\$2.95
DB25C 25 pin cover	P10902	\$1.20



**ECONOMY ROTARY SWITCHES**

Cat. No.	Description	Price
S13021	1 pol 2-12 pos.	\$1.99 \$0.95
S13022	2 pol 2-6 pos.	\$1.99 \$0.95
S13033	4 pol 2-3 pos.	\$1.99 \$0.95
S13035	3 pol 2-4 pos.	\$1.99 \$0.95



**12 WAY TERMINAL BLOCKS**

P18050	240V 10AMP	\$1.50
P18052	240V 15AMP	\$1.75



**20% OFF ALL TOGGLE SWITCHES!**

**TOGGLE SWITCHES**

Cat.No.	Description	Price
S11009	SPST mini	\$1.20
S11010	SPDT econ mini	\$1.75
S11020	DPDT econ mini	\$1.95
S11025	C/OFF econ mini	\$2.25
S11030	DPDT C/OFF econ	\$2.50
S11034	4PDT mini	\$6.95
S11036	SPST std 125V 3A	\$1.30



**SPRING RETURN TOGGLE SWITCHES**

S.P.D.T.	Cat. S11012	\$2.25	\$1.95
D.P.D.T.	Cat. S11022	\$2.50	\$2.25



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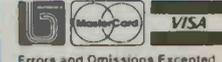


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\$10-\$24.99	\$3.00
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Registered Post for orders over \$200 included "free"  
All sales tax exempt orders and wholesale inquiries to RITRONICS WHOLESALE, 56 Renver Rd., Clayton, Phone (03) 543 2166



Errors and Omissions Excepted.

# DIGITAL SAMPLER

## Part 3: The sound of music

With the digital sampler built it's time to plug it in and put it to work. In this final part to the series we tell how to solve a problem like no echo as well as a few of our favourite things for the sampler.

Glen Thurect  
& Andrew Robb

IN THIS, the final part of our series on the sampler we look at testing and using the unit. Before getting into that, we should outline what else is needed. The essentials are a microphone and some sort of amplifier. Obviously the better the mic, the better the sound, but that is up to you. The variable gain stage will accommodate most microphone types.

The sampler output level is around 140mVrms so the amp used should be able to handle this. You could use a home stereo set-up or, if available, a more rugged instrument amp.

### Testing

Before applying the power, double check to see that the diodes are correctly orientated, all electrolytic capacitor polarities are in the right place, all integrated circuits have pin number one in the proper place (note that all the ICs face the same direction), wiring is as per the wiring diagram and that no solder has bridged between tracks during construction.

Now assuming all is well connect the 9V power supply plugpack and turn the power on. No smoke? Good, we can connect the amplifier and the sound source. Set the frequency control to about 50%, DELAY mode switch to DELAY, INT/EXT switch to INT and PLAY/RECORD to RECORD. Also keep MIX at 50% and REGEN to 0%. The gain control depends on the amplitude of the input signal and must be set by experimentation. Next make a short sound on the input. If the sampler is operating correctly, you should hear the original sound and shortly after, the delayed sampled sound. Set the gain to a point just below where distortion can be heard. If the unit passes this test it is almost certainly in proper working condition. If it produces no echoed signal, or no sound at all don't panic since troubleshooting will be looked at next.

To check the other modes of operation, firstly connect the 9V battery if you wish to keep the sample after power is removed and

then go on to "Using it".

The first thing to do when troubleshooting is to check all the power supplies. Using a multimeter set to dc volts see that the input 9Vdc from the powerpack does not exceed 15V. If it is above 15V or below 8V then the pack is probably faulty.

Before we continue you should remember that there are two system commons (or grounds) that are used. One is an analog common and the other is a digital common. When taking a voltage measurement at any point you must know what common it is referred to. If in doubt at any stage refer to the circuit diagram.

So, with reference to the analog common (say pin 3 or 5 of IC1) see that +V (pin 4, IC1) is between +4 volts and +7.5 volts. Also -V (pin 11, IC1) should be between -4 volts and -7.5 volts. Now if the two analog rails are unbalanced by more than 2 volts, IC1 or IC2 is drawing too much current and problems should be looked for in this region. Also look to see that R38 and R39 are the correct values. Switch your common connection to the digital one (say pin 12 of IC6) and look at pin 24 of IC6. This should be very close to 5 volts. If not, IC13 is likely to be faulty.

If the power supplies are working correctly and there is still no sound, re-check the wiring to the frequency pot to make sure that the clock is operating correctly. If you are not lucky enough to own an oscilloscope you can still test the clock by measuring the voltage on pin 3 of IC11 on the dc volts range of a multimeter. This should read between 2 and 3 volts since the clock is a square wave with fairly even mark/space ratio. If the reading is 0V or +5V (ref digital common) then the clock is not working so check all associated components R45, R44, C22, RV5 and, as a last resort, change IC11.

If there is a dc voltage of more than 20mV on the output (ref analog common) then IC1 is the likely culprit but check to see that the gain pot has been wired correctly,

specifically looking for dry joints on the connections.

For problems associated with the unit not triggering properly look firstly at the wiring of the threshold pot. Then measure on the 2Vdc range the voltage at pin 13 of IC1. This should vary between -10mV and approximately 1V as the pot is rotated. If not check values and solder joints of R33, R34, R35. Next, with no signal present, pin 12 of IC1 should be around -20mV. As an input is applied the dc voltage should change and go positive. If it doesn't, check for an ac signal at pin 1 of IC1 with an input present. For no ac voltage check components around IC1a, b, c. When the ac signal is there the fault lies with the precision rectifier based around IC4d.

If all these are OK but there is still no triggering, make sure D8 is the correct way around. The incorrect wiring of any of the switches will also prevent triggering, so carefully review this. Again, as a last resort if nothing else can be found, look at the input and output levels on IC10b, c, d, and IC9a, b, c, d. For a NOR gate if there is +5V on either input the output will be 0V. A NAND gate will have +5V output if either input is 0V. If the gates don't obey these rules replace the IC.

Another possible problem may arise if Q1 and Q2 are placed in the pc board the wrong way. This could mean that the chip select signals are not getting through to the memories. This can also cause large standby currents to be drawn from the battery when power is removed.

Now we will look at a few problems that could possibly occur when the unit is working but not sounding terribly good. Firstly, even though turning the frequency control to zero gives an apparent 3.4 second sample time, the sampler is only designed to give a 1/2 second sample. So if you set the frequency to below the 1/2 second point two things will occur: clock noise will be heard, and aliasing will corrupt the original signal. As a result, the frequency control should be

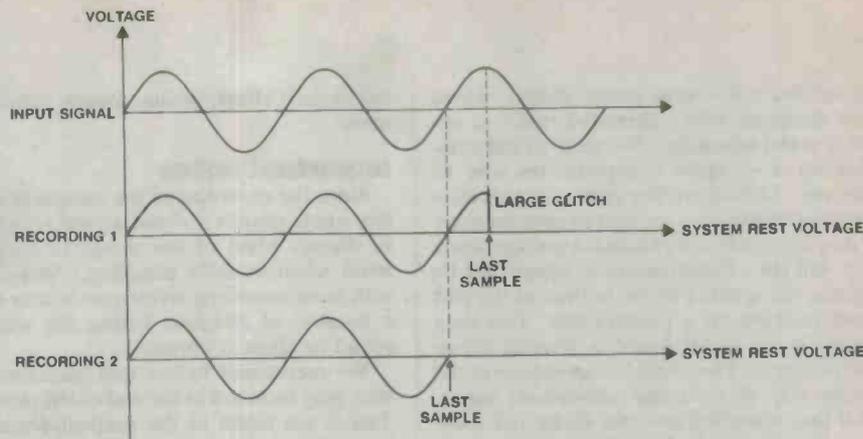


Figure 1: If it is not close to the system rest voltage, the last sample can produce an audible click.

set to approximately 60% or greater to do sound quality tests.

Assuming this has been done and the sampled sound is still squawking like a dalek then the anti-aliasing filter is not working. Check all component values associated with IC1b and IC1a paying particular attention to the capacitance values. If the signal is getting through to the ADC nothing much can be wrong other than incorrect filtering.

If the clock noise is heard at the output then the output filtering is at fault. Check all components around IC4a, b, and c.

### Using it

Hopefully your sampler has passed the power-up smoke test without too much trauma — now we can properly explain how to use it and what all that unusual triggering logic is there for.

Throughout the testing you probably jumped the gun and started experimenting, but we will go through the complete operation anyway. Starting with a recording, switch to INTERNAL and RECORD (DELAY off). In this mode as soon as you hit the TRIGGER button, recording begins. Set REGEN to zero and GAIN about half way. The correct gain setting will depend on your mic. MIX should be fully clockwise, giving just the sampled sound. As you should know, having digested the theory part of this series, the sampler is designed around a storage time of a 1/2 second with a corresponding sampling rate of 8kHz. The actual clock design allows for a variable sample rate to produce pitch variation during playback. We'll talk more about this later, for now keep FREQ at about half way.

Now clear your throat and simultaneously speak and press. You should also hear the sound go directly to the amp (the DAC converts anything on the bus). Switch to PLAY and press again. Hopefully your voice should be faithfully reproduced.

There may be some clicks at the end of

the recording, we'll get on to them later as well. Now you can hear the result of varying FREQ — noting that clock noise will be expected below 1/2 second replay. Recording using INTERNAL triggering is useful when the sound being recorded is continuous. In this case manual control over the duration of recording is necessary. If the playback sounds distorted lower the gain accordingly for future recordings.

EXTERNAL recording allows more control over the triggering, particularly for sharp bursts of sound. Because it relies on the actual sound for triggering, an 'arming' phase is incorporated. This means you can set the unit up for recording without having to worry about accidentally bumping the microphone and triggering the thing off. Then, after arming, the next sound to cross the threshold-level triggers the recording. Unless you have ultra fast reflexes, this is the only way to fully record any sound. The sampler is armed to record by switching to EXTERNAL and pressing the TRIGGER pushbutton when ready. The only external trigger source of use when recording is the actual input signal. A bit of trial and error is needed to get the threshold setting to a point where it doesn't trigger until the desired moment, but is still sensitive enough to capture the complete sound.

Externally triggered, playback bypasses the arming step but is otherwise set up the same way. You don't need to switch to EXTERNAL (this control is only recognised when recording). If the TRIGGER threshold is turned fully anti-clockwise, the biasing set-up on the EXT TRIG input enables a short-circuit to trigger the comparator. A remote footswitch can then be used in the same way as the built-in pushbutton.

Increasing the threshold changes the biasing so that the comparator expects a more positive voltage for triggering. Thus any piece of equipment capable of generating a positive-going voltage pulse (not greater than about 5V) can be plugged into EXT TRIG (high level triggering). Alternatively

the low-level signal input can be used.

Because playback allows retriggering at any time, feeding an input signal straight into EXT TRIG would cause problems. The system would continually retrigger on every positive-going section of the waveform. To overcome this the signal, when fed into the low-level input, passes through a precision rectifier and filter which forms an accurate positive envelope follower. This ensures only one major leading edge per sound burst. For one trial we used a guitar to trigger the unit. Some rapid-retriggering did still occur occasionally until the threshold was increased to the level of the initial 'pick' spike.

That about covers the essential operations. More advanced recordings can be made by using the regeneration control. This controls the amount of playback signal fed back to the input. Beginning with REGEN off, record a simple sound. Now turn it to about half way and record another sound. The result will contain both recordings. By adjusting the amount of 'previous' sound you can create your own multi-part harmony. If the REGEN is set too high, the additional gain added with each regeneration will rapidly cause distortion.

Some interesting noises can be generated by using the feedback produced by the amplifier/microphone to trigger the unit. It is a bit hard to describe the result, so hold the microphone in front of your amp and trigger in EXTERNAL mode. The sound should retrigger continually at a particular point dependent on the distance between the mic and amp.

So far the unit has been fine for playing around with at home, but if you're more musically oriented you'll probably want something more dynamic. Instead of a continually bruised thumb (from rapping a microphone) you should rig up a drum-pad. Of course, if you have the bucks, you can buy professionally made pads but the home-made style will work just as well.

Begin with a commercial practice pad ▶

## Project 1402

(available from most music shops). These are designed with a threaded insert to enable stand mounting. We used an old cymbal stand — again it depends on your finances. Linked to the pad is a precision audio transducer — a junked minispeaker. (Anything that will produce a voltage when hit will do.) Construction is completed by gluing the speaker to the bottom of the pad and hooking up a phono-cable. This then goes to the signal input to provide a low level trigger. Threshold set-up is done in the same way as a normal microphone input. All that is needed now are sticks and some interesting sounds. It is amazing what sorts of everyday noises can be used in a musical way. For every hour of our testing we spent another hour playing around with the wide variety of noises created simply using a microphone.

There is a lot of emphasis placed on communication or synchronisation between electronic instruments nowadays, the most prominent being the microprocessor-based MIDI interfacing system. On a less complex scale most synthesisers, sequencers and drum machines also have a separate trigger output suitable for use with our sampler. Depending on the type of pulse, you may have to use the low level input rather than the high level one. High level accommodates open/closed contacts or positive-going pulses. One drum machine we tested, a Korg model, provided a +6V signal which went low on triggering. In this case the low level input must be used. (There is sufficient attenuation provided on this input to handle +6V.) This pulse duration was measured to be about 15ms and hence easily passed by the input ac coupling. The pulse is then inverted by the precision rectifier to give a positive going trigger signal. When using the signal input for this purpose the gain should be decreased to unity.

Finally, the DELAY mode — keeping in mind the limited specifications, the delay is still good enough for most purposes. It is activated by switching to RECORD, EXTERNAL and DELAY ON. The frequency pot now controls the delay length, from 88ms to 3.4 seconds. It is in this mode that the MIX control is needed to enable the original signal to be louder than the delayed version. With REGEN set to zero, one echo should be produced. Increased regeneration increases the number of repeats, until infinite regeneration, and finally feedback swamping is reached. With very short delay and a bit of regeneration the sound produced should be similar to the reverberative ringing of your favourite small room. Formally, reverberation is a mixture of the signal passing through many different delays (analogous to the sound taking longer to bounce off the roof than the walls of a room). Although the sampler has only one delay, the sound produced is quite similar to

the desired effect, giving 'psuedo reverberation'.

### Important notes

Since the recording of the sample is what this whole project is about we will take time to discuss some of the things to keep in mind when actually sampling. As is true with most recording techniques it may take a number of attempts before the wanted sound or effect is obtained.

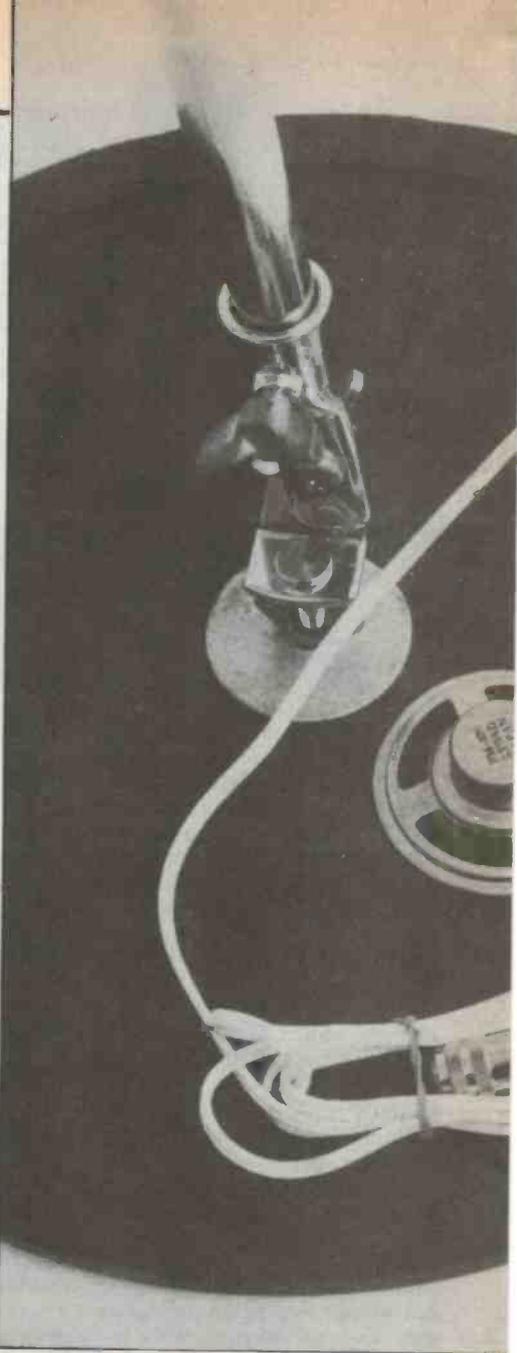
We mentioned before that sometimes a click may be heard at the end of the sample. This is the result of the particular sample and will not always occur. In sampling jargon this click is called a glitch. It can be best explained by looking at the diagram in Figure 1. This shows two different samples being taken of the same input signal. The first recording is the worst case example of a large glitch. This happens when the last sample that is taken is furthest away from the system rest voltage (the system rest voltage is the idle or non-operative voltage output of the DAC). This glitch is heard as a click if it is large. The loudness of the click varies depending on how close to the system rest voltage the final sample is. The best case condition is shown in recording 2. The last sample here is exactly the rest voltage and hence no click will be heard at all.

In some of the more sophisticated sampling devices there is the opportunity to define the start and end points of a particular sample on playback. This means that a glitch can be removed by backing up the end point to the first sample that is very close to the rest voltage. But alas, we do not have this facility. We can get around it though, by simply recording the same sound until the glitch is too small to be heard. This is usually not much of a problem since the sounds are mostly easily repeatable.

Another interesting recording technique that can be used is to alias the sample on purpose. This means that the recording is made with the frequency control between 0 and 50%. The sound is recorded as normal but when replayed it is a very warped (but still intelligible) replica of the original. This can give some strange synthesised sounds that can be quite useful, ranging from daleks to chipmonks. After the recording, try turning the frequency up on playback — it's even stranger.

But most of the time aliasing is not wanted. Keep the frequency control above 60% and the input filter will do the rest.

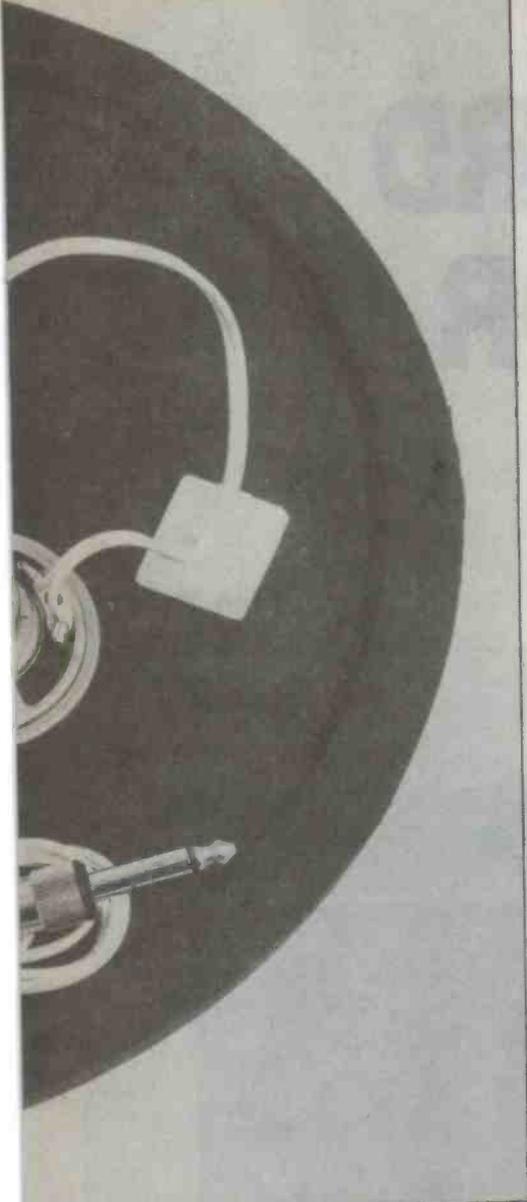
Sometimes a very distorted or noisy sample is obtained. This may be the result of either the gain being too low and hence not using the full dynamic range of the ADC or gain is too high and the input is clipping. In either case a little experimentation is called for in trying different gain settings until the correct one for your input signal is found. Once it is found, however, it will probably



not be changed until you use a new sound source.

It is also very important to keep in mind the way in which the sampling will be started or triggered. Totally different effects can be obtained using different triggering methods. For instance, say we wish to record someone saying 'hello', we can use external triggering with a low threshold setting and get 'hello' or with a higher threshold setting and get 'ello'. We could use internal triggering and get 'hello' or 'hel'. Each of these techniques gives a different sound so try them to get a few ideas.

When playing back a sample there are a number of sources that can lead to retriggering the sound when it is not needed. Firstly, if a microphone is connected to the input, acoustic feedback from the speakers may have enough level to retrigger. This can be fixed by turning the gain down or setting the trigger threshold high.



## MINIMART

FOR SALE: EIGHT 256K PARALLEL Printer buffer short form kit \$39, serial converter board to suit \$18, printer sharer board to suit \$12. For more info send SAE to Don McKenzie, 29 Ellesmere Cres, Tullamarine 3043.

FOR SALE: IBM PC type printer cables, DB-25-to-Centronics 36-way, 2 metres long, \$25 plus \$3 p&p. Don McKenzie, 29 Ellesmere Cres, Tullamarine 3043.

FOR SALE: OSBORNE O1 CP/M portable computer with 2 single-density single-sided drives; Fax-80 printer (Epson clone), 80 characters per second; Zenith amber monitor; software, documentation, and manuals included; \$1500 (whole lot). Joanne Ells, Block C, Flat 2, Hayman Is, Qld 4801. (079) 46-9100 ext 693.

FOR SALE: CO-1686 CO-PROCESSOR. Runs MS-DOS on a CP/M RAM-DISK driver, & Z80 source code. \$570 ono. (07) 359-1740 ah, (07) 221-1124 bh.

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FOR SALE: GOODMAN SPEAKERS, Triaxlom 212C, beautiful sound, large enclosures, \$280 pair. Also Audlom 61, Audlom 70, Axlom 201, Triaxlom 212C and Axlom 150 MkII from \$20 each. (02) 869-1840.

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ETI READER SERVICE 175

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Secondly, if the regeneration control is not set to zero the sampled signal may re-trigger itself. This can be very useful in some circumstances to get a sound re-triggering at regular intervals but can be very annoying if not wanted.

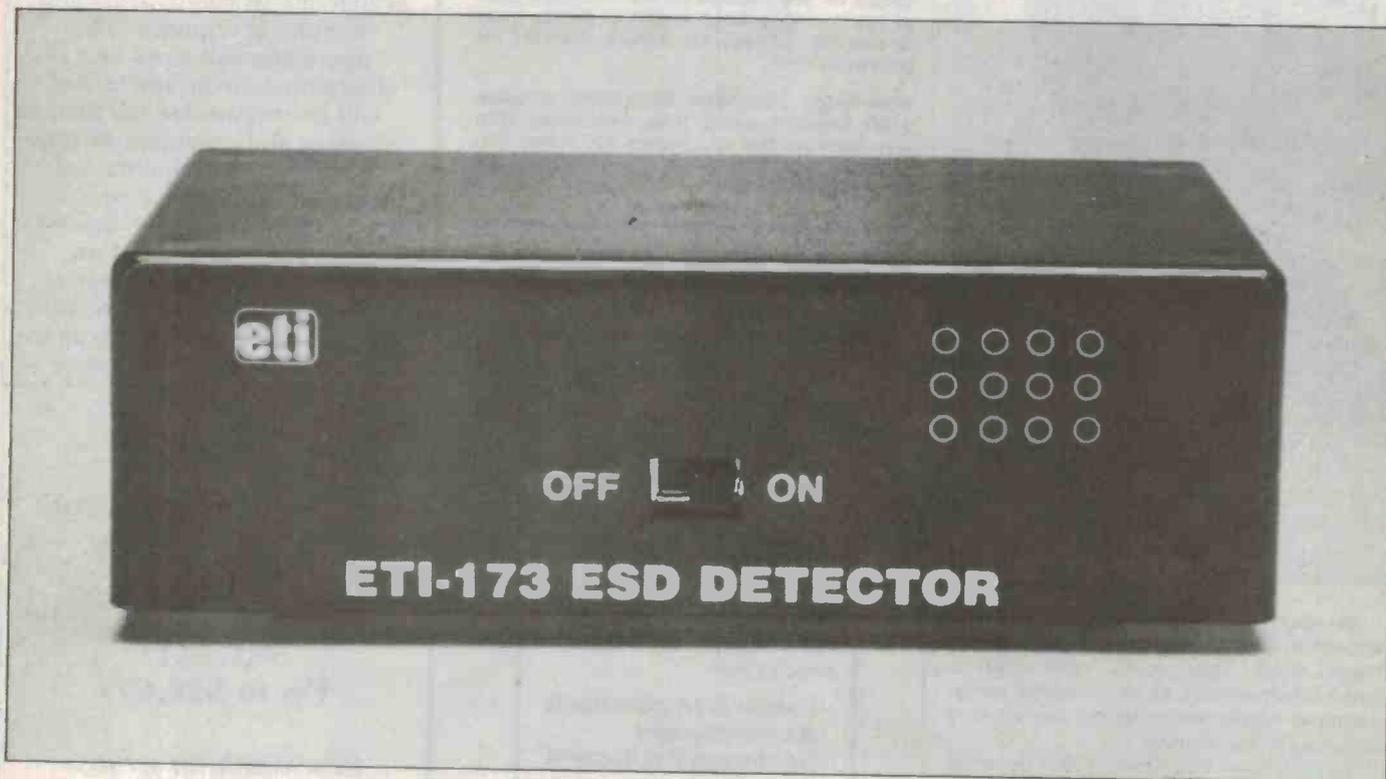
So there it is, a complete audio sampling system. It has numerous practical applications in the music industry and can provide hours of fun for friends and family. All the techniques and theory discussed can be applied to digital acquisition systems in general and it is in no way limited to audio sampling.

Sampling is only going to get more and more entrenched in modern day recording so understanding the fundamentals will go a long way. In the future with semiconductor memory prices falling and microprocessor-controlled sampling, flexibility will increase and 'real life' sounds of sampling will be heard coming from the strangest places. ●

# ESD HAZARD DETECTOR

Electric shock therapy is about the last thing you want for your vulnerable semiconductor components. But electrostatic discharge can be as hazardous as any pair of probes in a cuckoo's nest. This device gives warning of any moving electrostatic field which might zap your precious parts.

Ian Thomas



TO THOSE LESS aware than most, this title might appear to be about a device to detect some of the more brain disrupting chemicals that are currently around. However it isn't brains that this device protects, it's silicon.

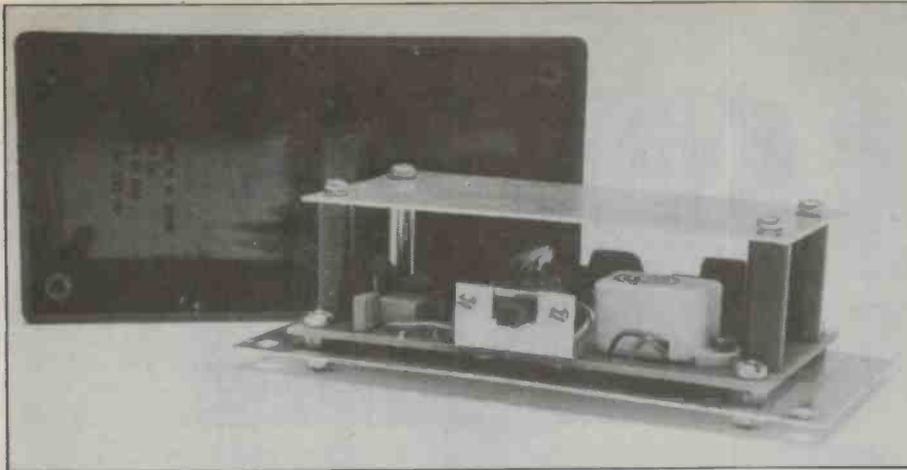
Everyone's aware that on a cold dry winter's day you tend to build up an electrostatic charge on your body so that when you touch some metal object such as a tap or door knob you cop a most unpleasant ZAP! This zap is called an electrostatic discharge and if it happens to jump on to a lead of an IC or transistor then the poor device is

never quite the same again. In the last few years it has become more and more commonly recognised that semiconductor devices are extremely sensitive to these stray high voltage transients, and MOS devices more than most. From a manufacturing point of view it isn't so much the outright broken bits that matter (they can be found during test) but the bits that are somewhat bent. They appear to work but will go toes-up after the equipment has been in use for a few days or weeks.

IC manufacturers are aware of this problem and go to great pains to build protection

into the devices where pins are connected out. There is, however, a limit to what you can do without degrading the device performance. In general the distributors are pretty good and try to do the right thing; but you, dear reader, may not.

An electrostatic charge is generated when two insulating dissimilar materials are rubbed together or even touched together then pulled apart. The degree of dissimilarity and the amount of charge generated is a function of the position of the two materials in an order known as the Triboelectric Series, part of which is given in Table 1. It is



**Table 1. THE TRIBOELECTRIC SERIES**

Air	}	POSITIVE
Human skin		
Glass		
Human hair		
Wool		
Fur		
Paper	}	NEGATIVE
Cotton		
Wood		
Hard rubber		
Acetate rayon		
Polyester		
Polyurethane		
PVC (vinyl)		
Teflon		

also a function of the humidity of the air, intimacy of contact of the two materials and the rate of separation and is in general a pretty inexact sort of thing but there are clear trends. You can see from the table that cotton is pretty much neutral (and hence cotton shirts don't charge up and zap you). In general it's the materials that tend to reject moisture that create the worst charge problems as moisture tends to conduct and bleed charge away.

To give you an idea of the sorts of potentials that can be built up, Table 2 shows the effect of various actions on a dry day and a relatively humid one. It's easy to see why you can get a belt by walking across a carpet on a cold winter's day! A normal human body insulated by your average sort of running shoes has a self capacitance in the order of 100pF. A few quick prods at a calculator shows that the stored energy in your delicate body is about 60 millijoules. The energy per discharge in the ETI-342 Pulse Shaped CDI (Feb '85) was only 120 millijoules which explains why it hurts when you touch something. Obviously a piece of silicon, the dimensions of which are measured in micrometres, is blown to a thin haze!

In general MOS devices tend to be the most delicate as a fundamental part of their structure is a very thin layer of silicon dioxide which can be absolutely guaranteed to rupture at the order of a 100 volts or so. For this reason even power MOSFETs that can cope with tens of amps at hundreds of volts can be ruined by one little zap on the gate lead. This certainly doesn't mean that you can do what you want with bipolar devices. If sufficient energy is dumped into the input junction then the device will fail.

In industrial situations where it's absolutely essential that these terrible things don't happen, quite exotic precautions are taken. The top of the bench being worked on is covered with conductive material (usually a type of conductive rubber) which is grounded. The workers wear conductive wrist straps which are grounded (through a large resistor). Ionised air (which is slightly conductive) may be blown over the work area. On top of all this there is a whole bunch of specifications and procedures to cover all phases of assembly. About this

**Table 2. TYPICAL ELECTROSTATIC VOLTAGES**

Means of generation	Humidity	
	10-20%	60-90%
Walking across carpet	35,000	1500
Walking on vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes as per work instructions	7,000	600
Common poly bag picked up from bench	20,000	1200
Work chair padded with polyurethane foam	18,000	1500

stage you're probably thinking it's a miracle anything ever worked and you might as well give it all away. But ETI has a simple, precautionary device that should help.

### Design

Whenever a body is charged up to a high potential then it is surrounded by an electrostatic field normally expressed in volts/metre, and if the body moves then the field moves with it. If you've just been dancing on your lovely new nylon carpet and charged yourself up to 10 zillion volts then the field from that charge spreads out from your body quite a long way.

It seemed to me that an instrument that detected the approach of this field and sounded an alarm would go a long way to avoiding blasted silicon. At least you would be warned to discharge yourself. It's extremely difficult (read expensive) to detect a completely static electrostatic field but a moving one is not such a great problem. A simple thought experiment will explain the problem and show how a detector could be built.

Suppose we have two parallel plates of a capacitor magically suspended in space 25mm apart and with an area of about 5000mm<sup>2</sup>, a not inconvenient size for a detector. The capacitance between its plates works out to be very roughly 2pF. Suppose a field of 500 volts/metre is suddenly imposed across these capacitor plates (definitely ESD hazard conditions!). The potential between the plates will immediately rise to 12.5 volts (500 volts/metre times 2.5/100 metres). The problem is that any attempt to measure the voltage (cheaply) will immediately bleed the charge away. Even a 10 megohm resistor gives a time constant of only 20 microseconds.

This transient could possibly be detected except for another major problem. The whole world is filled with (it would seem) literally thousands of volts/metre of 50Hz mains hum and if a detector was built with a bandwidth sufficient to detect the spikes then it would be continually set off by mains. This means that the detector needed to operate on our parallel plate capacitor must have a filter that cuts off fast before 50Hz to keep mains out. If the detector doesn't respond to frequencies above 50Hz then the input RC time constant needs to be very long, about a second! Hence the problem in building such a device. It must have an incredibly high input impedance or alternatively huge capacitor plates to up the sensing capacitance. With 2pF input capacitance this gives a detector input resistance of 500 gigohms! Even though the input impedance of some MOS input op-amps approaches this figure, it isn't a lot of use as an actual resistor is needed to define reference voltages. As 500 gigohm resistors are just a little hard to buy this basic approach won't work.

It then occurred to me that we were trying to detect voltages in the order of tens of volts. This combined with the fact that these days gain is cheap gave me the clue. If one plate of the sensor capacitor plates was connected to the other through say a 5000pF capacitor then the input tens of volts would be attenuated to fours of millivolts, but then the detector capacitor forms a potential divider with the 5000pF and increases the size of the source capacitance. In this case the needed detector input resistance drops to around 100 megohms to be usable. This is still a bit gross but getting closer. From an engineering point of view ▶

## Project 173

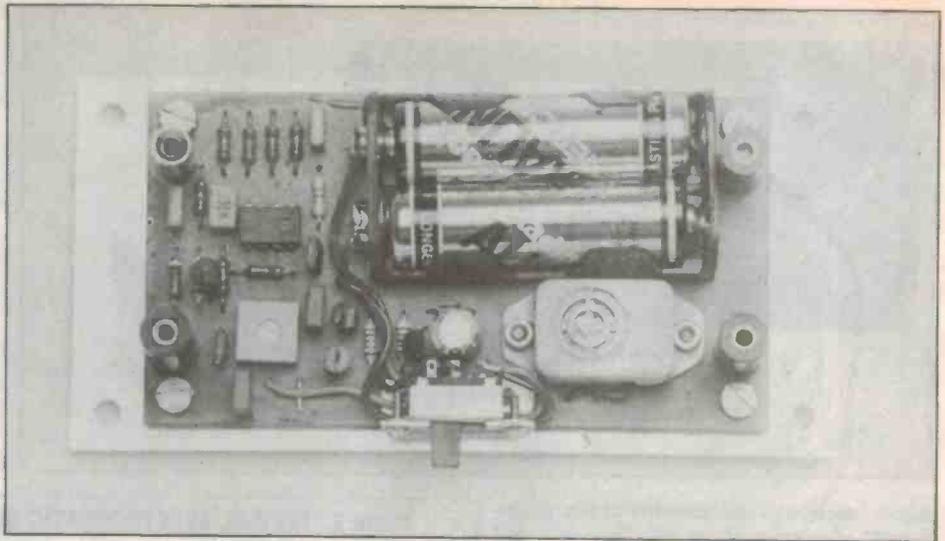
you can get 100 megohm resistors but they are expensive and hard to procure. About the largest I could find at Geoff Woods' was 10M. He had 22 megs but I settled for 10M for reasons I'll go into later.

The next problem is how one can magically change a 10 meg resistor into a 100 meg resistor. The method goes by the delightful term "bootstrapping". Consider a resistor with a voltage applied to one end as shown in Figure 1. The current through the resistor due to the imposed voltage is  $I$ . If a buffer amplifier with a very high input impedance is connected to the top of the resistor with a gain of say 0.9 and its output is connected to the earth end of the resistor then the voltage drop across the resistor is no longer  $V$  as in Figure 1 but  $V-0.9V$  or only  $0.1V$ . This means that even though the full  $V$  volts is being imposed on the resistor, the current flowing into it is only  $0.1I$  so the effective resistance is multiplied by 10. This would seem to be a pretty good trick to use. It does have bad side effects like multiplying all offset problems by 10 but if these can be managed then a 10 meg resistor can be changed into a 100 meg resistor.

Given the ability to artificially create a very high input impedance amplifier, the idea of a detector of changing strong electrostatic fields seemed to be quite workable. It should be in a small box to one side of the work area and preferably run off batteries. As the detector does not need a large bandwidth (in the final device there is a lot of circuitry to reduce it) a very low power op-amp such as the National LM4250 can be used. The power drawn by this IC can be set to almost any value required by an external resistor. The op-amp bandwidth varies accordingly but even at microamp levels has more than enough. The LM4250 is specified down to 3 volts total supply voltage so the detector could be powered off two penlight cells. If the total IC power drain is kept below a few microamps then the life of the cells in the detector is effectively their shelf life.

### Circuit details

The actual filter used to attenuate the 50Hz is straightforward and 10M resistors were used throughout. As there is effectively 30 megohms between the positive input and ground it is necessary to add in about 30 megohms between the negative input and the output to balance the effect of bias currents in the op-amp. For the LM4250 operating at a few microamps the offset current (that is the *difference* in bias currents of the op-amp inputs) is still up to 5 nanoamps. With 30 megohms this generates a differential offset voltage at the input in the worst case of 150 millivolts. This could be adjusted out with an offset adjust pot but the problem is further aggravated by the bootstrapping with R7 and R8. C7 had to be



added to remove both the bootstrapping and the high gain for very low frequencies or the input simply floated all over the place.

However, for frequencies between 0.5Hz and 15Hz the detector gain is pretty much flat and set by the ratio of R10 to R7+R8. When I slogged through the algebra to calculate the transfer polynomial for the circuit, one very interesting fact emerged: the gain of the detector is proportional to the size of C8. You will recall that the input to the detector is actually a capacitive divider made up of the detector plates and C8 so the larger C8 is the higher the input capacitive divider attenuation *but then so is the amplifier gain!* They cancel out. Most serendipitous! Once again, there are always limits like offset problems that don't show up in the mathematics but basically it's whatever is convenient in the filter for C8.

Transistors Q1 and Q2 act to turn on the Darlington transistor Q3 when the op-amp output exceeds one  $V_{be}$ . I wanted a nice loud alarm when there was a hazard situation so I used one of the small 3 volt self contained alarms. They're nothing if not loud. A quick estimate of the board area needed showed it would fit nicely into a plastic jiffy box 130mm x 70mm x 40mm with a metal bottom. The metal case bottom serves as one plate of the sensing capacitor so plastic cases aren't any good.

### Construction

Everything is mounted on the pc board including the batteries. You can copy the artwork provided or purchase transparencies from ETI, or do it the easy way and buy from the kit suppliers. However you do it, try to stick exactly to the layout given.

Mounted over the board on 25.4mm spacers is the second plate of the sensing capacitor. Three of the spacers are made of insulating material and the fourth is metal and carries the received voltage to the detector input. I even chose to put a tiny slide switch and the buzzer on the board (both of which I got from Tandy) just to make things complete. The switch is included in case a situa-

tion arises where high fields can't be avoided (say you're building a Van de Graaff generator and you don't want to have to throw it out the window).

Before the board components are assembled it's a smart idea to use it as a template to drill the holes for the base plate and the detector plate.

Hold the board *exactly* in the centre of the base plate for the four mounting holes. A dimensional drawing is given for the detector plate but it's a lot easier to simply hold the board and plate together and drill them (more accurate too!). *Note that the detector plate is offset if you wish to use the small slider switch mounted on the board.*

Make sure that the IC and the electrolytic capacitors are in the right way. The battery case I used was one which held four penlight cells. You can get battery holders that only take two cells but if you look at where the holder is mounted you'll see that it would be impossible to get one of the cells in. The four cell holders come in various brands, some with nickel plated steel contacts and some with aluminium. The aluminium ones aren't so good here as it's necessary to solder to the springs and you can't solder aluminium! It's difficult enough with the nickel.

Carefully cut away the side of the battery holder that doesn't have terminal clips. This will leave you with a spring protruding which should be straightened out. On the piece of holder that was cut away there is a second spring still riveted to the plastic. Drill, bash or bend the rivet out and retrieve the spring. Straighten out the end of the spring that was riveted so it can be inserted in a hole in the printed circuit board. Mix up some Araldite or similar and glue down the battery holder then insert the straightened out spring so as to make a neat two cell battery holder as pictured.

The next and nastiest bit is to solder the nickel plated springs on to the large ground area of the printed board. Nickel is a beast of a material to solder and I must confess I weakened and used el corodo Bakers soldering flux but it has to be washed off com- ▶

## ETI-173 — PARTS LIST

Resistors.....all 1/4W, 2% metal film

R1, 2, 3, 4, 5 ..... 10 megohm  
 R6 ..... 4M7  
 R7, 12 ..... 1k0  
 R8 ..... 9k1  
 R10, 9 ..... 2M2  
 R11 ..... 100k  
 RV1 ..... 100k trimpot

Capacitors

C1, 2 ..... 100n 10% met poly\*  
 C3, 4 ..... 1n 10% met poly\*  
 C5 ..... 150p 10% met poly\*  
 C6 ..... 6n8 10% met poly\*  
 C7 ..... 100µ 10% 3V tag tantalum  
 C8 ..... 47µ Al electro  
 C9 ..... 4n7

Semiconductors

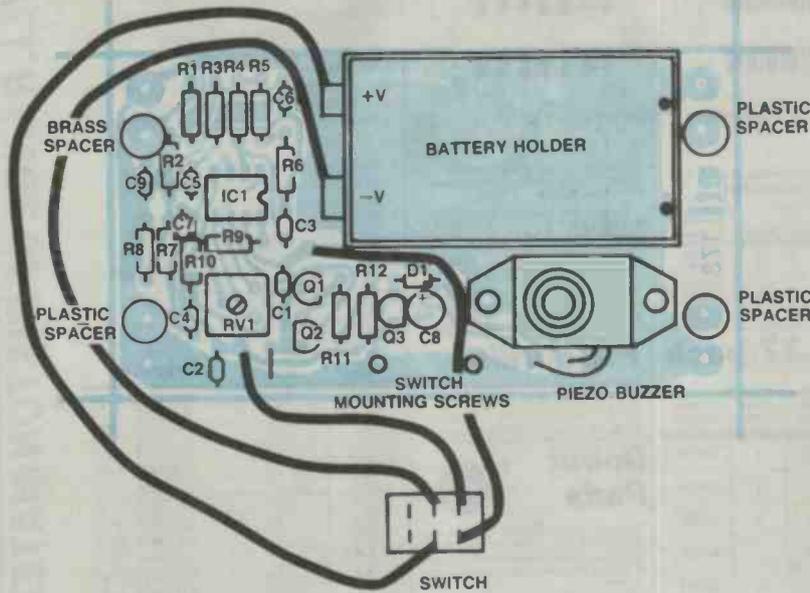
IC1 ..... LM4250  
 D1 ..... 1N914  
 Q1, 2 ..... BC559  
 Q3 ..... Motorola MPS-A14

Miscellaneous

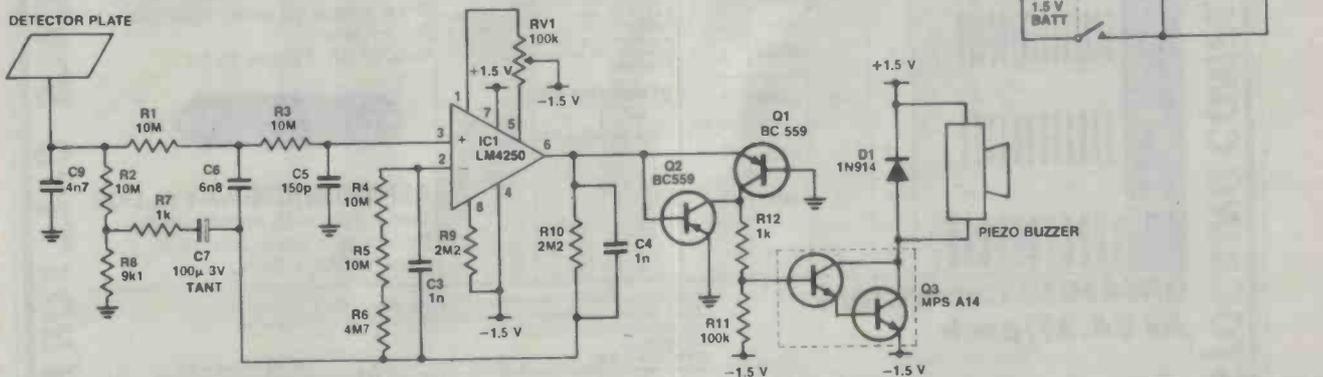
ETI-173 pc board; 2 x AA batteries; battery holder; Piezo buzzer; slide switch; 3 x 25.4mm insulated spacers; 1 x 25.4mm metal spacer; hookup wire; 130mm x 70mm x 40mm jiffy box with metal bottom; 5cm x 100cm metal plate; 4 x 4BA 3/8" screws and nuts; Scotchcal front panel.

**Price estimate: \$25**

\*The prototype used metallised polyester film caps such as ERO MKT1817 or MKT1826, or Wima PR21 or PS21 but greencaps could be substituted.



DETECTOR PLATE



## ETI-173 — HOW IT WORKS

The alarm detects electrostatic fields by sensing the potential difference they generate on a parallel plate capacitor. One plate is the base plate of the case and the other is a plate held by spacers above the detector.

Resistors R1 and R3 form a low pass filter with C5 and C6 to attenuate mains hum. Further attenuation is provided by C4 which rolls off the operational amplifier IC1's response. R7 and R8 serve two purposes. The first is to act as a gain determining element which, together with R10 sets the gain of

the op-amp at 220. Also the node of R7 and R8 has a voltage of 0.9 times the voltage on the positive input of the amplifier (and the negative input too — such is the nature of operational amplifiers). R2, the input bias setting resistor, is connected to this node so that any signals that appear at the input to the detector are also imposed, multiplied by 0.9, on the other end of R2. This is known as bootstrapping and effectively multiplies the value of R2 by 10.

The overall effect of this is that any voltage that would be induced on a capacitor

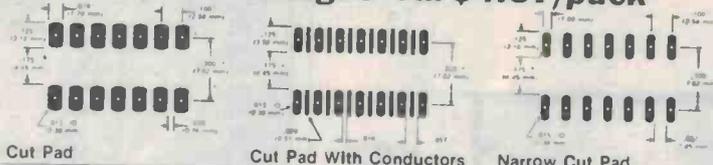
with plates about 20mm apart appears with a low source impedance at the output of the op-amp, attenuated 10 times when everything is taken into account.

Transistor Q1 is turned on if the op-amp output goes more than 0.6 volts positive and Q2 is turned on if it goes negative. Both collectors drive the base of the Darlington transistor Q3 which in turn powers the alarm. Thus excursions of  $\pm 0.6$  volts set off the alarm or, tracing back through the circuit, the detector will pick up fields of greater than 300 volts/metre.

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Cut Pad

Cut Pad With Conductors

Narrow Cut Pad

No. of Leads	Qty/Plg.	Scale	Catalog Number
14	32	1X	E26014
	28	2X	E26038
16	32	1X	E26034
	28	2X	E26109
18	28	1X	E26900
	26	2X	E26901
24	12	1X	E26535
	12	2X	E26536
26	12	1X	E26903
	12	2X	E26904
40	8	1X	E26906
	8	2X	E26907

• Use where conductor traces must be routed between pads

• Use where a longer terminal area is desired. Can be used with conductors between terminals.

No. of Leads	Qty/Plg.	Scale	Catalog Number
14	32	1X	E26760
	28	2X	E26761
16	32	1X	E26763
	28	2X	E26764
40	8	1X	E26984
	8	2X	E26985

No. of Leads	Qty/Plg.	Scale	Catalog Number
14	32	1X	E26013
	28	2X	E26071
18	32	1X	E26453
	28	2X	E26244
40	8	1X	E26987
	8	2X	E26988

## Pre-Spaced Pads \$4.37/pack

Center to Center Spacing	Pad Type	Scale	Pads Per Strip	Strips Per Pack	Catalog Number
100"		1X	40	8	E25000
		2X	20	7	E25001
		1X	40	8	E25003
		2X	20	7	E25004
		1X	40	8	E25017
		2X	20	7	E25018
156"		1X	40	8	E25020
		2X	20	7	E25021
		1X	25	8	E25014
		2X	13	7	E25015

## P.C. Drills

Take your pick of tungsten carbide or high speed steel. Available in 0.8, 0.9, 1.0 and 1.2mm. T.C. drills \$5.85 each. H.S. Steel \$1.75 each.

## Donut Pads



The basic all-purpose PC terminal area for termination of wire or component leads extending through the PC board. ID aids in accurate pad location to grid centers.

E-Z CIRCUIT Tape Donut Pads are unsurpassed for uniformity and accuracy. These photographically opaque terminal areas are accurate to ± .002" (0.05mm). E-Z Circuit opaque black pads are only .005" (0.13mm) thick.

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1. Select the largest possible pad. Allow enough room for conductor traces and the physical conditions of artwork preparation and manufacturing of the actual board (MIL-STD-275).
2. A small ID makes registration easy, but may make it difficult to locate pad center after photo reduction.
3. Choose an ID smaller than hole to be drilled. (Drill size for plated-through holes must be larger than final hole.)
4. Use Multi-Pad configurations for multi-pad terminal patterns. It is much easier, much faster, and much more accurate to lay down a whole pattern printed to specific tolerances than to tediously position individual pads.

## STANDARD INCH

OD	ID	Cat. No.	Qty/Pkg.
In.	mm		
.080	2.03	031	0.79
.100	2.54	031	0.79
.120	3.05	031	0.79
.125	3.18	031	0.79
.150	3.81	031	0.79
.175	4.45	031	0.79
.200	5.08	031	0.79
.250	6.35	062	1.57
.300	7.62	062	1.57

## Precision Slit Tapes

"Super" 201 is a flexible extra-strong photographically opaque, pressure-sensitive precision slit tape with exceptional adhesive characteristics. It will not creep or lift if stretching is avoided during application. "Super" 201 is extremely flexible and has a non-reflective matte finish. Only .005" (0.13 mm) thick.

- Precision slit to exacting tolerances to assure highest quality PC artwork and photography
- Manufactured from the same high quality materials as E-Z CIRCUIT PREKUT TAPE SHAPES to insure compatible PC artwork and photography

## STANDARD INCH

20 Yds./Roll

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In.	mm	
.020	0.51	EZC3000 \$3.05
.026	0.66	EZC3002 \$3.05
.031	0.79	EZC3004 \$3.25
.040	1.02	EZC3006 \$3.25
.050	1.27	EZC3008 \$3.25
.062	1.57	EZC3010 \$3.35
.080	2.03	EZC3012 \$3.35
.093	2.36	EZC3014 \$3.35
.100	2.54	EZC3016 \$3.35
.125	3.18	EZC3018 \$3.35
.200	5.08	EZC3020 \$3.46
.250	6.35	EZC3022 \$4.57
.500	12.70	EZC3024 \$5.70

## Accurate Grids

Grids are produced on accurate, stable film with 0.1" pattern for maximum accuracy. Matte one sided. .003" thick.

Sheet Size	Catalog Number	Price
8" x 11"	E21463	\$2.63
11" x 17"	E21466	\$4.87

## CONNECTOR SPECIALS

### 25 WAY 'D' CONNECTORS

Great special on panel mounted D connectors.  
Male \$2.50 Female \$3.50



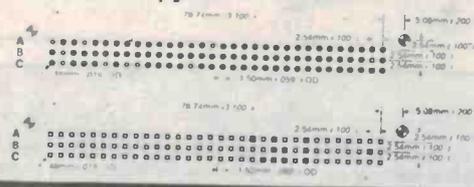
### CENTRONIC 36 WAY PLUGS

Solder type with metal backshell. No special tools needed to fit these!! ONLY \$4.50

## Edge Connectors \$4.37/pack

Center to Center Spacing	Scale	Contacts/Strip	Catalog Number	Strips/Pack
100"	1X	44	E26006	2
	2X	22	E26008	5
125"	1X	35	E26704	2
	2X	17	E26716	4
156"	1X	26	E26708	3
	2X	14	E26720	5

## DIN41612 Connectors All \$4.37/pack



DIN41612 connectors patterns have three row designations A, B and C. Three pattern combinations are available AB, AC and ABC. They are also available with round or square pads.

### ROUND PAD

64-Pin Pattern (A-B)				64-Pin Pattern (A-C)				96-Pin Pattern (A-B-C)			
Scale	Symbols Per Plg.	Catalog Number	Price	Scale	Symbols Per Plg.	Catalog Number	Price	Scale	Symbols Per Plg.	Catalog Number	Price
1X	2	E26875	1.18	1X	2	E26875	1.18	1X	2	E26875	1.18
2X	2	E26876	1.18	2X	2	E26876	1.18	2X	2	E26876	1.18

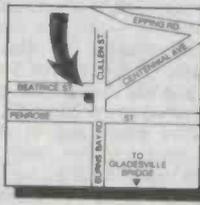
### SQUARE PAD

64-Pin Pattern (A-B)				64-Pin Pattern (A-C)				96-Pin Pattern (A-B-C)			
Scale	Symbols Per Plg.	Catalog Number	Price	Scale	Symbols Per Plg.	Catalog Number	Price	Scale	Symbols Per Plg.	Catalog Number	Price
1X	2	E26877	1.18	1X	2	E26877	1.18	1X	2	E26877	1.18
2X	2	E26878	1.18	2X	2	E26878	1.18	2X	2	E26878	1.18

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pletely. The buzzer is screwed down and both its leads soldered into the relevant pads. Be careful as the polarity must be right. Finally the board must be cleaned absolutely scrupulously of all flux and residue. There are a lot of high impedances and leakage could be a nuisance.

You need three insulating spacers and one metal one to support the pickup plate. The metal one connects to the pad that has C8, R1 and R2 connected to it. If you choose to use the little slide switch you'll find it necessary to trim one side of the pickup plate so the electronics can be assembled into the box. If you use another type remember that both the positive and negative supplies must be switched. I didn't bother with the clip leads for the battery holder but simply soldered pieces of hookup

wire on to the terminals as they will never be disconnected.

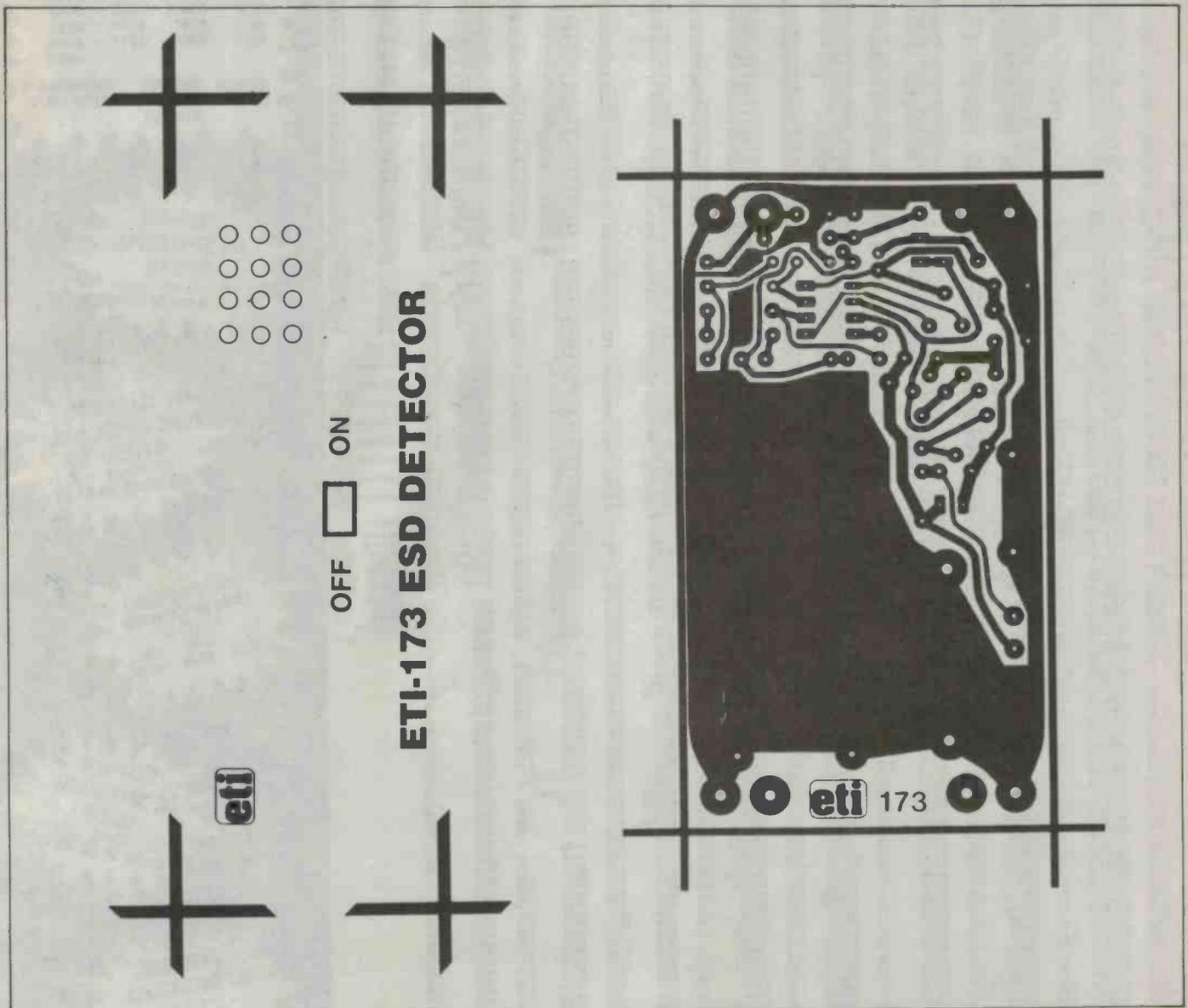
The board assembly is mounted on the base plate of the box with four 4BA 3/8 screws. The screws are passed through the board and one nut done up tight on each screw, then the protruding ends of the screws are passed through the four holes in the base plate and another four nuts done up to hold the board neatly in place.

### Testing

Testing is really quite easy. Insert two batteries and turn it on. The alarm should sound for about 20 seconds or so as C7 charges to the offset voltage then it shuts off. Let it settle for a few minutes then measure the voltage between pin 6 of the IC and ground. Adjust RV1 until it averages out to

zero. This is a fiddly and odious task as you only have to (literally!) wave your hand near the detector input and pin 6 slams up against the rails. Fortunately, it isn't all that critical. Once this is done, screw on the detector plate and the unit is ready to go into the box.

Finally before fitting the unit together you'll have to cut a hole for the power switch. It makes sense to drill a few holes to let the buzzer sound out. Slip the unit into the box and screw it in place with the four screws provided then turn it on. If you keep well away from it, it should sound for 10 seconds or so then go quiet. Just waving your hand close over it or touching the box will set it off. Then you may leave it on in a corner of your workbench and breathe a bit easier! ●



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4015	4043	4161	40014
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4017	4049	4503	6802
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4019	4066	4511	6845
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ICL7106	19.50	74C374	4.45	74LS324	2.20	LM377	4.90	BD238	.80	2M3055	1.00	6AMP		8271	89.00	HLM3420.395	4056	4.20
ICL7111	19.50	74C375	4.45	74LS325	2.20	LM378	4.90	BD262	1.20	2M3060	1.00	BPC602	2.90	8272	33.00	LEDS	4060	2.00
ICL7116	8.95	74C376	2.90	74LS326	2.20	LM379	4.90	BD263	1.20	2M3109	1.00	BPC604	3.90	8273	65.00	3mm RED Z5	4063	2.00
ICL7181	19.50	74C377	4.45	74LS327	2.20	LM380	4.90	BD264	1.20	2M3158	1.00	BPC606	4.50	8274	42.50	3mm YEL Z5	4066	2.50
ICL7660	9.50	74C378	2.90	74LS328	2.20	LM381	4.90	BD265	1.20	2M3167	1.00	10AMP		8275	34.50	3mm GRN Z5	4067	1.90
ICM8711	12.50	74C379	4.45	74LS329	2.20	LM382	4.90	BD266	1.20	2M3176	1.00	KBPC1002.420		8276	28.50	3mm RED 18	4068	1.90
ICM7216A	46.50	74C380	2.90	74LS330	2.20	LM383	4.90	BD267	1.80	2M3185	1.00	KBPC1004.430		8277	31.50	3mm GRN 18	4069	1.90
ICM7216B	46.50	74C381	2.90	74LS331	2.20	LM384	4.90	BD268	1.80	2M3194	1.00	35AMP		8278	6.90	5mm YEL 30	4070	9.00
ICM7224A	46.50	74C382	2.90	74LS332	2.20	LM385	4.90	BD269	2.00	2M3203	1.00	KBPC3502.590		8279	8.50	5mm ORG 30	4071	4.00
ICM7224B	46.50	74C383	2.90	74LS333	2.20	LM386	4.90	BD270	2.00	2M3212	1.00	KBPC3504.600		8280	6.90	5mm ORG 30	4072	9.00
ICM7227A	46.50	74C384	2.90	74LS334	2.20	LM387	4.90	BD271	2.00	2M3221	1.00	KBPC3506.620		8281	6.90	5mm YEL 30	4073	9.00
ICM7227B	46.50	74C385	2.90	74LS335	2.20	LM388	4.90	BD272	2.00	2M3230	1.00	A3504	5.90	8282	6.90	RED RECT 30	4074	9.00
ICM7227C	46.50	74C386	2.90	74LS336	2.20	LM389	4.90	BD273	2.00	2M3239	1.00	KBPC3510.MDA		8283	6.90	GRN RECT 30	4075	9.00
ICM7227D	46.50	74C387	2.90	74LS337	2.20	LM390	4.90	BD274	2.00	2M3248	1.00	3510	9.90	8284	6.90	RED CHROME	4076	1.80
ICM7227E	46.50	74C388	2.90	74LS338	2.20	LM391	4.90	BD275	2.00	2M3257	1.00	7407		8285	6.90	BEZEL 1.20	4077	1.80
ICM7227F	46.50	74C389	2.90	74LS339	2.20	LM392	4.90	BD276	2.00	2M3266	1.00	7408		8286	6.90	YELLOW	4078	1.80
ICM7227G	46.50	74C390	2.90	74LS340	2.20	LM393	4.90	BD277	2.00	2M3275	1.00	7409		8287	6.90	CHME BEZEL	4081	4.00
ICM7227H	46.50	74C391	2.90	74LS341	2.20	LM394	4.90	BD278	2.00	2M3284	1.00	7410		8288	6.90	BEZEL 1.20	4082	1.80
ICM7227I	46.50	74C392	2.90	74LS342	2.20	LM395	4.90	BD279	2.00	2M3293	1.00	7411		8289	6.90	GRN CHROME	4085	2.20
ICM7227J	46.50	74C393	2.90	74LS343	2.20	LM396	4.90	BD280	2.00	2M3302	1.00	7412		8290	6.90	BEZEL 1.20	4086	2.20
ICM7227K	46.50	74C394	2.90	74LS344	2.20	LM397	4.90	BD281	2.00	2M3311	1.00	7413		8291	6.90	BEZEL 1.20	4087	2.20
ICM7227L	46.50	74C395	2.90	74LS345	2.20	LM398	4.90	BD282	2.00	2M3320	1.00	7414		8292	6.90	BEZEL 1.20	4088	2.20
ICM7227M	46.50	74C396	2.90	74LS346	2.20	LM399	4.90	BD283	2.00	2M3329	1.00	7415		8293	6.90	BEZEL 1.20	4089	2.20
ICM7227N	46.50	74C397	2.90	74LS347	2.20	LM400	4.90	BD284	2.00	2M3338	1.00	7416		8294	6.90	BEZEL 1.20	4090	2.20
ICM7227O	46.50	74C398	2.90	74LS348	2.20	LM401	4.90	BD285	2.00	2M3347	1.00	7417		8295	6.90	BEZEL 1.20	4091	2.20
ICM7227P	46.50	74C399	2.90	74LS349	2.20	LM402	4.90	BD286	2.00	2M3356	1.00	7418		8296	6.90	BEZEL 1.20	4092	2.20
ICM7227Q	46.50	74C400	2.90	74LS350	2.20	LM403	4.90	BD287	2.00	2M3365	1.00	7419		8297	6.90	BEZEL 1.20	4093	2.20
ICM7227R	46.50	74C401	2.90	74LS351	2.20	LM404	4.90	BD288	2.00	2M3374	1.00	7420		8298	6.90	BEZEL 1.20	4094	2.20
ICM7227S	46.50	74C402	2.90	74LS352	2.20	LM405	4.90	BD289	2.00	2M3383	1.00	7421		8299	6.90	BEZEL 1.20	4095	2.20
ICM7227T	46.50	74C403	2.90	74LS353	2.20	LM406	4.90	BD290	2.00	2M3392	1.00	7422		8300	6.90	BEZEL 1.20	4096	2.20
ICM7227U	46.50	74C404	2.90	74LS354	2.20	LM407	4.90	BD291	2.00	2M3401	1.00	7423		8301	6.90	BEZEL 1.20	4097	2.20
ICM7227V	46.50	74C405	2.90	74LS355	2.20	LM408	4.90	BD292	2.00	2M3410	1.00	7424		8302	6.90	BEZEL 1.20	4098	2.20
ICM7227W	46.50	74C406	2.90	74LS356	2.20	LM409	4.90	BD293	2.00	2M3419	1.00	7425		8303	6.90	BEZEL 1.20	4099	2.20
ICM7227X	46.50	74C407	2.90	74LS357	2.20	LM410	4.90	BD294	2.00	2M3428	1.00	7426		8304	6.90	BEZEL 1.20	4100	2.20
ICM7227Y	46.50	74C408	2.90	74LS358	2.20	LM411	4.90	BD295	2.00	2M3437	1.00	7427		8305	6.90	BEZEL 1.20	4101	2.20
ICM7227Z	46.50	74C409	2.90	74LS359	2.20	LM412	4.90	BD296	2.00	2M3446	1.00	7428		8306	6.90	BEZEL 1.20	4102	2.20
ICM7227AA	46.50	74C410	2.90	74LS360	2.20	LM413	4.90	BD297	2.00	2M3455	1.00	7429		8307	6.90	BEZEL 1.20	4103	2.20
ICM7227AB	46.50	74C411	2.90	74LS361	2.20	LM414	4.90	BD298	2.00	2M3464	1.00	7430		8308	6.90	BEZEL 1.20	4104	2.20
ICM7227AC	46.50	74C412	2.90	74LS362	2.20	LM415	4.90	BD299	2.00	2M3473	1.00	7431		8309	6.90	BEZEL 1.20	4105	2.20
ICM7227AD	46.50	74C413	2.90	74LS363	2.20	LM416	4.90	BD300	2.00	2M3482	1.00	7432		8310	6.90	BEZEL 1.20	4106	2.20
ICM7227AE	46.50	74C414	2.90	74LS364	2.20	LM417	4.90	BD301	2.00	2M3491	1.00	7433		8311	6.90	BEZEL 1.20	4107	2.20
ICM7227AF	46.50	74C415	2.90	74LS365	2.20	LM418	4.90	BD302	2.00	2M3500	1.00	7434		8312	6.90	BEZEL 1.20	4108	2.20
ICM7227AG	46.50	74C416	2.90	74LS366	2.20	LM419	4.90	BD303	2.00	2M3509	1.00	7435		8313	6.90	BEZEL 1.20	4109	2.20
ICM7227AH	46.50	74C417	2.90	74LS367	2.20	LM420	4.90	BD304	2.00	2M3518	1.00	7436		8314	6.90	BEZEL 1.20	4110	2.20
ICM7227AI	46.50	74C418	2.90	74LS368	2.20	LM421	4.90	BD305	2.00	2M3527	1.00	7437		8315	6.90	BEZEL 1.20	4111	2.20
ICM7227AJ	46.50	74C419	2.90	74LS369	2.20	LM422	4.90	BD306	2.00	2M3536	1.00	7438		8316	6.90	BEZEL 1.20	4112	2.20
ICM7227AK	46.50	74C420	2.90	74LS370	2.20	LM423	4.90	BD307	2.00	2M3545	1.00	7439		8317	6.90	BEZEL 1.20	4113	2.20
ICM7227AL	46.50	74C421	2.90	74LS371	2.20	LM424	4.90	BD308	2.00	2M3554	1.00	7440		8318	6.90	BEZEL 1.20	4114	2.20
ICM7227AM	46.50	74C422	2.90	74LS372	2.20	LM425	4.90	BD309	2.00	2M3563	1.00	7441		8319	6.90	BEZEL 1.20	4115	2.20
ICM7227AN	46.50	74C423	2.90	74LS373	2.20	LM426	4.90	BD310	2.00	2M3572	1.00	7442		8320	6.90	BEZEL 1.20	4116	2.20
ICM7227AO	46.50	74C424	2.90	74LS374	2.20	LM427	4.90	BD311	2.00	2M3581	1.00	7443		8321	6.90	BEZEL 1.20	4117	2.20
ICM7227AP	46.50	74C425	2.90	74LS375	2.20	LM428	4.90	BD312	2.00	2M3590	1.00	7444		8322	6.90	BEZEL 1.20	4118	2.20
ICM7227AQ	46.50	74C426	2.90	74LS376	2.20	LM429	4.90	BD313	2.00	2M3599	1.00	7445		8323	6.90	BEZEL 1.20	4119	2.20
ICM7227AR	46.50	74C427	2.90	74LS377	2.20	LM430	4.90	BD314	2.00	2M3608	1.00	7446		8324	6.90	BEZEL 1.20	4120	2.20
ICM7227AS	46.50	74C428	2.90	74LS378	2.20	LM431	4.90	BD315	2.00	2M3617	1.00	7447		8325	6.90	BEZEL 1.20	4121	2.20
ICM7227AT	46.50	74C429	2.90	74LS379	2.20	LM432	4.90	BD316	2.00	2M3626	1.00	7448		8326	6.90	BEZEL 1.20	4122	2.20
ICM7227AU	46.50	74C430	2.90	74LS380	2.20	LM433	4.90	BD317	2.00	2M3635	1.00	7449		8327	6.90	BEZEL 1.20	4123	2.20
ICM																		

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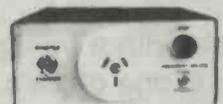
### ELECTROSTATIC HAZARD DETECTOR KIT

It's called electrostatic hazard and if it, or even its baby brother, jumps on the back of your IC or transistor, then the poor device is never likely to be quite the same again. So, out of a very ordinary collection of bits and pieces, ETI has fashioned a black box that will sit quietly on a corner of your bench for years at a time and beep when ever high tension appears. It may save you a lot of trouble, particularly if you ever work with CMOS. (ETI 173 May 86)  
 Cat. K41720

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### PLAYMASTER FM/AM STEREO TUNER

The new Playmaster FM/AM stereo tuner will perform anything presently available on the market, regardless of price. As well as including a FM tuner section which is every bit as good as any other synthesised design, it is also the only unit featuring a genuine wideband, low distortion AM stereo tuner. Naturally, it has a digital readout, 12 station memory, automatic seek and an optional infrared remote control. (EA Dec. '85 Jan-Feb '86 85tu12)  
 Cat. K86200 **\$399**



### 40 W INVERTER

This 12 240V inverter can be used to power up mains appliances rated up to 40 W, or to vary the speed of a turntable. As a bonus, it will also work backwards as a trickle charger to top up the battery when the power is on. (EA May '82) 82IV5  
 Cat. K82050 **\$69.95**

### MULTI SECTOR ALARM SYSTEM

Protect your home and possessions from burglars with this up to the minute burglar alarm system. It's easy to build, costs less than equivalent commercial units, and features eight separate inputs, individual sector control, battery back up and self-test facility.

**Specifications:**

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- Built-in siren driver.

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 Cat. K85900 **\$129**

### EA AM STEREO DECODER

AM stereo is now broadcast in Australia on an experimental basis. This add-on decoder works with the Motorola C-QUAM system. (EA Oct '84) 84MS10  
 Cat. K84100 **Normally \$26.95**  
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### ELECTRIC FENCE

Wants to battery power, this electric fence controller is both inexpensive and versatile. Based on an automotive ignition coil, it should prove an adequate deterrent to all manner of livestock. Additionally, its operation conforms to the relevant clauses of Australian Std 3129. (EA Sept. '82) 82EF9  
 Cat. K82092 **Normally \$19.95**  
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# SAVINGS BOILING WATER!



### OP AMP TESTER

The Op Amp Tester which could save you hours in agonising whether that old op amp that's been sitting in the draw for the last year. (ETI April '85, ETI 183)  
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### FUNCTION GENERATOR

This Function Generator with digital readout produces Sine, Triangle and Square waves over a frequency range from below 20Hz to above 160KHz with low distortion and good envelope stability. It has an inbuilt four-digit frequency counter for ease and accuracy of frequency setting. (EA April '82, 82A03A/B)  
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 Cat. K82041



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Ever wanted to build an earsplitting alarm which would be compact and not draw much current? This is just the circuit for you. It uses a piezo electric tweeter in a pulsed mode to form an arresting and very efficient alarm. (EA Nov '82) 82AL17  
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 Nominal Supply: Voltage 12V DC  
 Output: Voltage see table  
 Frequency: 50Hz +/-0.05%  
 Regulation: see table  
 Maximum Load: 300VA  
 Current Limiting: 30A (primary)  
 Efficiency: see table

Relative Load Watts	Output Voltage (RMS)	Input Current (A)	Efficiency (%)	Battery life 40Ah/20h Rate (minutes)
0	210	1.2	0	240
40	235	4.5	60	240
100	240	11.3	62	80
140	240	15.0	69	60
200	240	20.1	78	50
240	240	24.0	79	32
300	235	29.6	82	28

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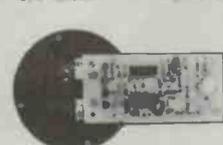
### PARALLEL PRINTER SWITCH KIT

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 Cat. K46660 **\$79.95**



### ELECTRONIC MOUSETRAP

This clever electronic mousetrap disposes of mice instantly and mercifully, without fail, and resets itself automatically. They'll never get away with the cheese again! (ETI Aug. '84) ETI 1524  
 Cat. K55240 **\$34.95**



### STEREO ENHANCER

It's not just the sound that it sounds good! The greatest stereo hi-fi system loses its magnificence if the effect is so narrow you can't hear it. This project lets you cheat on being cheated and creates an 'enhanced stereo effect' with a small unit which attaches to your amp. (ETI 1405, ETI, MAR '85)  
 Cat. K54050 **\$79.50**

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#### COMPUTER DRIVEN RADIO-TELETYPE TRANSMITTER KIT

What if you've been asking for, a full transmit-receive system for computer driven radio teletype station. The software provides all the latest "whizz-bangs" like split-screen operation, automatically repeating text message, printer output and more. The hardware uses tried and proven techniques. While designed to team with the popular Microbee, tips are available on interfacing the unit to other computers. (ETI Nov. '84) ETI 755)  
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Have you ever doubted a suspect transistor, only to find that it checks OK? Trouble-shooting exercises are often hindered by this type of false alarm, but many of them could be avoided with an "in-circuit" component tester, such as the EA Handy Tester. (EA Sept. '83) 83TT8  
 Cat. K83080 **Normally \$18.95**  
**SPECIAL, ONLY \$14.95**



### STEREO ENHANCER

It's not just the sound that it sounds good! The greatest stereo hi-fi system loses its magnificence if the effect is so narrow you can't hear it. This project lets you cheat on being cheated and creates an 'enhanced stereo effect' with a small unit which attaches to your amp. (ETI 1405, ETI, MAR '85)  
 Cat. K54050 **\$79.50**



### COMPUTER DRIVEN RADIO-TELETYPE TRANSMITTER KIT

What if you've been asking for, a full transmit-receive system for computer driven radio teletype station. The software provides all the latest "whizz-bangs" like split-screen operation, automatically repeating text message, printer output and more. The hardware uses tried and proven techniques. While designed to team with the popular Microbee, tips are available on interfacing the unit to other computers. (ETI Nov. '84) ETI 755)  
 Cat. K47550 **\$135**



### STROBE KIT

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### ZENER TESTER

A simple low cost add-on for your multimeter. This checks zeners and reads out the zener voltage directly on your multimeter. It can also check LEDs and ordinary diodes. (ETI May '83) ETI 164  
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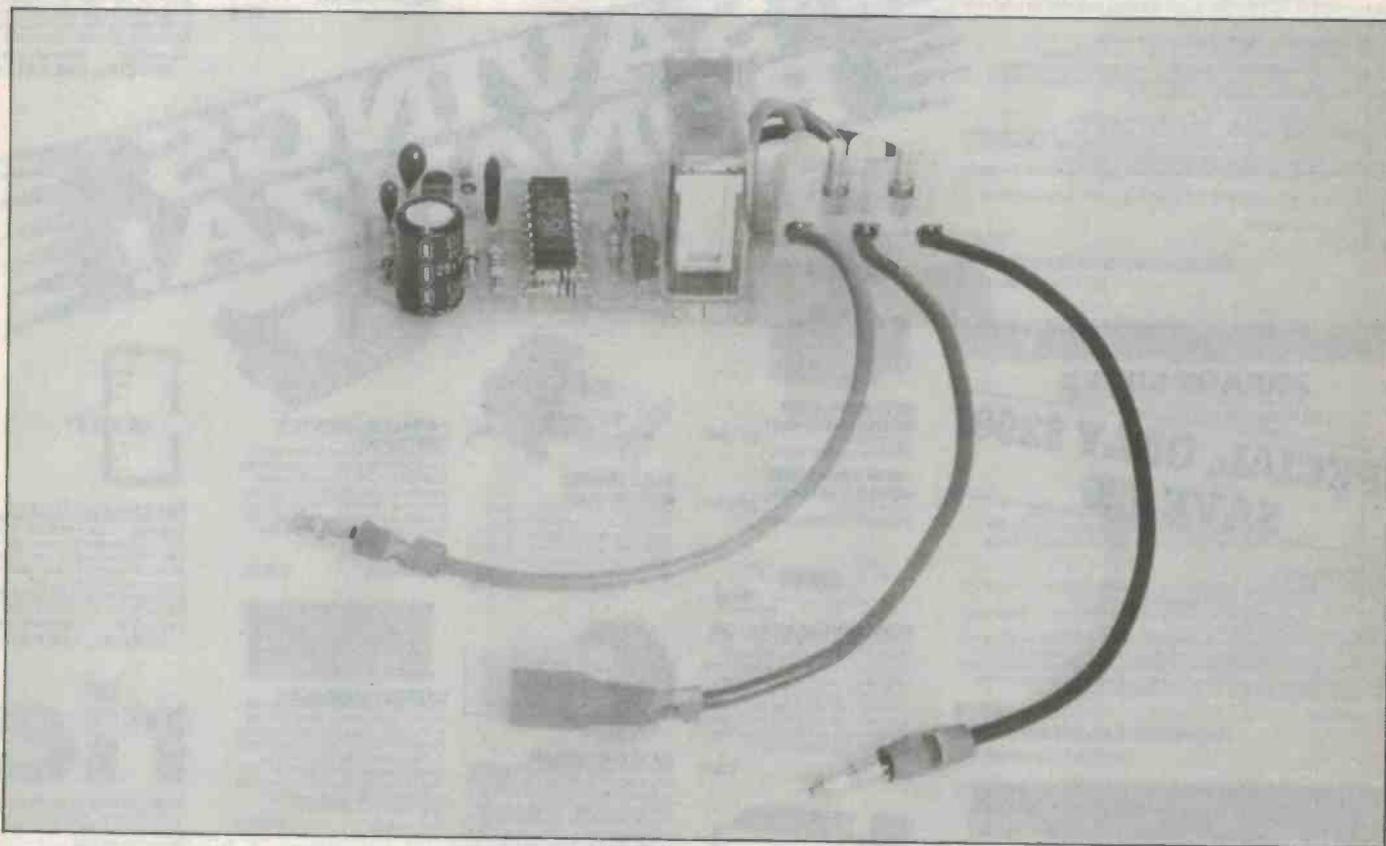
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# DEMISTER TIMER

Driving along in the wind and rain with a transparent rear window thanks to your demister is one of life's small satisfactions. Knowing it is heavily draining your battery is one of its small, cruel but typical tradeoffs. Forgetting to turn the demister off is an extra twist you can do without if you install the ETI-345 demister timer.

Neale Hancock



WINTER IS NOW here, bringing with it cold dark mornings and equally unpleasant evenings and a few extra problems for cars. Whenever we brave the elements to go to work or out raging, the electrical systems of

our cars in particular will have heavy demands placed on them.

Driving along with headlights on as well as the internal heater and a few hundred watts of music blasting out from the car hi-fi system, large amounts of current are drawn. Add to this the electrical current needed to supply a rear window demister and the car's ability to supply charging current to the battery is somewhat reduced. This situation is made worse when driving in wet conditions and in heavy traffic, because the alternator is not capable of supplying as much current when the car is travelling slowly. And reduced charging current can cause the car's battery to be undercharged, leading to difficulties in starting the car.

The rear window demister needs to be

switched on only long enough for the window to demist, then it can be switched off. However, when concentrating on the traffic, especially in adverse weather conditions, that is easy to forget and the demister draws current unnecessarily.

The amount of current drawn by a rear window demister can be in excess of 10 amps, which is not surprising considering the area to be heated. Therefore, by reducing the amount of time for which the demister is operating, a lot of current can be saved — current which is better used to charge the battery.

The ETI-345 demister timer has been designed to switch off the rear window demister after a preset time of either 10 or 20 minutes. The circuit is triggered when the

TABLE 1

Timing constant M	Pins connected
1	1
3	1,2
7	1-3
15	1-4
31	1-5
63	1-6
127	1-7
255	1-8

## HOW IT WORKS — ETI-345

When power is supplied to the voltage rails of the circuit, the combination of R1, C2, R2 and Q1 creates a delayed positive going pulse. R1 and C2 set the delay time for this trigger pulse to go high. This delay gives the circuit time to settle after the power has been applied to the voltage rails. R2 provides the negative going edge of the pulse. Q1 is a programmable unijunction transistor (or PUT for short) and its unique switching characteristics enable this delayed pulse.

The pulse from Q1 is received by pin 11 of IC1, which is an XR-2240 timer chip. The timing period is set by the combination of R5 and C3; the following formula can be used to calculate this time:  $T = M \times R5 \times C3$ . When  $M = 255$ ,  $R5 = 4.7M$  and  $C3 = 1\mu F$ , thus  $T = 1198$  seconds, which is about 20 minutes. C3 has to be a tantalum capacitor to reduce leakage thus making the timing more accurate.

Since pins 1 to 8 are connected together

the timing constant, M, is equal to 255. When the link connecting pins 7 and 8 is omitted M is equal to 127, making the timing period 10 minutes. This timing constant is determined by the number of pins connected to the output (see Table 1). Resistor R7 provides a signal path from the output to the reset pin (pin 10).

The output signal from IC1 is high when it is counting through the timing period and goes low when it is finished. When the output is high the pnp transistor Q2 turns on, allowing current to flow through the coil of the relay. This current closes the contacts of the relay, thus switching on the rear window demister. When the output from IC1 is low, Q2 turns off and the coil of the relay de-energises via D2.

The zener diode D1 protects the circuit from ignition spikes when the car is started and C1 provides smoothing of ripples or irregularities on the voltage rails.

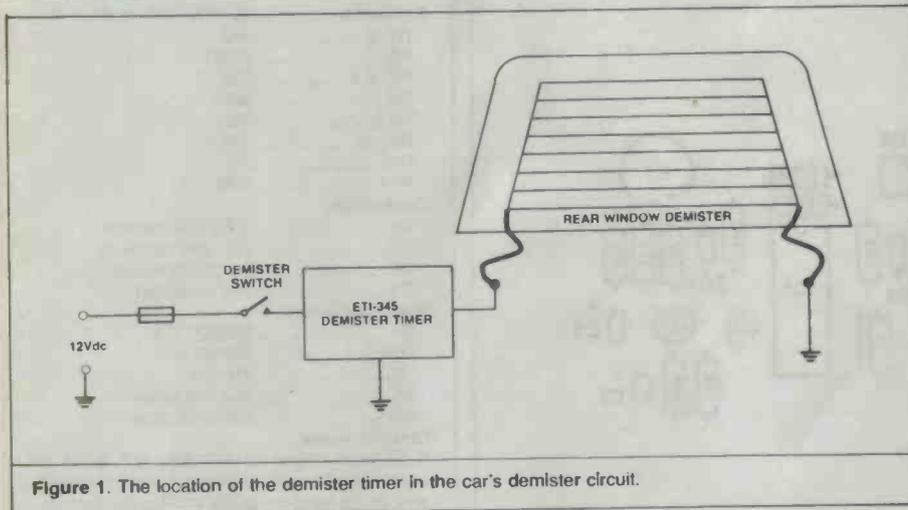


Figure 1. The location of the demister timer in the car's demister circuit.

rear window demister is turned on. Since the timer is triggered in this way, it does not require any external controls, and the circuitry for the timer can be located anywhere in the car.

The demister and the demister timer have a common source of current. Therefore when the demister is turned on, the timer is turned on. And since the timer is triggered by the demister being turned on, the trigger signal has to be delayed to give the circuitry time to settle before it is triggered.

### Construction and testing

Firstly check your printed circuit board for shorted tracks especially in the vicinity of the two transistors; also check for breaks in the tracks. Solder in all the resistors and the capacitors, making sure that the tantalum and electrolytic capacitors are orientated correctly. Next mount the semiconductors and the IC, but check their orientation against the overlay before you solder them in.

If you require the unit to time for 20 minutes solder in the link located near IC1; if you require only 10 minutes of timing omit this link. However, to make testing the

unit less time consuming it would be a good idea to leave the link off the board until it has been tested.

Finally mount the relay and the terminal block and solder in three short lengths of 16 gauge wire to connect the pc board to the terminal block. To connect the demister timer to the car, use short lengths of wire with standard automotive connectors, such as bullet head or spade and lug type connectors to one end, then screw the other end into the terminal block.

To test the unit out of the car, connect the circuit to any twelve volt source. The relay contacts should close (this can be checked by testing for continuity between the wires which connect the circuit to the heating element). They should open again after 10 or 20 minutes (depending on whether you have the link in or out). If this does not happen check your pc board for wrongly mounted components or solder bridges.

### Mounting and operation

The demister timer can be located anywhere in the car close to the car's demister circuit. Under the rear shelf near the rear

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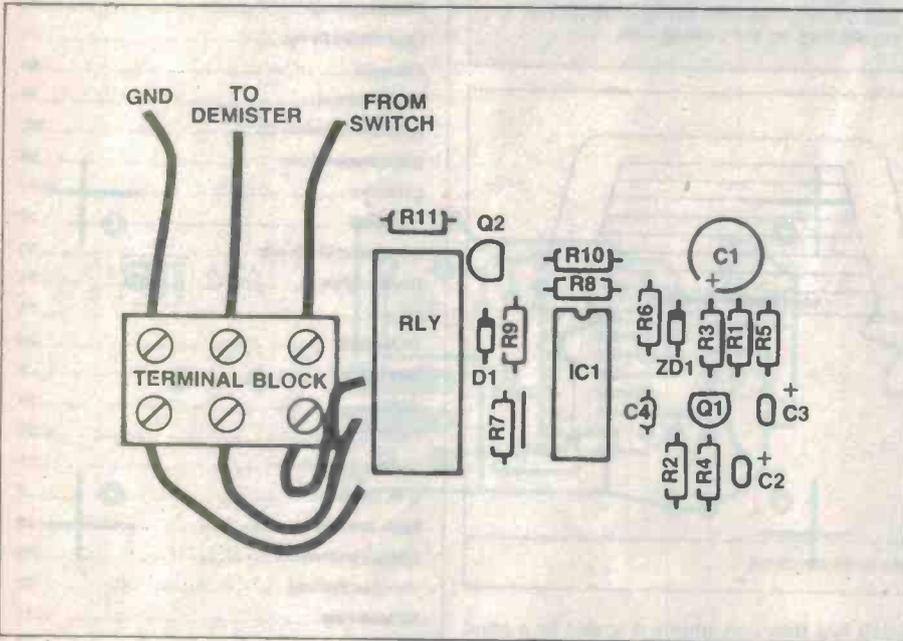
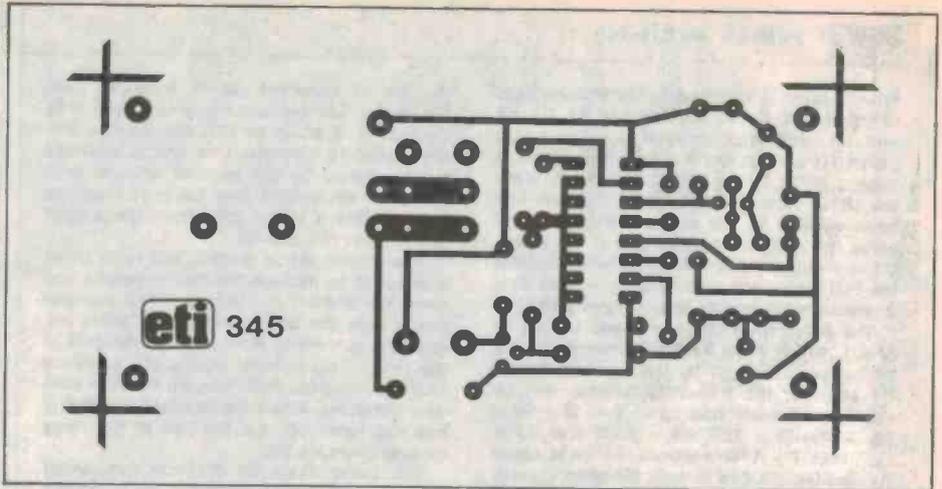
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# Project 345

window would be an ideal position, as it is accessible to all wiring and is out of the way. Wiring the demister timer into the car's demister circuit is illustrated in Figure 1.

Since the circuit is triggered by switching on the demister, its operation is pretty much automatic, however if the rear window starts to mist up again for any reason (heavy breathing in the back seat?) it can be retriggered by switching the demister off then on again. This will begin a new timing cycle.

Hopefully the ETI-345 demister timer will save our motorist-readers some hassles this winter. Happy and safe motoring!



## PARTS LIST — ETI-345

Resistors.....all 1/4W, 10% carbon film

- R1, 9.....4k7
- R2.....220R
- R3, 4, 8.....10k
- R5.....4M7
- R6.....22k
- R7.....47k
- R10.....1k
- R11.....47R

### Capacitors

- C1.....100μ 25V electro
- C2.....22μ 25V tantalum
- C3.....1μ 25V tantalum
- C4.....10n greencap

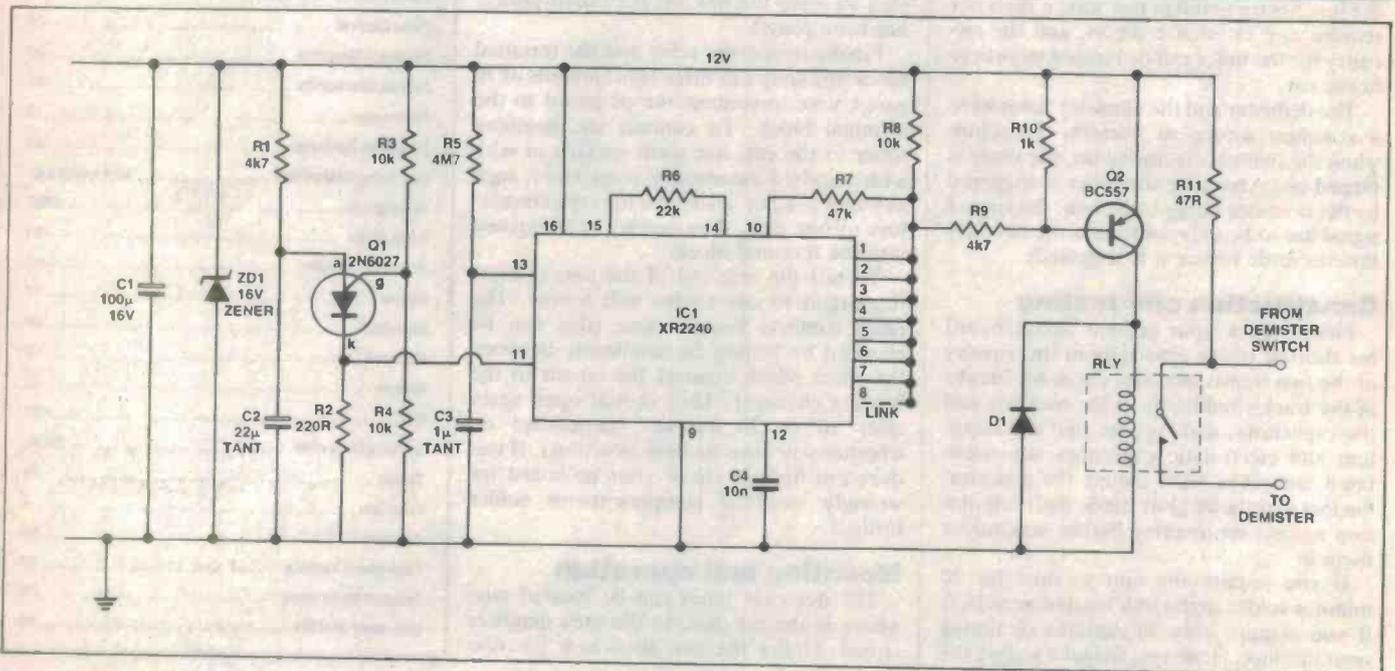
### Semiconductors

- Q1.....2N6027 PUT
- Q2.....BC557 BJT
- D1.....1N4004
- ZD1.....1N4745 zener
- IC1.....XR-2240 timer

### Miscellaneous

ETI-345 pc board; 12 volt relay; 12 volt relay with 270R coil and 16 amp contacts; terminal block; 16 gauge wire; bullet head or spade and lug connectors.

**Price estimate: \$15**



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# INTELLIGENT MODEM

The ETI-684 is without doubt the most complex software project ever undertaken in an Australian magazine. It has a list of features equal to that of professional models worth twice the price, and conforms to all the principle data transfer standards available in Australia. If you own a micro and need to get into data transfer this is the answer. If you build nothing else this year, build this one!!

Part 4  
S. K. Hui

UNFORTUNATELY, SPACE DOES not allow us to publish all the information you need this month. Those of you who are satisfied with kits will find them at quality suppliers with the complete series of articles. The circuit diagrams, artwork and construction instructions will be in next month's issue for those who like to make their own circuit boards.

In a departure from normal practice, we will not be publishing the software listing. It extends over 4K, and we cannot imagine anyone trying to enter it by hand. Copies of the EPROM will be available from ETI for a small fee if you can't get it from a kit supplier. Real suckers for punishment, or the

plain bloody-minded, will no doubt want to disassemble it to see what we did. Go for it!!!

### Features

- V21 300/300 full duplex
- V23 1200/75 half duplex
- Automatic baud rate selection on reception (auto bauding)
- Other standards found overseas like Bell 103 and other 600/600 and 1200/1200 standards supported by the hardware
- Intelligent auto answer
- Intelligent auto dialling
- Fully software driven
- 48K RAM buffer

- Cassette interface under Viatel standard control
- Software controlled loudspeaking
- Responds to industry standard Hayes commands
- Especially tailored for use by both professional and hobby users

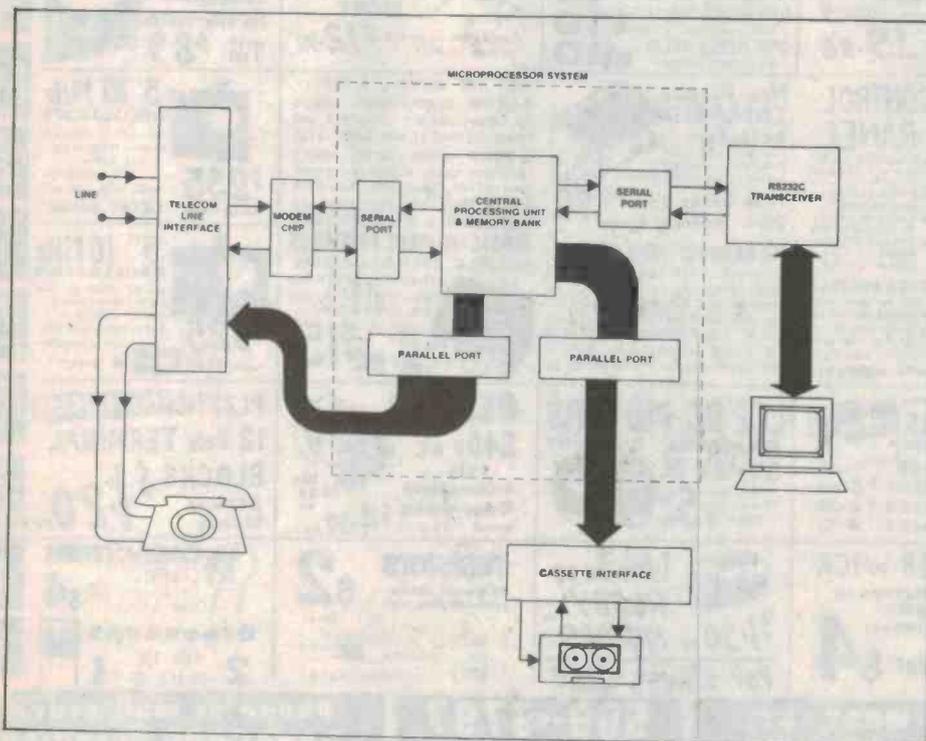
### Protocols

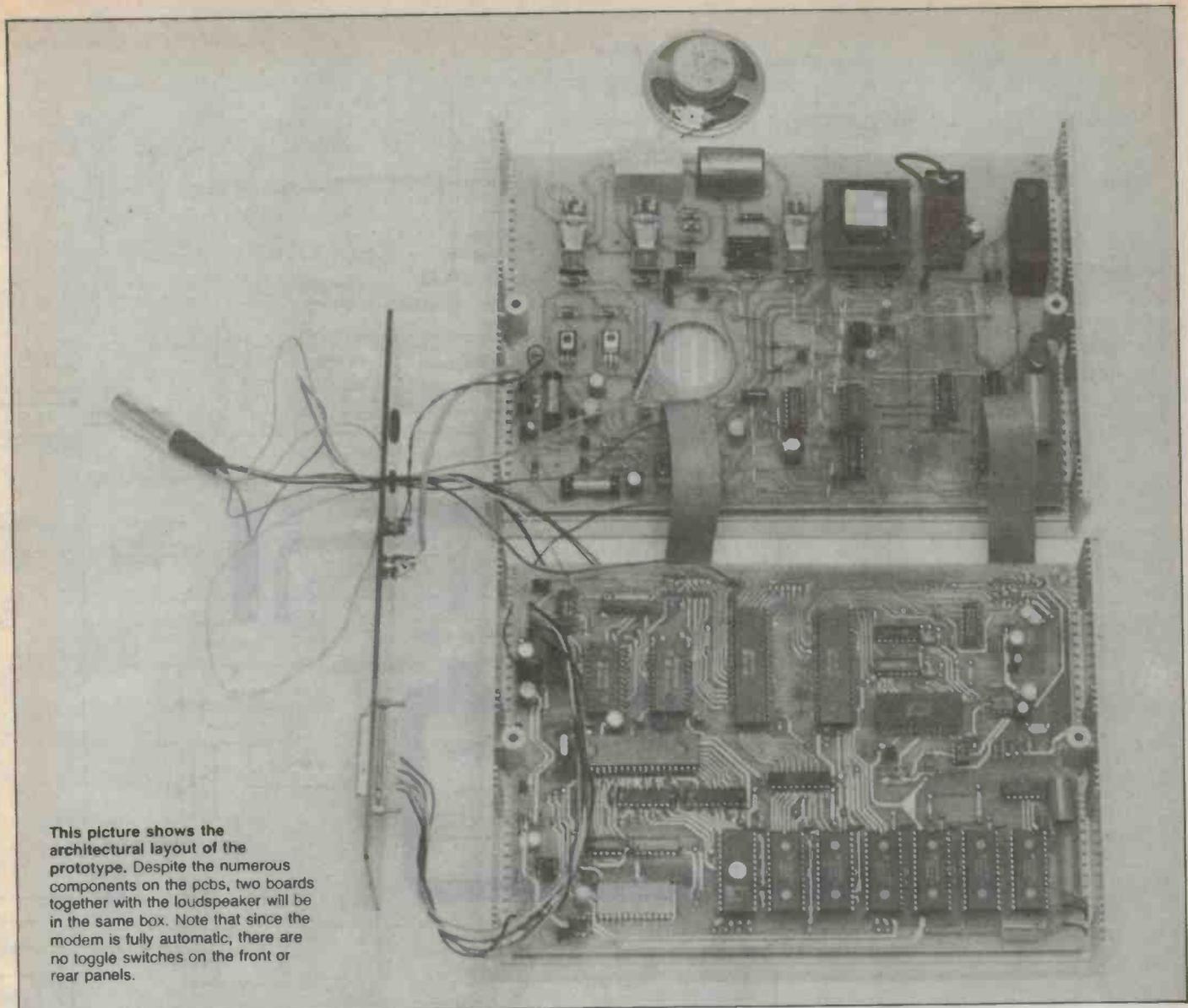
We have only implemented two software protocols in version one of the software, because there are only two worth bothering about in Australia: the CCITT V21 and V23. The V21 standard is used by bulletin boards and in many other data communications that involve personal computers. Indeed, ETI has published several modems already that use this standard.

The V23 standard requires the modem to receive at 1200 baud and transmit at 75. This is the Viatel standard.

The total range of speeds that could be supported is defined mostly by the 7910 modem chip, and could include 75, 300, 600 and 1200 in both directions. If it is desired to use some of the other standards, this can be done by altering the software and it is likely that there will be some discussion on this in a future article. There are some applications where it would be handy to go faster, but the chips necessary to implement these are horrendously expensive.

Another way of increasing speed without recourse to faster chips is to use non-standard coding techniques. For instance, the standard dictates that the modem communicates in a series of bytes, each containing seven bits. The bits are coded according to the ASCII standard. This means that every letter requires seven bits. Often, however, it's possible to put more information into the code than one would think. For instance, the code for A is 42hex. The code for B is 43h. Say we wish to send AB. One strategy might be to code A as 42h and B as 43h, and send 14 bits. Another way might





This picture shows the architectural layout of the prototype. Despite the numerous components on the pcbs, two boards together with the loudspeaker will be in the same box. Note that since the modem is fully automatic, there are no toggle switches on the front or rear panels.

be to code A as 42h, but B as +1, ie, one more than the previous letter. Thus we need only eight bits to send the two letters.

In practice, it's possible to devise simple codes like this that almost double the speed of the modem, without any change to the hardware. Of course, there are obvious problems in implementing non-standard procedures in any transmission device so we have not offered that as an option in this software. Nevertheless, it's worth thinking about if you are setting up a network where you will have access to the modems at both ends of the line.

The CHDF command has an intelligent coding mode which, when active, sets a flag in the program. This can be used to cause a jump to a custom subroutine. If you are interested in this option it will be necessary to obtain a complete software listing.

One procedure we have adopted in order to increase both flexibility and operator ease is auto bauding. In this procedure, the chip is cycled through the four speeds, looking for the carrier from a sending modem. It

does this automatically when it wakes up, so the operator doesn't need to set it before it can receive.

### Intelligence

The automatic dial and answer functions employ a considerable degree of sophistication to enable them to do their job properly. In parts 1 and 2 (December and February) we published in-depth descriptions of how they work.

In our experience, the modem is now intelligent enough to recognise any conceivable situation on the line and respond appropriately. The situation is complicated by the fact that the ETI-684 is designed to be fitted in parallel with the phone. Many auto answer modem designs require a separate dedicated phone line because it's so difficult to handle all the permutations of line condition caused by the local phone.

For instance, we experienced considerable difficulty in making the software recognise the difference between the local phone being picked up and incoming ring tone.

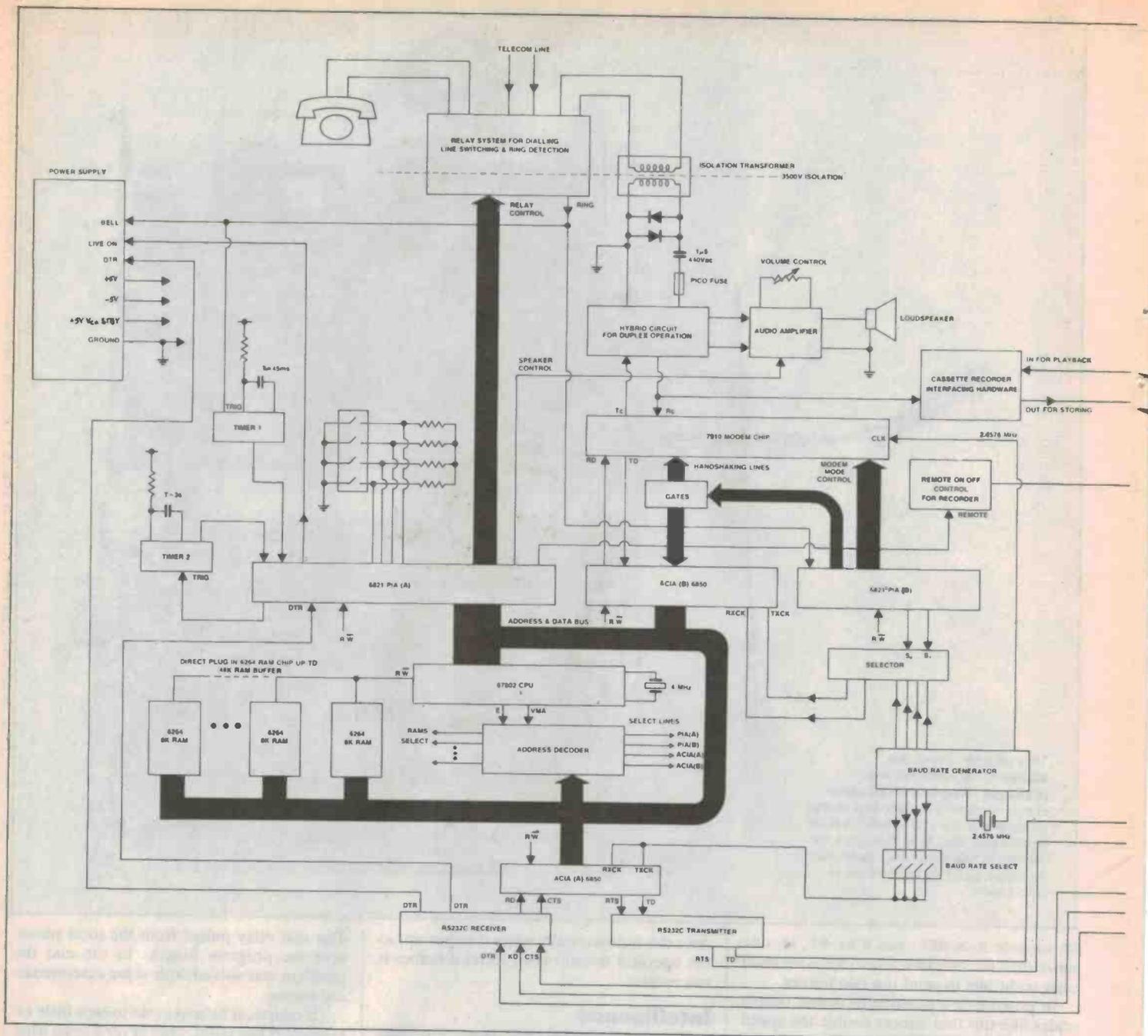
The dial relay pulses from the local phone sent the program berserk. In the end the problem was solved with some discriminating timing.

Of course, it behoves one to be a little bit humble at this point. One never knows what the real world is like until it's been experienced.

### Storage

There are two storage mediums on the ETI-684: RAM and cassette. The RAM has a number of uses. It's used to store files, either from the local terminal or from the line. It's necessary to run the software, because stack pointers and other temporary numbers are stored there. Also important: it's used to store user selectable parameters that allow the modem to be configured to the user's requirements.

A minimum of 8K must be in place for these functions to work. This is contained in one 6264 RAM chip. It's possible to increase RAM size to 48K by simply plugging in another five ICs. The primary function of



the extra RAM is for storing long files when the modem is unattended. It's also useful to transfer files into the modem memory from the local terminal's memory because then the modem can do its transmission while the terminal is used for other things. To extract files from the modem it's merely necessary to enter NEWS at the terminal. This will cause the stored text to be displayed one page at a time on the screen.

48K is a reasonably long text file, but it's rather limiting if you're transferring extensive data files, or programmes. The software will send an overload signal when the RAM overflows, which stops the data coming down. This is probably OK if the operator is in attendance, but the idea of the auto answer facility is that the unit should be able to operate without human interference.

What to do? Bigger memory is certainly a viable answer, but it's a very expensive way of providing sizable mass storage. A disk drive would be a better bet, but the drive and control circuitry is rather complex, and the data storage not all that great, say 360K.

What about some old fashioned storage? Tape has some fantastic advantages. Apart from being cheap, it records the audio signal direct from the line. To operate a disk it's necessary to strip off the audio frequency and then record standard binary bits, together with a substantial overhead in terms of control bits generated within the drive itself. The usual problem with tapes, their slowness, is not really relevant here because it's quite capable of recording at the same frequency as the signal coming down the phone line.

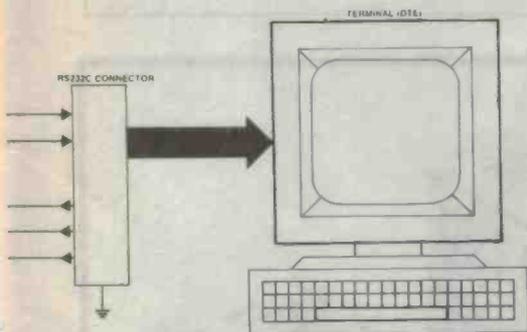
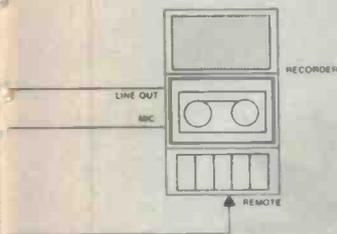
An additional advantage of tape is that a special escape code has been formulated within the Viatel protocol to allow for automatic start/stop of the tape player. This means if the modem receives the escape code IBh 36h, it will start the tape and so record the message. IBh 35h causes the tape to pause, and IBh 37h stops it. To see the tape contents on the screen of the terminal the operator enters PYBK on the keyboard.

### Hayes commands

The full extent of the operating ability of the modem will be seen by considering the commands it responds to. Most of these are standard Hayes commands, although there are a couple that are non-standard, which we deal with separately.

# Project 684

Modem block diagram



**Speaker control:**

- M0 turns speaker off.
- M1 turns speaker on during dialling, answering and call establishment, but off as soon as the call is established.
- M2 turns speaker on.

**Online/offline control:**

- ATO go to online.
- +++ go to offline after one second wait.

Online means the terminal is connected directly to the line through the modem, so that anything typed on the terminal will be sent directly to line. Offline means that the modem is no longer connected to the line. Anything typed on the terminal and sent to the modem will be interpreted as a command rather than a message.

**Terminating a call:**

ATH hang up the call and go offline.

**Response message:**

Q0 enable the sending of the modem response message to the monitor screen.

Q1 disable modem response message.

**Dialling command:**

ATDv, nnnnnnx dial telephone number nnnnnn, redial if busy, wait if ringing and put modem into the originate mode as soon as the other end loops the line. Initiate call set-up procedure automatically.

The prefix 'v,' is used if dialling through a PABX. If used, the modem will dial the number v, then wait for dial tone and then dial the number.

The suffix x may be any combination of R, # or ;. R puts the modem into the answer mode, # causes the modem to automatically transmit a user code up to 16 digits entered under the ID command, and ; causes the modem to go to offline mode once the call is established.

For instance, the code ATD9, 6639999# R, will dial through a PABX using 9 to get out, call the number 663-9999, send a user code and put the modem into answer mode. On the other hand ATD6639999 just dials the number.

**Non-standard commands**

ATDnnnnnnnB The argument B instructs the modem to send out messages stored in the buffer automatically as soon as the call to number nnnnnn is established.

CHDF displays the parameters stored in the RAM and allows them to be changed. These parameters are baud rate, protocol, number of redials, number of repeats to a non-data answer, intelligent coding mode and on/off control.

BUF Every character received from the local terminal will be put into the buffer instead of being transmitted to line. Buffer overflow message will be reported if RAM buffer overflows.

ID sets the Viatel user identity number or bank transaction number (up to 16 digits).

PYBK displays the contents of the tape on the screen.

CS0 turns on the local cassette recorder.

CSF turns off the local cassette recorder.

NEWS displays RAM contents.

KILL instructs the modem to shut down its power supply. It is only used if the terminal does not have a DTR line. If the modem has a DTR line on its RS232 interface, then the power supply will shut down as soon as the terminal is turned off.

- Been burgled?
- Engine cross-firing?
- Light bulbs burning out?
- Can't share your printer?
- Haven't got a light meter?
- Aren't sure of your CRO's calibration?
- Can't pick-up stereo on your AM radio?
- Don't know where those vibrations come from?

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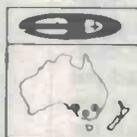
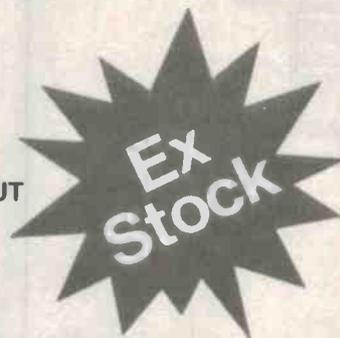
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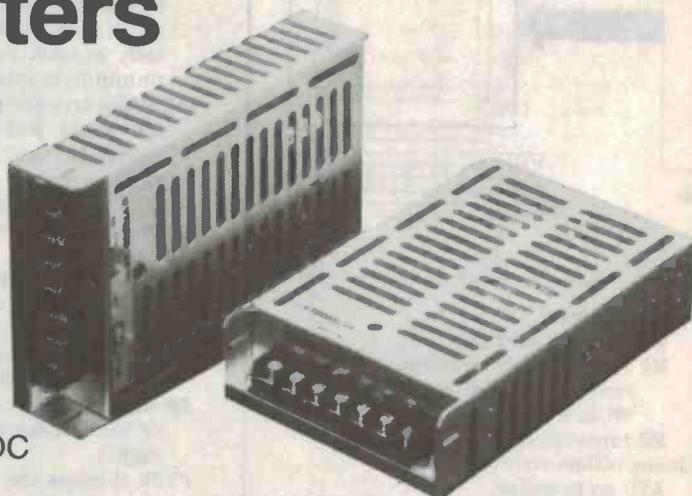
ETI READER SERVICE 178

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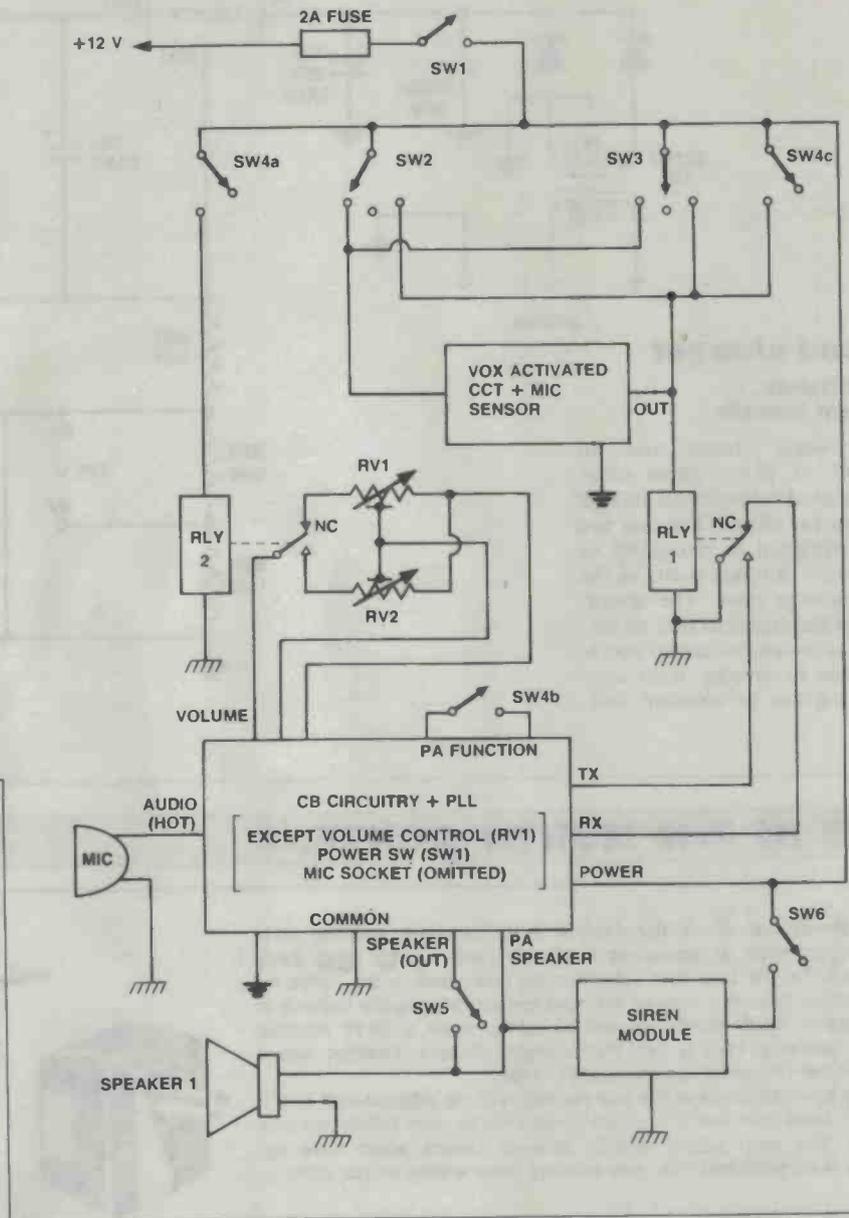
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ETI READER SERVICE 179

### Mad Max radio

The idea of this circuit from Todd Groman of Swan View, WA is to adapt a CB radio so that it resembles those used in the movie "Mad Max". This involves hands-free operation, instant PA access and use of a well disguised siren in the car.

In this option, the mouth-piece is from a telephone mounted inside the CB, to provide better pickup. SW1 is the standard power on switch, SW2 and SW3 are for driver and passenger respectively and provide line transmit and voice operated transmit options. SW4 engages the PA option and sets the appropriate volume. SW5 allows the speaker to be used as an extension of the CB. SW6 controls the siren module.

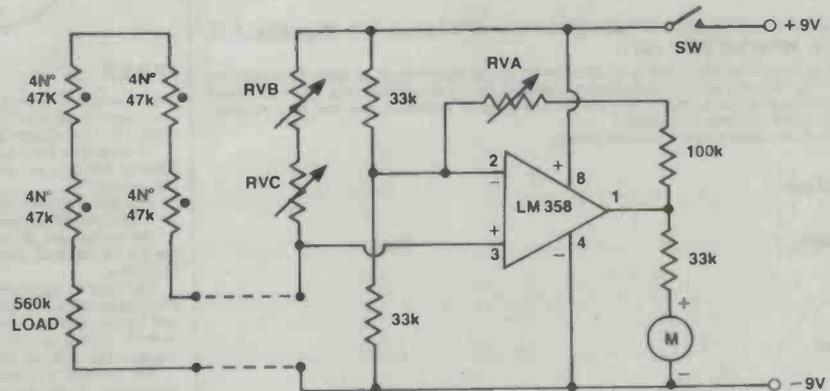


### Sensitive heat detector

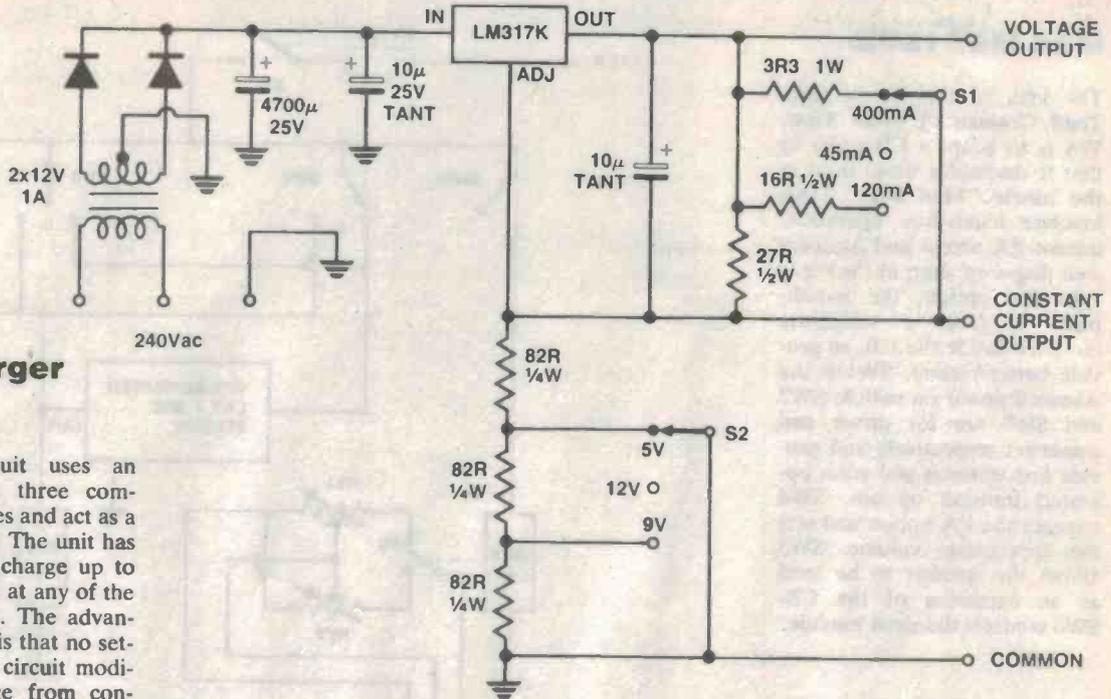
This idea from J.P. van Leuven of Everton Hills, Qld, was originally designed as a thermal detector for use in aero modelling. Free flying model aircraft depend on thermal conditions to gain height. A simple electronic detector is not sensitive enough to monitor the rate of increase in temperature necessary for this purpose. It can also be used around the house as a draught detector or to find where heat is being lost from a house.

An LM358 is mounted on a DIL board together with other components and the whole thing mounted in a small zippy box. From this extends a fibreglass arrow shaft, connected to the box via a coaxial line plug.

At the sensing end four bead thermistors are protected from sun and wind by a shrouded head constructed out of rigid foam and a plastic cup. This assembly is epoxied on to the arrow shaft.



## IDEA OF THE MONTH



### Nicad charger

H.F. Nisslnck,  
Western Australia

This simple circuit uses an LM317 to derive three commonly used voltages and act as a charger for nicads. The unit has been designed to charge up to eight cells in series at any of the three charge rates. The advantage of the circuit is that no set-up is required, or circuit modifications to change from constant current to constant voltage.

## 'IDEA OF THE MONTH' CONTEST

Scope Laboratories, which manufactures and distributes soldering irons and accessory tools, is sponsoring this contest with a prize given away every month for the best item submitted for publication in the 'Ideas for Experimenters' column — one of the most consistently popular features in ETI Magazine. Each month we will be giving away a 60 W Portable Cordless Soldering Iron, a 240 Volt Charging Adaptor together with a Holder Bracket. The prize is worth approx. \$100.

Selections will be made at the sole discretion of the editorial staff of ETI Magazine. Apart from the prize, each person will be paid \$20 for an item published. You must submit original ideas of circuits which have not previously been published. You may send as many entries as you wish.



### COUPON

Cut and send to: Scope/ETI 'Idea of the Month' Contest, ETI Magazine, P.O. Box 227, Waterloo NSW 2017.

"I agree to the above terms and grant *Electronics Today International* all rights to publish my idea in ETI Magazine or other publications produced by it. I declare that the attached idea is my own original material, that it has not previously been published and that its publication does not violate any other copyright."

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Name .....

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### RULES

This contest is open to all persons normally resident in Australia, with the exception of members of the staff of Scope Laboratories, The Federal Publishing Company Pty Limited, ESN, The Litho Centre and/or associated companies.

Closing date for each issue is the last day of the month. Entries received within seven days of that date will be accepted if postmarked to and including the date of the last day of the month.

The winning entry will be judged by the editor of ETI Magazine, whose decision will be final. No correspondence can be entered into regarding the decision.

The winner will be advised by telegram the same day the result is declared. The name of the winner, together with the winning idea, will be published in the next possible issue of ETI Magazine.

Contestants must enter their names and addresses where indicated on each entry form. Photostats or clearly written copies will be accepted but if sending copies you must cut out and include with each entry the month and page number from the bottom of the page of the contest. In other words, you can send in multiple entries but you will need extra copies of the magazine so that you send an original page number with each entry.

This contest is invalid in states where local laws prohibit entries. Entrants must sign the declaration on the coupon that they have read the above rules and agree to abide by their conditions.

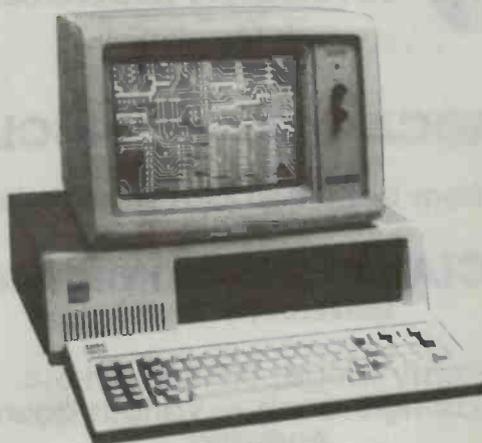
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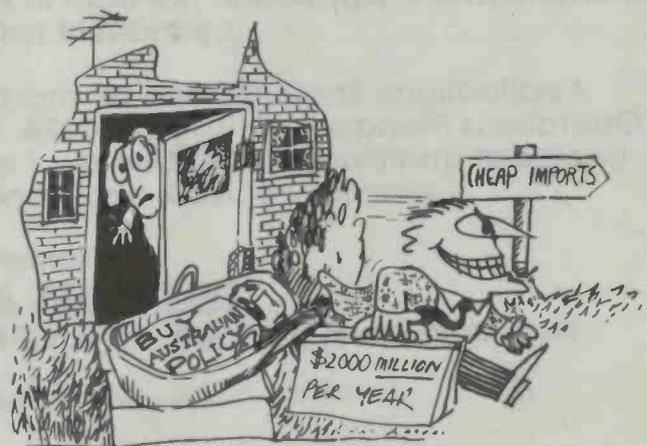
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---

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# Epson PC debut



The new Epson PC is a high-performance 16-bit desktop computer that features streamlined design and modularity to meet needs for expansion, at a competitive price.

In base configuration, the Epson PC will sell for \$2450 plus tax while a completely optioned system featuring a Taxan Supervision III colour monitor will retail for \$3450 plus tax.

The Epson PC will be available in two factory configurations: dual floppy disks or single floppy with a 20 megabyte internal hard disk, both with a massive 512K of RAM.

The base configuration comes standard with an 8088 microprocessor, 512K of RAM (expandable to 640K), a 360K, 5¼" floppy disk drive, an IBM AT-type detachable keyboard, a built-in Centronics parallel printer port, an RS232C serial port and will be bundled with MS-DOS.

The other factory-built configuration

features a single floppy disk with a 20 megabyte internal hard disk.

A full line of components and peripherals includes a 12" RGB colour monitor with a corresponding colour/graphics video card; and a monochrome video card for either the floppy or hard disk versions.

The Epson PC can also be configured with all IBM-compatible enhancement cards. Other features include three full-size IBM standard option slots; an 8087 numeric co-processor socket; speaker; and front panel ac power reset and option switches for easy access.

For further information contact Epson Australia, 17 Rodborough Road, Frenchs Forest, NSW 2086. (02) 452-5222.

## Lower cost LAN

Software Corporation of Australia has begun shipments to its dealers of an innovative network product which it claims will meet most of the networking needs of a majority of users — at a fraction of the usual cost.

The product, EasyLan, carries a recommended retail price of \$275 (plus tax if applicable) and consists of a 10 metre length of cable, a standard RS232 serial connector at each end of the

cable, and two floppy disks.

Installation of EasyLan is achieved simply by plugging the cable into the serial port of each IBM-PC standard computer and booting up with the provided software. Once mounted, the EasyLan software allows users to share disk drives, printers and modems.

Developed by Server Technology of Sunnyvale, California, the new product includes a pass-

word capability to aid security of files. While lacking many of the features of higher-end LANs, EasyLan does accomplish the two tasks which the majority of users need most of the time: transferring disk files from one computer to another, and sharing an expensive letter-quality printer or other peripheral.

Up to 10 personal computers can be linked in a star pattern using EasyLan. Because the

method of connection involves the serial port of the PC, an RS232 serial communications card needs to be available on each PC. Most IBM-PC standard computers already have that capability. In addition, the PC at the hub of the star needs a separate serial port for each PC connected to it. This is easily achieved through the use of a serial cable with inexpensive DB-25 connectors.

### New diskettes

Skarbek Trading has released a complete range of computer diskettes including Media Tech disks, which are well established in the US. These disks are suitable for all popular PCs and come as single and double density, one or two sided. For more information contact Skarbek trading on (03)842-7087.

### CSIRO Viatel service

The CSIRO now has a database on Viatel carrying information on home building hints, recently available CSIRO scientific informational video programs, CSIRO school project information and CSIRO publications. It can be accessed by the CSIRO Viatel index on screen 232.

### Low cost serial/parallel converter

The Model 775 serial/parallel converter from Alfatron comes with an RS232 cable ready for plugging into a serial interface

## BRIEFS

on a PC. It converts all serial data to parallel in the Centronics format. Internal shunts are provided to select baud rates, stop bits and parity for the serial side. For further information contact Alfatron on (03)758-9000.

### PC-DOS to support extended memory boards

Digital Research Inc has modified Concurrent PC-DOS to take advantage of the extended memory capability now offered on the IBM PC. The boards enable Concurrent PC-DOS operating systems to run multiple large applications simultaneously. As well as the IBM PC, Concurrent PC-DOS runs applications for compatibles such as dBASE, Lotus 1-2-3 and WordStar. For further information contact Arcom Pacific on (07)52-9522.

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(A microcomputer has already been produced to replace the mechanical programmer on a domestic washing machine. In example.)

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usually referred to as the "hardware". This is backed up by showing how to program a microcomputer (or produce its "software") in the most fundamental form of computer language called "machine code". No previous knowledge of computers is necessary, though a little basic knowledge of electronics plus digital and logic circuits will be found helpful.

A special introductory short course is available to provide this back-ground information, if required by an individual student on the course without extra fee.

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# PROCESSOR AND MEMORY

Day one: the computer breakfast; a whirring processor and 1024 bytes of special K!

Phil Cohen

**THIS BEGINS** a new series that looks at the fundamentals of your computer. It's designed to teach you what actually makes a computer tick. By the end of the series, you should be familiar with all of the concepts you need to write simple programs in assembly language, and have a good knowledge of what goes on inside your computer.

## Hardware

The most important parts of the computer are the processor and the various types of memory.

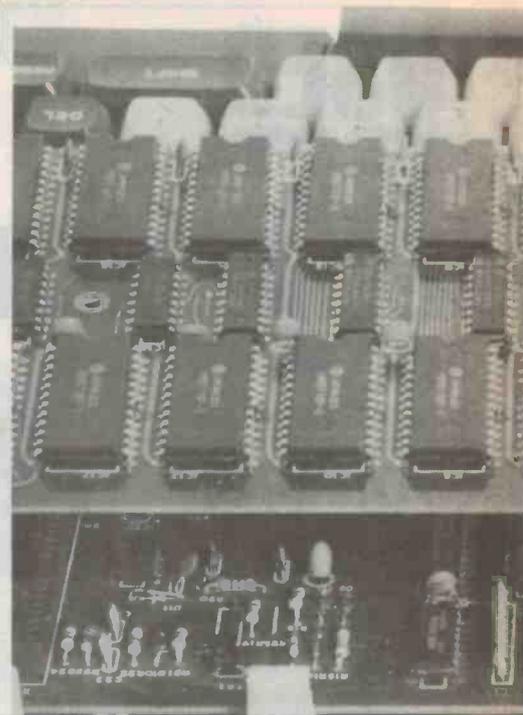
The processor is the central control mechanism of the computer, and everything

that the machine does depends on it. The processor follows the instructions that the programmer has given and passes commands and information to other parts of the machine, to the screen display, the loud-speaker, disk drive, and so on.

Physically, the processor looks unimpressive, it's just a large IC. Other ICs provide the computer's memory and a number of other interesting bits and pieces.

## Memory

While it's following a program, there is often the need for the computer to store the intermediate results of a calculation, or



keep track of a game score or other transient facts. For this, the processor uses the 'RAM' part of its memory.

'RAM' stands for read and write memory (or random access memory) and it's the computer's scratchpad. Any information which is stored in RAM is lost when the computer is turned off. Of course, for things like game scores this doesn't matter at all.

There is another type of memory in the computer, called 'ROM' (read only memory). The difference between RAM and ROM is that the information in ROM is not lost when the computer is turned off, in fact, it's not possible to change what's stored in ROM without taking out the ICs that make up the ROM.

When a computer changes the information in its RAM memory, it's said to be 'writing to memory', just as you would write on a blackboard. When it looks at the information in its memory, it is said to be 'reading from memory'. This is the significance of the terms 'read and write memory' and 'read only memory'. The computer can never write to ROM, but it can read from and write to RAM.

## Programs

Some types of program are stored in ROM and some in RAM. When you first turn the computer on, without a games cartridge in it (if it is that sort of computer) and with no cassette or disk in it, it will respond in some way by putting information on the screen, even just the name of the computer.

The program that tells the processor what to put on the screen when the computer is first turned on is in its ROM memory. It has to be, of course, because if it was in its

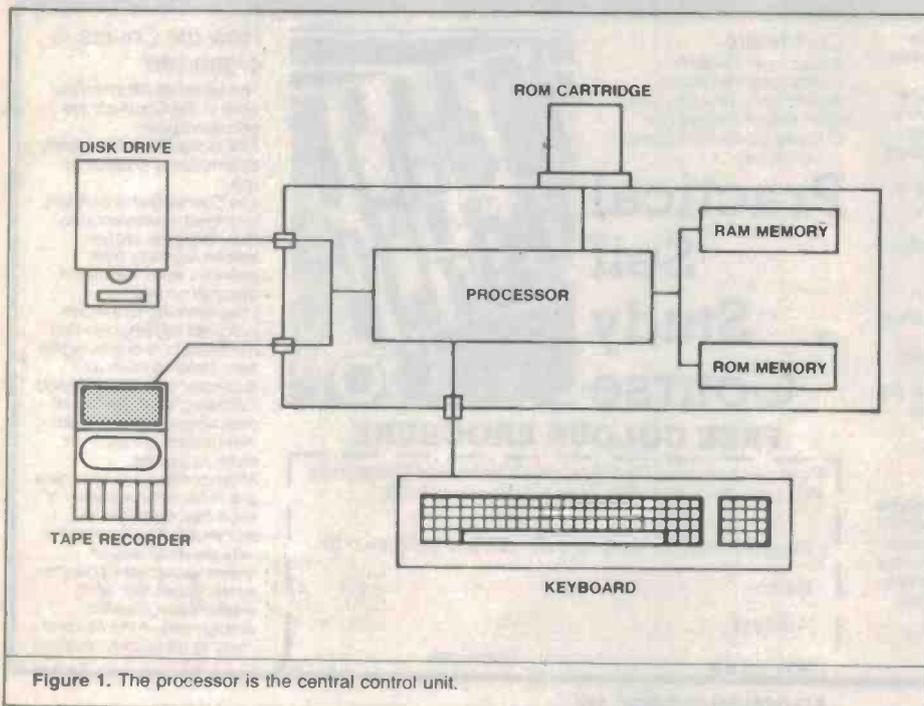
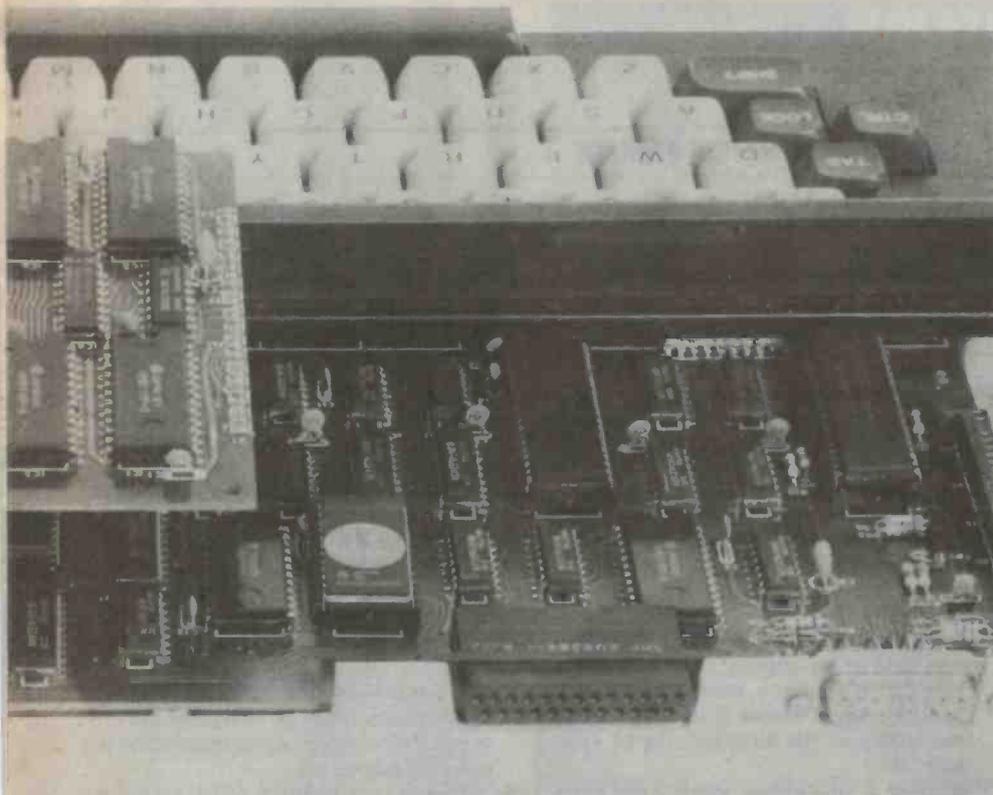


Figure 1. The processor is the central control unit.



# "WHICH RADIO DO I NEED?"

RAM, it would be wiped clean when the machine was turned off!

Programs that are not already in the computer when it is first turned on are stored in a number of different ways. These include a standard cassette tape that the computer stores a series of tones on like Morse code which it can later read as a program; a floppy disk which apart from its shape works in much the same way as tapes; and a cartridge or plug-in module that holds one program.

Programs that are loaded from tape or disk, or typed in from the keyboard are stored temporarily in RAM. When you turn the computer off, any program that you loaded in from tape or disk is lost. Of course, it's still on the tape, and when you want to use the program again all you have to do is to get the computer to load it from the tape into its RAM again.

Game cartridges are a little different. They actually contain ROM on to which the game program (or word processor, or whatever) has been stored. The advantage of cartridges over disk or tape is that you don't have to wait for the program to be loaded into RAM — it's right there on ROM waiting to be read by the processor as soon as the computer is turned on.

Tapes and disks are a bit like RAM in that the information on them can be altered by the computer. If, for example, you type a new program into the computer, you can store it on tape or disk so that it can be used again later. The information on the tape or disk is not forgotten when the computer is turned off.

You can also store other information such as a sequence of letters on tape or disk.

Inside a home computer. It's not as complicated as it looks.

Why do computer makers bother with RAM when tape and disk are better? Because RAM is a lot faster. Table 1 summarises the advantages and disadvantages of the various types of computer memory.

## The 'K'

The amount of memory that a particular computer has is measured in 'Ks'. One K is 1024 addresses. Each address can hold one character such as a letter, digit or symbol, one thousand words of a magazine article (at an average five letters per word, plus a space) will take up around 6000 bytes, or approximately 6K of memory.

Notice by the way that 'K' is not the same as 'k'. The 'k' means 1000, while the 'K' means 1024. So one km is 1000 metres, and one kV is 1000 volts, but 1024 bytes is one K.

When measuring the size of memory, it doesn't matter which type of memory you are talking about; the K is used to measure the size of ROM, RAM, and even disk sizes.

For example, a typical computer nowadays will have 20K of built-in ROM (which holds all of the programs the computer needs when it is first turned on), 64K of RAM, and maybe a disk drive which can hold 360K of programs or other information.

## Processor power

There are a number of different processors and different versions of the same processors on the market all of which have their

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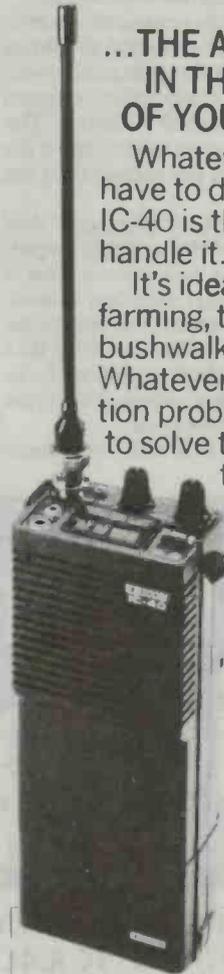
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# INSIDE YOUR COMPUTER 1

advantages and disadvantages. Two important measures of the power of a processor are its clock speed and the number of bits of information it can handle at the one time.

Processor speed is usually measured (a little misleadingly) in terms of the frequency of the clock oscillator that it is designed to run with. For example, one processor may be designed to run at 6MHz and another at 8MHz. I called this figure misleading because it is really only of use in comparing different versions of the same processor.

For example, a cheap version of a particular processor may be designed to run at 4MHz, but its military-specification counterpart (identical in every other respect) may run at twice the speed — 8MHz. The 8MHz version will process exactly twice the amount of information per second than the 4MHz version.

But a different type of processor altogether may run at 3MHz, and yet outperform either of the two 'faster' ones. This is because although it performs less instructions per second, the instructions may be far more powerful in themselves, allowing it to process *more* information per second. So speed is only of use in comparing different versions of the same processor.

The second figure that tells you some-

TABLE 1. INFORMATION STORAGE

Memory	Erased when machine is turned off?	Able to be changed by the computer?	Fast?
RAM	yes	yes	yes
Built-in ROM	no	no	yes
ROM cartridge	no	no	yes
Tape, disk (magnetic media)	no	yes	no

thing about processor power is the number of 'bits' it will handle. The 8080 processor, for example, is an 8-bit processor, while the 8086 is a 16-bit processor. I'll explain bits later on in the series, but in much simplified terms this means that the 8086 can handle twice as much information in a single step than the 8080 can.

### Glossary

**Byte:** a measure of the amount of information held in a computer's memory; each byte can represent a number between 0 and 255, which allows it to store any of the letters of the alphabet, digits, symbols, etc.

**Cartridge:** a plug-in box which holds extra ROM with a program on it.

**K:** each K represents 1024 bytes of memory, enough for about 160 words.

**Magnetic media:** a name given collectively to disks, tapes and anything else that uses a magnetic field on a moving material to store information.

**Memory:** that part of a computer where information is stored outside the processor.

**pcb:** printed circuit board, on to which the computer is built.

**Processor:** the central control mechanism of the computer; a large IC.

**Program:** a series of instructions which the processor follows step by step.

**RAM:** read and write memory, memory whose contents can be altered by the processor, but which is wiped clean when the power is turned off.

**ROM:** read only memory which retains its information with the power off, but whose contents cannot be altered by the processor.

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**Sphere**

Warren Wilson,  
Altona, Vic 3018

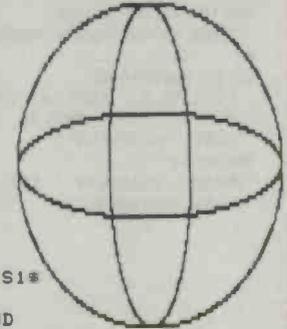
This program uses the hi-res graphic facilities of the Microbee to produce a simple sphere.

It has three options in size: large, medium and small. The large size sphere is large enough to see the effect of simple 3D graphics.

This program could be modified to use the colour facilities of colour Microbees or the simple structure of the sphere could be modified to produce many different sphere-like shapes, for instance footballs or doughnuts.

```
00100 REM GRAPHICS/MATHEMATICAL WARREN WILSON WOSOFT SOFTWARE1985
00110 CLS:POKE 220,25:INVERSE:CURS 16,1:PRINT" BASIC SPHERE BY WARREN WILSON
":NORMAL
00120 INVERSE:CURS 22,5:PRINT" INPUT SIZE OF SPHERE ":NORMAL
00130 CURS 25,6:PRINT"[1] LARGE SPHERE":CURS 25,7:PRINT"[2] MEDIUM SPHERE":CURS
25,8:PRINT"[3] SMALL SPHERE"
00140 CURS 21,10:INPUT"WHICH SPHERE NUMBER 1-3 ?";G
00150 IF G<=0 OR G=>4 THEN CURS 21,10:PRINT[A50 32]:GOTO 120
00160 IF G=1 THEN LET N1$="LARGE SPHERE":GO=80:HO=15:G1=80:H1=45:G2=25:H2=45
00170 IF G=2 THEN LET N1$="MEDIUM SPHERE":GO=40:HO=7.5:G1=40:H1=22.5:G2=12.5:H2=
22.5
00180 IF G=3 THEN LET N1$="SMALL SPHERE":GO=20:HO=3.75:G1=20:H1=11.25:G2=6.25:H2
=11.25
00190 HIRES
00200 CURS 0:PRINT N1$
00210 FOR N=1 TO 700
00220 S1=S1+0.009
00230 SO=SIN(S1):CO=COS(S1)
00240 A=INT(GO*SO):B=INT(HO*CO)
00250 REM A=INT(80*SO):B=INT(15*CO)
00260 SET A+220,B+120
00270 C=INT(G1*SO):D=INT(H1*CO)
00280 REM C=INT(40*SO):D=INT(7.5*CO)
00290 SET C+220,D+120
00300 E=INT(G2*SO):F=INT(H2*CO)
00310 REM E=INT(25*SO):F=INT(12.5*CO)
00320 SET E+220,F+120
00330 NEXT N
00340 CURS 17,14:INPUT"DO YOU WANT ANOTHER SPHERE Y/N ?";S1$
00350 S1$=KEY:IF S1$="" THEN 350
00360 IF S1$="Y" OR S1$="y" THEN 110 ELSE POKE 220,111:END
```

LARGE SPHERE



**Sight read music**

R. McFadyen,  
Turramurra, NSW 2074

'Sight Read Music' is intended to be used by instrumentalists and singers.

When a note appears on the bar lines, the note should be played or sung. After a short delay (which is preselected at the start of the program) the note is sounded and named.

The range of notes is selected using the note code for the Microbee (1 to 23). The range can be limited to one note only if needed.

The program is for naturals only; a program for sharps would require the note codes in lines 350 to 410 to be changed to those for sharps. The data in lines 470 to 500 are read two at a time, the first being the vertical position on the screen and the second the corresponding note code.

```
00100CLS
00110 PRINT" Sight Read Music"
00120 INPUT"Select lowest note code ( 1 to 23 ) ";L
00130 INPUT"Select highest note code ( 1 to 23 ) ";H
00140 INPUT"Select delay (1 to 9)";T
00150 IFH<=LTHEN100
00160 HIRES:REM draw lines
00170 FORY=112TO144STEP8
00180 PLOT 80,YTO440,Y
00190 NEXTY
00200 PLOT 80,112TO80,144:PLOT 84,112TO84,144:PLOT 440,112TO440,144
00210 PLOT 120,96TO128,88TO128,160TO136,160TO120,120TO128,112TO136,120TO128,128
00220 FORY=96TO160STEP8
00230 PLOT 300,YTO315,Y
00240 NEXTY
00250 FORN=1TO28:REM select note
00260 READY.C
00270 IFC<LTHEN460
00280 IFC>HTHEN460
00290 X=306:REM draw note
00300 PLOT X,YTOX+4,Y:PLOT X+1,Y+1TOX+3,Y+1:PLOT X,Y-1TOX+4,Y-1
00310 PLOT X,Y-2TOX+4,Y-2:PLOT X+1,Y-3TOX+3,Y-3
00320 CURS272:PRINT" "
00330 PLAYO.T*4
00340 CURS272
00350 IFC=1ORC=13THENPRINT"A"
00360 IFC=3ORC=15THENPRINT"B"
00370 IFC=4ORC=16THENPRINT"C"
00380 IFC=6ORC=18THENPRINT"D"
00390 IFC=8ORC=20THENPRINT"E"
00400 IFC=9ORC=21THENPRINT"F"
00410 IFC=11ORC=23THENPRINT"G"
00420 PLAYC.8:REM play note. erase note
00430 PLOTI X,Y-1TOX+4,Y-1:PLOTI X,Y-2TOX+4,Y-2:PLOTI X+1,Y-3TOX+3,Y-3
00440 PLOTI X,YTOX+4,Y:PLOTI X+1,Y+1TOX+3,Y+1
00450 FORY=96TO160STEP8:PLOT 300,YTO315,Y:NEXTY
00460 NEXTN
00470 DATA 133,16,105,4,145,21,117,9,149,23,121,11,101,3,125,13,97,1,109,6
00480 DATA 137,18,113,8,141,20,129,15,109,6,137,18,121,11,125,13,149,23
00490 DATA 133,16,117,9,141,20,101,3,129,15,97,1,113,8,105,4
00500 DATA 145,21
00510 RESTORE:GOTO250
```

# COMMODORE COLUMN

## Banner

Chris Baird  
Glendale, NSW

The idea for this program came as a result of looking at all the printouts around high school that had been done by 'Print Shop'. It prints strings up to ten characters long on to the printer. The word can be centered or not, have the letters character used as the pixel or a character of your choice as the pixel.

People with 64s will need to find a friend with a VIC-20 and save the CHAR ROM on tape and reload it before running this program.

Steps for running the program on a 64:

On the friend's VIC:

POKE 43,0 : POKE 44,128  
POKE 45,255 : POKE 46,143  
SAVE 'CHAR ROM'

On the 64:

LOAD 'CHAR ROM',1,1  
LOAD 'BANNER'

```
0 REM BANNER
1 PRINT"J"
10 INPUT"STRING"AS$
20 IFLEN(AS$)>10THENPRINT"SORRY, BUT THE STRING IS TOO LONG."GOTO10
25 IFAS$=""THENEND
30 INPUT"CENTERED (Y/N)"B$
35 Z$=""
40 IFB$="N"THENS1
50 IFB$="Y"THENS1
60 PRINT"JUST TYPE Y OR N"IGOTO30
61 INPUT"CHARACTER PRINTED(Y/N)"C$C$=RIGHT$(C$,1):AL=0
62 IFC$<"Y"ANDC$<"N"THENPRINT"TYPE Y OR N ONLY"IGOTO61
63 IFC$="Y"THENAL=1
64 IFC$="N"THENINPUT"CHARACTER"Z$Z$=LEFT$(Z$,1)
65 IFB$="N"THEN100
70 A=5-(LEN(AS$)/2)
80 FORI=1TOA:Z$=Z$+" "INEXTI
90 Z$=Z$+AS$
91 IFLEN(Z$)=10THENS4
92 Z$=Z$+" "GOTO91
94 AS=Z$
95 GOTO110
100 IFLEN(AS$)=10THEN110
105 AS=AS+" "GOTO100
110 OPEN3,4:OPEN5,4,6:PRINT#6,CHR$(21):CLOSE6
120 FORJ=0TO7
130 FORI=1TO10
140 PRINT"MIOS(AS,I,1)
150 A=PEEK(7680)
160 S=32768+(A*8)+11
170 A=PEEK(S)
180 IFAL=1THENZ$=MIO$(AS,I,1)
190 FORJJ=7TO0STEP-1
200 J=2+JJ
210 IF(AANDJ)=JTHENPRINT#3,Z$:GOTO220
215 PRINT#3," "
220 NEXTJJ,1:PRINT:NEXTI
230 PRINT:CLOSE3
240 GOTO1
```

## Status

C. Groenhout,  
Watson, ACT 2602

Status is written simply to show the status of the user port at any time. When RUN the program clears the screen and prints up eight 0s in the top left hand corner of the screen. When any switch from S0 to S7 is depressed a 1 appears in the appropriate position to represent the individual bits.

Status Draw, based around Status, uses the Super Expander to draw on the VIC's screen in high resolution. Pressing S0 will make the line go up, S1 goes down etc with diagonal lines possible. By pressing all four switches at once (S0-S3) the screen clears and the 'cursor' is reset to the centre of the screen.

```
* STATUS *
5 C=.5:PRINT"J"
10 A=PEEK(37136)
20 FORB=0TO7
30 C=C*2
40 IF(AANDC)=0THENAS="1"+AS:GOTO50
45 AS="0"+AS
50 NEXT
60 PRINT"MIOS(AS,I,1)C=.5:GOTO10
```

```
* STATUS DRAW *
10 GRAPHIC2
20 X=80:Y=80:POINT2,511,511
30 A=PEEK(37136)
40 IF(AAND1)=0THENY=Y-1:IFY<0THENY=0
50 IF(AAND2)=0THENY=Y+1:IFY>159THENY=159
60 IF(AAND4)=0THENX=X-1:IFX<0THENX=0
70 IF(AAND8)=0THENX=X+1:IFX>159THENX=159
75 IFA=240THEN:SCNCLR:X=80:Y=80
80 POINT2,X*6.4,Y*6.4
90 GOTO30
```

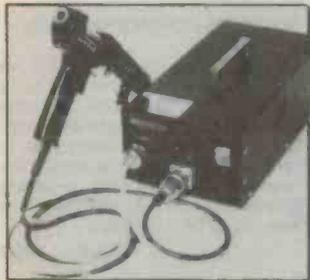
## Quado

C. Groenhout,  
Watson, ACT 2602

Quado is a simple experiment in quadrophonic drawing in high resolution. The cursor starts in the centre of the screen and by using the keys I, J, K and M the cursor is moved around the top right hand quarter of the screen with the other three quarters following in suit. The result? A picture, in four colours, symmetrical in two axes which you can sell off to any uninformed person for a top secret plan of a new microprocessor! Note: This programme uses the Super Expander.

```
10 GRAPHIC2:X=80:Y=80:POINT2,511,511:POKE650,128
20 GETAS:IFA$=""THEN20
30 IFA$="I"THENY=Y-1:IFY<0THENY=0
40 IFA$="M"THENY=Y+1:IFY>80THENY=80
50 IFA$="J"THENX=X-1:IFX<0THENX=80
60 IFA$="K"THENX=X+1:IFX>160THENX=160
70 IFA$<"I"ANDAS$>"J"ANDAS$>"K"ANDAS$>"M"THEN20
80 REGION2:POINT2,X*6.4,Y*6.4
90 REGION4:POINT2,X*6.4,(511-Y*6.4)+511
100 REGION5:POINT2,511-(X*6.4-511),Y*6.4
110 REGION6:POINT2,511-(X*6.4-511),(511-Y*6.4)+511
1000 GOTO20
```

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ETI READER SERVICE 185

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### ETI-173: Electrostatic hazard detector

Having this project in your workshop will save you heaps of trouble with your ICs or transistors by beeping whenever electrostatic hazard threatens. The complete kit will be available from Geoff Wood Electronics (02)427-1676 (nb: the new phone number following the GWE move) and All Electronic Components (03)662-3506. Printed circuit boards will be available from Force Electronics (08)212-2672 and from All Electronic Components.

### ETI-345: Demister timer

This project is used to automatically turn off a rear window demister after 10 or 20 minutes. All Electronic Components, (03)662-3506, will stock the complete kit, as well as the pc boards. Force Electronics, (08)212-2672 will also stock pc boards. The only parts that might be difficult to obtain are the 16A relay, which will be obtainable from RS Components, (02)669-3666; and the XR 2240 timer, which will be available from Jaycar, (02)747-2022.

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All Electronic Components  
 118 Lonsdale St  
 Melbourne, Vic 3000

RCS Radio  
 651 Forest Rd  
 Bexley, NSW 2207

For pc boards produced in recent years, the following suppliers either keep stocks on hand or can supply to order:

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 Bass Hill, NSW 2197  
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Jaetronics  
 58 Appian Drive  
 St Albans, Vic 3021

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 117 York St  
 Sydney, NSW 2000

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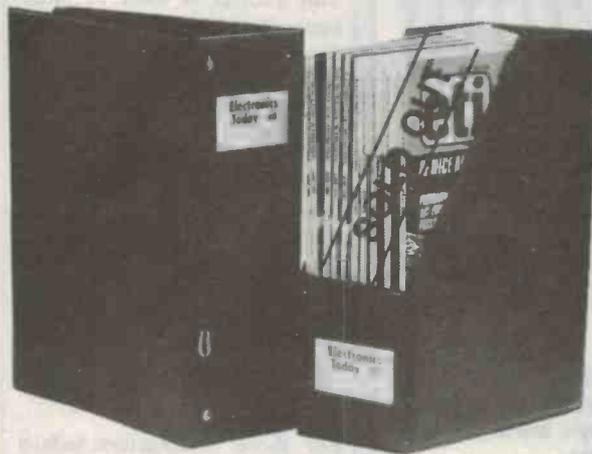
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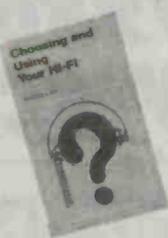
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# THE 1986 SECONDARY SCHOOLS

## ELECTRONICS



## COMPETITION



## GUIDANCE FOR SCHOOLS ENTERING THE ETI ELECTRONICS COMPETITION

Peter Phillips

The aim of this article is to give those teachers and students participating in the ETI schools competition some help and ideas. It is about how to make the most out of very little with some advice on projects and purchasing.

### Equipment

As money and equipment for electronics in high schools is in short supply existing equipment will need to be adapted. It may be possible to excite the P&C organisation into allowing funds to be used to buy some more suitable gear or to at least purchase a range of components and hardware. A recommended shopping list is included to give support to those approaching the P&C organisation for some funds.

The most important requirement in electronics is a supply of soldering irons. All high schools have a stock of 12 volt power supplies, and 12 volt soldering irons costing around \$10 each could be used in conjunction with these. Although suitable only for small soldering jobs, these irons offer safety and cost effectiveness. Perhaps one temperature controlled soldering station could be bought for use by the teacher. By using low voltage soldering irons the risk of the iron burning through the 240 volt lead is overcome.

The next concern is whether to use printed circuit boards. If pc boards are to be avoided, consideration could be given to either pre-etched multipurpose pcb or veroboard. Veroboard can be cut up easily into small sections for student use and is

easily adapted for a variety of designs. It has the disadvantages of requiring wire links between strips, fiddly soldering and requiring track cutting.

If the intended undertaking is likely to contain only a few items, you may like to design a 'blob' board. This consists of a pcb with a number of 10mm (or so) squares separated from each other. Students surface mount the components and the board can then be cleared afterwards for others to use.

Printed circuit board manufacture is possible, providing the necessary chemicals can be purchased. Several options are available here, the simplest being to draw the design on the board with a 'dalo' pen (pc resist pen) and to then etch it. If a sophisticated design is envisaged, a good reference is "Making your own pc board" which appeared in ETI April 1985.

Because it is unlikely a room can be dedicated to an electronics laboratory it may be necessary to set up a number of portable 'stations'. A wooden board with the necessary items attached to it could be used and made to a size that allows its storage in a cupboard. The board might contain a few basic tools, solder and soldering iron and some sort of pcb holder

made from a bulldog clip bolted at a suitable height above the board.

Measuring equipment such as a voltmeter should be normally part of the school's stock. If teacher expertise is available a basic meter movement could be converted into an ohmmeter an ammeter or multirange voltmeter. Alternatively, cheap multimeters could be purchased, although capabilities of the really cheap ones will be limited.

Although the items mentioned only provide a fairly crude set-up, teachers are no doubt aware of the difficulty of doing advanced work with a class whose knowledge of the field is minimal. Any undertaking in either the competition or just as an interest group will most likely be low key, perhaps with an emphasis on mechanics as well. If a highly motivated group of skilled children are participating then the basic items discussed may need to be augmented.

### Some ideas for projects

As a TAFE teacher of industrial electronics, I have had contact with kids attending link courses, as well as in purchasing and setting up for electronics courses. A point worth mentioning is that an interested teacher may like to contact the local TAFE college for ideas. Not all colleges run electronics courses, but those that do would no doubt be only too pleased to show the set-up they have and to discuss ideas. In my experience a lot can be done with limited equipment providing the teacher is well organised and prepared.

Typical popular projects are door chimes, flashing light indicators, continuity testers or projects based on the 555 timer. These projects are generally built on veroboard and run from a 9 volt battery. Other ideas that spring to mind are a burglar alarm system, a basic electronic music instrument that uses a number of 555 oscillators tuned to give a scale, weather monitoring equipment such as wind direction, temperature and rainfall indicators. One TAFE college I know of actually set up a model train which provided lots of reasons for some attached electronics.

The ETI Simple Projects book is also an invaluable source. It has been sent to schools participating in the competition, but is also available from newsagents.

Another possibility is interfacing with a computer. The actual electronics need only be simple, in the form of an interface

between, for example, some lights and the computer's outputs. Naturally the interface deals with TTL (5 volt logic) and that may need to be the province of the teacher.

Small dc electric motors are cheap and lots of imaginative possibilities arise. The use of simple optocoupling devices, perhaps to count items passing a point, or to detect the presence of an object can be incorporated. At a recent exhibition, a TAFE college set up a tube that had a number of steel balls rolling from one end to the other. Once all the balls had passed one way, the tube was tilted with a motor and all the balls then flowed the other way, controlled with a simple electromechanical gate. The balls were counted with an opto device and the number displayed on a fabricated display using incandescent lights.

Another possibility is some form of robot. There is no need to have it remote or computer controlled, trailing wires are sufficient.

Other projects might include actual test equipment or equipment to enhance other school activities, (eg, an electronic stop watch for sport involving a conventional but large clock face and a motor to drive the hands; an electronic scoring system using large digits is also a possibility).

In summary, ideas for projects are limitless. By using simple schemes, success is more likely.

### Where to buy

It is difficult to generalise on where to buy throughout Australia. One point worth stressing at the outset is the power of bulk buying. Most retailers offer some form of discounting for



wholesale purchasing, although this will imply a minimum number per item and often a minimum overall value. The Dick Smith chain offers bulk purchasing through DS Distributors (not Dick Smith, but DS Distributors) from its centre in Sydney. Information on this can be obtained from any Dick Smith catalogue.

Rod Irving Electronics in Melbourne and Altronics in Perth, offer a similar deal, as does George Brown (Protronics in WA and SA). Note that George Brown in Sydney offers a 30 day account specially for high schools, alleviating the need for cash transactions. The account will be sent to the principal, whose permission in the first place will have been sought.

Government stores do not generally stock much in the way of electronic items. However, examination of the government contracts may show deals that are cost effective. Care is required in selecting a firm from which to purchase. Some firms offer high quality, relatively expensive components that represent good value if quality is important. A firm that deals in this type of good is RS Components. Its catalogue is a model and the range offered very extensive. It also provides good literature backup, but costs are often more than other outlets'.

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15 jumbo components bags from Dick Smith Electronics:

Congratulations to the first 15 schools which registered including Kogarah Marist High, NSW, Tarooma High, Tasmania and Mawson High, South Australia.

Throughout the year ETI will invite other electronics suppliers to join in and offer other great prizes.

### HOW TO ENTER

Groups representing their schools should submit the attached registration form which itself brings no obligation. Entry forms and suggested project designs will be forwarded to the groups on receipt of the registration form. Entrants are required to build an electronic device to their own or one of our designs and write a report on its operation, construction (and design) and the group's involvement. The device and report must be lodged with us by 15 September, 1986. State, Territory and New Zealand finalists will be announced on 19 September, 1986. The competition winner will be announced 16 September, 1986.

### REGISTRATION FORM

COMPLETE AND SEND TO "SECONDARY SCHOOLS COMPETITION", ELECTRONICS TODAY INTERNATIONAL, PO BOX 227, WATERLOO, NSW 2017.

SCHOOL .....

ADDRESS .....

GROUP LEADER'S NAME .....

SCIENCE TEACHER'S NAME .....

DOES YOUR SCHOOL ALREADY HAVE AN ELECTRONICS GROUP OR COURSE? .....

Often, convenience to a store is important. After all, spending money by driving or telephoning all over the place to save a few cents is pointless.

The best advice is to try for bulk purchases if possible. No tax is payable and components and hardware can often be had for as low as half the cost of retail prices. The temperature controlled soldering iron station available from DS Distributors is much less than the advertised cost from the retail outlets, providing a number are bought. If a wholesale shopping list costing around \$200 was presented to the P&C association, its acceptance could be aided with the information that this amount represents around \$400 worth of retail components but is contingent on purchasing a minimum value of components.

Other good sources are disposals stores, car wreckers and the like. I have often purchased remnants from industry, such as pcb cutoffs, end of production throwaways and so on. A phone call to large manufacturers often brings to light incredible bargains. Typical of this was a purchase I once made from STC at Liverpool (NSW). By buying a number of superseded plug-in printed circuit cards for \$1 each, I obtained 50 diodes, 15 transistors, 100 resistors, 30 capacitors and 2 relays from each card. The desoldering exercise could well be undertaken by students and lots of usable components obtained.

### Recommended shopping list

- Resistors, 100 each value, in the decades of x1, x10, x100, x1k, x10k, x100k: 1, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, 4.7, 5.6, 6.8 and 8.2.
- Soldering irons and solder.
- Small long nose pliers, side cutters and screwdrivers.
- Desoldering wick or a desoldering tool.
- One or more multimeters.
- Printed circuit board and chemicals for preparation and etching.
- Storage cabinet for the resistors.
- Wire, connectors, plastic sleeving.
- Miscellaneous components, eg, capacitors, transistors, integrated circuits to suit planned projects.

### Purchasing outlets

The following firms are representative of those that supply the sort of components you will need. Not all the firms are found in all states, and many others are not listed due to the lack of awareness of their existence by the author. This particularly applies to firms outside NSW. Those enterprises not listed may well offer deals superior to the following.

- George Brown: (Protronics in SA and WA.) This firm deals in wholesale purchasing in a wide range of components.
- Dick Smith: The retail outlets are well known and offer most parts required by hobbyists. The wholesale division called DS Distributors is only situated in Sydney.
- Rod Irving Electronics: Based in Melbourne.
- Pre-Pak Electronics: Offers a mail order service.
- Jaycar Electronics: Stocks a wide range of kits and components. Has an agency in Brisbane.
- Ritronics: Minimum account order of \$50, based in Clayton, Victoria.
- Emona Instruments: Specialises in educational equipment rather than components. Head office in Sydney, agencies all states. May have low price test equipment suitable for project building.
- Circuit Components: Based in Bexley, (Sydney), this firm specialises in printed circuit board chemicals, drafting aids and photosensitive products.
- Altronics: Based in Perth, offers a wide range of components, similar to Dick Smith.
- RS Components: Deals in mail order components, the outlets in Australia are from the parent company in England.

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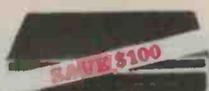
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# LIGHT AND ELECTRONICS

Peter Phillips

IT IS FAIRLY common knowledge that electricity produces light just as light can generate electricity. However, generating electricity in this way has, to date, not been developed much beyond the use of solar cells. Even in the most cost effective cases, other means of generating electricity are more attractive, limiting the use of solar energy to low power applications such as from powering calculators to trickle charging batteries. But the use of light in conjunction with electricity is far more common, in ways the average user may not even be aware of.

Opto-electronics is the term used to categorise the theory behind those devices that use light in combination with electricity. As usual, our coverage is brief but informative; enough to whet your appetite for more, not too much to confuse the issue.

### The facts of light

Around the turn of the century, arguments raged as to the nature of light. Was light composed of 'particles', or was it a form of wave energy? Evidence abounded to support both theories, ultimately resulting in a 'yes' verdict for both forms. The wave theory suggests that light is an electromagnetic vibration, a rapid succession of pulses, similar to a radio transmission but at a much higher frequency. The particle theory, developed by Einstein, assumes that light is a stream of small particles, now known as photons. The particle theory ushered in quantum physics, and provided insight to the atom, thus introducing the world to the atomic age. This theory identifies the photon as a quantum of energy, proportional to the frequency of the wave. Both these theories are inconsistent with each other but they are nevertheless both applied: light is considered a wave to explain certain phenomena and considered as

particles where the wave theory falls down. Confused? So are many scientists, and one can only speculate where it will all end.

By using both theories, all the phenomena of light can be explained. For our purposes, it is sufficient to recognise that light is a form of energy, with a wavelength depending on the colour of the light. A wavelength is the distance between two equal points of the wave, as shown in Figure 1. A relationship exists between the number of cycles occurring each second to the speed the wave travels. The velocity of light, as all school students know, is around 300,000 kilometres per second. Wavelength is determined by dividing the velocity with the frequency.

It is common to define each colour by its wavelength rather than its frequency, giving rise to terms such as the Angstrom. Figure 2 shows how the spectrum is portrayed as a series of very short wavelengths of electromagnetic energy, from red as the longest to violet the shortest. Thus, red light has the lowest frequency and becomes infrared once its frequency falls below that which the eye can perceive. Ultraviolet light is at the other end of the spectrum and green somewhere in the middle. As a further illustration, Figure 2b shows the entire frequency spectrum, depicting the relative position of each subgroup of uses. Light occupies frequencies around one thousand million million cycles per second ( $10^{15}$ Hz); sound extends up to only 20,000 Hz.

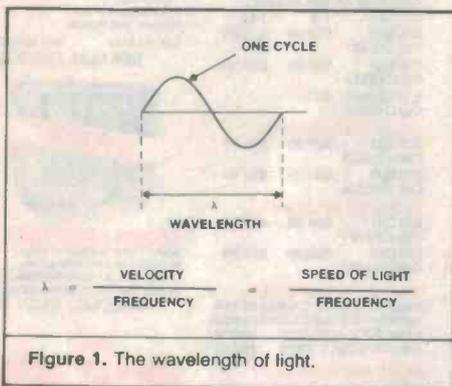


Figure 1. The wavelength of light.

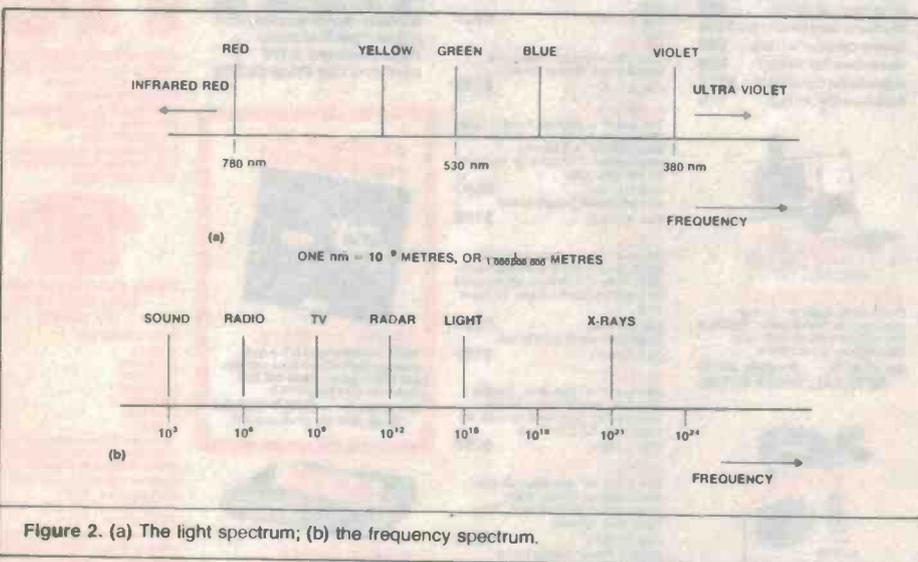


Figure 2. (a) The light spectrum; (b) the frequency spectrum.

### An overview

Opto-electronic devices can be grouped into two categories: those that produce light and those that react to light. The light emitting diode (LED) is the most common light producing device and many applications for these exist. LEDs often form the basis for displays, as light sources in conjunction with other light operated devices, and are currently used in most domestic remote control units. Liquid crystal displays (LCD) are not light producers, but the properties of the chemicals within the assembly allow areas to appear dark or light according to control voltages applied to sections of the display.

Another common display that produces light is the cathode ray tube (CRT). In the



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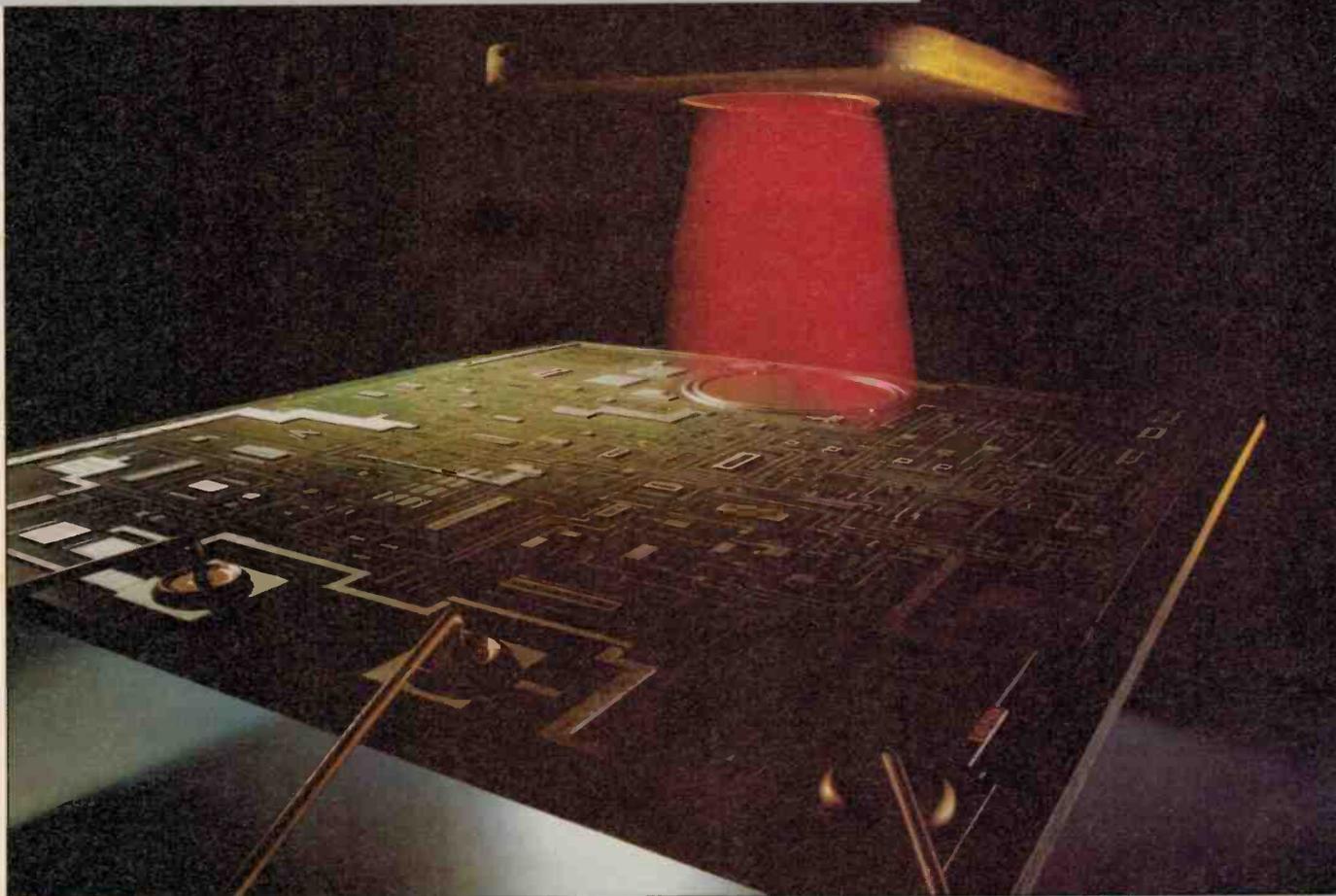
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The combination of light and electricity is a marriage of two abstract forms of energy. Both operate at the highest speeds known in nature, and together produce effects and functions as exciting as any technology can offer. The field of opto-electronics is probably still in its infancy and may well constitute a future technology.



Photograph courtesy of VSI Electronics Australia.

CRT, an electron beam is used to excite a phosphor-coated screen. When an area is bombarded with electrons, that section will glow a different colour according to the various phosphors.

Devices that react to light vary from those that produce a voltage when struck by light to devices whose electrical properties alter as a result of incident illumination. Solar cells, otherwise known as photovoltaic cells are the most common examples of a device that produces electrical energy from light. Devices whose electrical properties alter as a result of exposure to a light source include light dependent resistors (LDRs), photodiodes, phototransistors, even photo-FETs. These components are

used to allow a circuit to respond in some way to a light source, for example pulsed light often used to transmit information.

The use of fibre-optics is another area of great interest to those wishing to transmit information. This technology uses optical fibres to conduct light in much the same way as wire conducts an electric current. A light source at one end is acted upon to pulse the light at high speeds in such a way that information in the form of a digital pulse train is produced. Sensors at the other end or at a number of points along the way respond to the light, and circuitry to amplify and decode the information is used to regain the original information. Lasers are becoming more widely used, with applications ranging

from exotic light shows to surgery, warfare and data transmitting uses. Compact disc players use a laser in conjunction with a photosensitive detector so there is no physical contact with the disc as information on the disc is read.

Having summarised the topic, it now remains to examine these devices and to show their applications. Opto components are often very cheap, and many otherwise impossible tasks can be performed easily by the combination of light producing and light sensitive devices.

### Light sources

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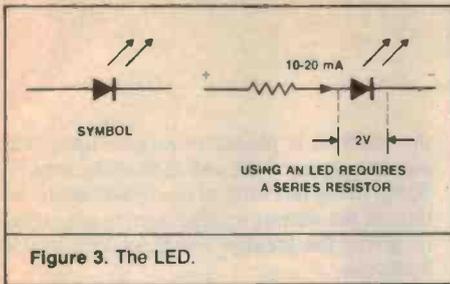


Figure 3. The LED.

placement of arc lamps that had been used previously. From an electronics standpoint, another eighty or so years had to elapse before the discovery of a light source in a solid state device. Certainly there were other methods of producing light: neon indicators, fluorescent tubes, phosphorescent indicators, but none so successful as the LED.

Light emitting diodes are semiconductor diodes emitting electromagnetic radiation when operated in the forward direction. The wavelength of the emitted radiation depends on the semiconductor material used and its doping. GaAsP LEDs (gallium arsenide phosphide LEDs) emit red light, GaP LEDs (gallium phosphide LEDs) produce green or yellow light, and GaAs diodes (gallium arsenide IRED) emit in the infrared region of the spectrum. The basis of the LED, as any other diode, is a pn junction. However, the energy given off by the junction under current-carrying conditions in a conventional silicon or germanium diode is largely in the form of heat. By using the various materials mentioned, a diode still results, but one that dissipates the energy in the form of light.

Figure 3 shows some of the various types of LEDs available. Apart from the conventional 5mm red LEDs so commonly employed, the range extends over LEDs of various shapes and sizes: dual LEDs, high brightness types, focused LEDs, bezel mounted varieties, and so on.

It is important to know some basic electrical characteristics of these easy to use devices. The current through the diode must be limited to around 10 to 20mA, depending on the size of the LED. The voltage drop across the device is approximately 2

volts, and the reverse breakover voltage is a very low value, about 3 to 5 volts. Thus, LEDs are generally used in dc circuits and require special consideration where ac is involved. Very little heat is generated allowing high packing densities, and their life is generally in the order of 100,000 hours.

Most TTL digital chips can drive an LED directly, allowing their use as state indicators. Dual LEDs, incorporating a green and a red LED in the one package are ideal to display up to three states: off, green and red. Flashing LEDs which require 5 volts for operation contain an IC within the package. These make excellent warning indicators such as a simple deterrent on a car dashboard. High intensity or prefocused LEDs are used as optical data transmitters, in conjunction with a light sensitive detector. Infrared LEDs (IREDs) are found in most remote control units. Because they emit energy just below the visible spectrum, many manufacturers include a conventional LED to indicate that the unit is transmitting.

**Displays**

Displays incorporating LEDs or LCD modules are as common as mud, and offer features that permit communication between a device and the user. LCD displays are more complex than the LED types, but operate with extremely low power consumption. A disadvantage of LCD displays is the need for an external light source. However, under bright light conditions, LED types become harder to read making the LCD device the better choice. LCD displays can include a wide range of characters, even pictures, with colour being incorporated as required. Solid state screens are usually LCD, and many car manufacturers are including dashboard instrumentation based on specially designed LCD panels.

Because of its relative simplicity, the LED display is best suited to the hobbyist. In general, seven segments are employed,

some including a decimal point, as shown in Figure 4. The segments are usually labelled from a to g, and special decoder/driver digital ICs are used to allow the display to show numbers and a limited range of letters. Reference to most texts on digital electronics will provide information on how to use these devices. One point to note is the polarity of the power supply to the display. Some varieties connect all the anodes to a common point, others the cathodes. The common anode types would require the positive supply to this pin; the device driving the individual segments would need to provide a path to the negative terminal. The opposite polarity would be used for a common cathode type.

Bar graph indicators are often incorporated in audio equipment, and can be used wherever a level of some type needs to be indicated. A bar graph indicator, integral to the driving electronics, is available in the National Semiconductor IC type 3916. This device contains ten LEDs, arranged in a line, and requires a minimum of external components to allow the display to provide an indication of a quantity being measured. The input signal to the unit needs to be a voltage proportional to the variable being monitored. Thus, a solid state petrol gauge, oil pressure indicator, thermometer, voltmeter and so on become simple but effective realities.

**The CRT**

Cathode ray tubes are, without doubt, the most common means of displaying complex visual information. Prior to computers, the usual applications were in TV sets or cathode ray oscilloscopes. The principle of operation of a CRT is simplicity itself. Figure 5 shows the basics required by a CRT that is to display information. A highly evacuated glass envelope, suitably shaped is arranged to have a source of electrons at one end and a phosphorous-coated screen at the other. The 'electron gun' is merely an

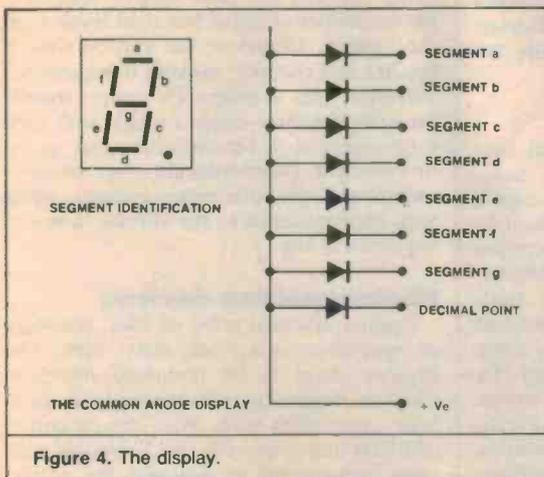


Figure 4. The display.

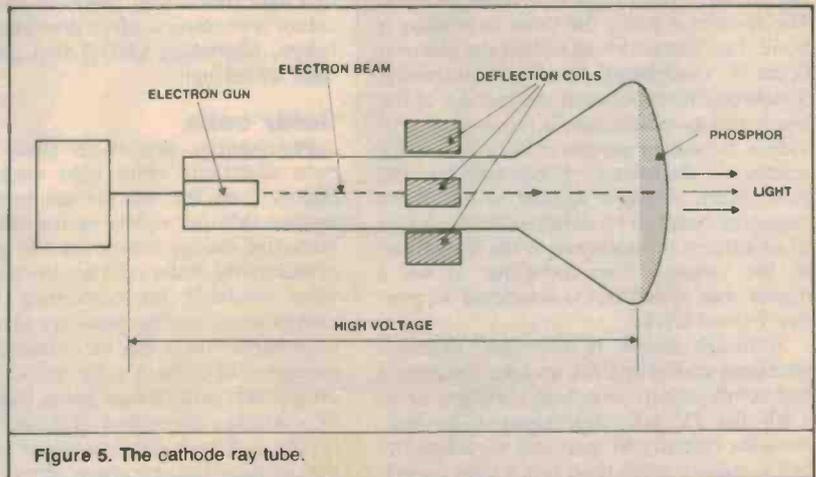


Figure 5. The cathode ray tube.

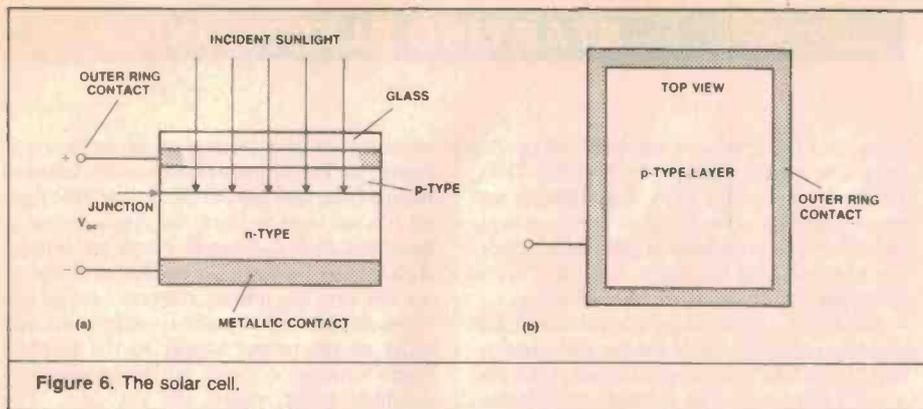


Figure 6. The solar cell.

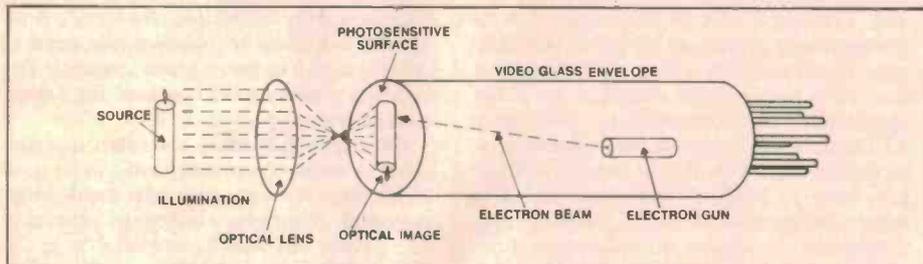


Figure 7. Principles of a TV camera. External coils for focusing and deflecting the electron scanning beam are not shown.

assembly containing a specially coated tube that is heated by a filament. Other electrodes within the gun focus the electron beam so that a high positive voltage present at the phosphor-coated end can attract the beam. The point of collision between the electrons and the phosphor results in the emission of light, the intensity of which is proportional to the strength of the electron beam.

Because a single point of light is relatively useless, a means of moving the beam over the entire face of the tube has to be provided. This can be done either by electrostatic or electromagnetic means. A TV set or a computer monitor uses an assembly called a yoke consisting of four coils arranged to allow the beam to be attracted vertically or horizontally. By applying suitable currents to the coils, the beam can be made to sweep the entire tube, usually from top left to bottom right in a series of lines. The motion is much the same as reading a book. Intelligence results when the electron beam is 'modulated' to vary its intensity. Synchronisation between the motion of the beam and its modulation is required to provide a stationary picture. CRTs in oscilloscopes use electrostatic plates built into the tube. Here, voltages applied to the plates cause the beam to be deflected from its axis at an amount proportional to the magnitude of the voltage. This technique allows a higher scan speed but is restricted to relatively small CRTs.

Although simple in principle, practical problems make the CRT and the beginner a bad combination. Very high voltages, up to 25kV for TV sets, are required; as well, complex circuitry to scan and modulate the beam require more than just a little knowl-

edge. However, a dissertation on optoelectronic devices would be incomplete without reference to this, the last living example of the valve.

### Light sensitive devices

Using light to control an electrical current requires the use of components that have a characteristic which alters when exposed to light. Such devices are classified as being either photovoltaic, photosensitive or photoemissive. The most common group is the photosensitive types, and these form the basis of most opto-electronic applications. All these devices are most sensitive to a particular colour or wavelength, and are usually given specifications for this colour. As white light (such as that from the sun), comprises all colours, many devices operate effectively if such a light source is provided. If maximum sensitivity is required, the use of a light source that produces the required colour is necessary, often involving filters or lamps, (including LEDs) that provide the right wavelength.

### Solar cells

Photovoltaic devices are those that produce electricity from light energy. Solar energy from the sun (at sea level) equals around 1kW per square metre, making it an attractive energy source for the generation of electricity. Solar cells are the simplest devices available for converting the sun's energy as no moving parts are involved and reasonable power can be obtained by using a number of cells. A solar cell consists of a pn junction constructed using either silicon or selenium, assembled as shown in Figure 6. The p doped semiconductor sufficiently thin to allow the maximum energy to fall on

the junction is placed to receive light. The power output of the cell is directly proportional to the intensity of the illumination, although the output voltage rises exponentially, giving the greatest rise from dark to half brilliance.

Because the response of a selenium solar cell is very similar to the eye, having its maximum output somewhere in the centre of the visible spectrum, these cells are used in exposure meters or for light measurement. Silicon cells have their highest output in the infrared region. Their most typical uses are in powering remote low power equipment, trickle charging batteries and providing energy for calculators and similar devices.

### Video camera tubes

A phototube is an example of a photoemissive device. Although relatively obsolete, the phototube deserves a mention as it was the precursor to the video camera tube. From a constructional point of view, an element called the cathode is coated with a material that will emit electrons when struck by a light source. A second element (the anode) is placed to attract the electrons when a positive potential exists between it and the cathode. The resulting current is proportional to the light intensity, and a common application was to use a phototube as the active device in reproducing the sound from a movie film.

Early camera tubes used the photoemissive principle in a device called the image orthicon tube. From this developed the vidicon and plumbicon tubes, both of which use a plate whose conductivity varies with incident light. An electron beam is 'scanned' across the surface of the plate to allow a complete frame to be produced line by line. Figure 7 illustrates the general principle. Such tubes are vastly more complex than the simple phototube which, nevertheless, owes its origins to this device. The plumbicon tube has a spectral response closer to the eye and suffers less from photoconductive lag at low light levels than the vidicon. However, the vidicon tube is smaller and cheaper, making it popular for video cameras. A colour TV camera usually incorporates three camera tubes, with each tube arranged to receive either red, green or blue light. Developments in recent tubes include a single tube colour camera, along with improvements to the vidicon tube giving reduced lag.

### Photosensitive devices

From a practical point of view, the story of opto-electronics really starts here. The devices about to be discussed represent those the beginning enthusiast can use, or at least experiment with. With the exception of LEDs and solar cells, the foregoing contains background to acquaint the reader

with devices outside basic electronics applications. Not so the components that follow. Using relatively simple circuitry, it becomes possible to build such items as a turns counter, a light activated switch, a remote control system and so on. A very popular device to control ac loads, including motors, lighting, heaters etc, is a solid state relay with an optocoupler input.

The basis of many opto devices is the pn junction alluded to in this and previous articles within the series. One device that does not rely on the pn junction is the light sensitive resistor. The LDR is a passive photoelectric component consisting of a layer of either cadmium sulphide or cadmium selenide, arranged between two connecting grids. Figure 8 shows the symbol, construction and a simple application.

The resistance of the LDR falls from a very high value (around 10M ohms) to only tens of ohms when illuminated. The response curve of a Cds device to colour is fairly similar to that of the eye, with a peak sensitivity in the centre of the spectrum. A problem with the LDR is its speed of operation. A reduction in light is detected quite slowly but a faster response can be measured when the incident light level is increased. Because the device is passive, its terminals are not polarised meaning the LDR can be used in ac or dc circuits.

**The photodiode**

A pn junction comprises two oppositely doped sections of semiconductor placed next to each other which allow the passage of a current when the p doped section has a positive voltage compared to the n doped section. Reversing the polarity prevents the flow of current, and in this way a semiconductor diode results. It is generally assumed that when the junction is subjected

to the reverse voltage no current flows. However, if measured with sensitive instruments, a small current, called the reverse leakage current, can be detected. The value of this current will increase with temperature and (you guessed it) with incident light.

The photodiode takes advantage of this interesting phenomenon and is arranged with its junction placed near a lens to focus the light on to this area. A circuit using a photodiode measures the reverse current caused by the light when the diode is operated with a reverse bias. The current is almost directly proportional to the intensity of the light, suggesting the photodiode be used in light measurement applications. Because the currents are small, some form of amplifier is usually required.

The photodiode is characterised by its small size, allowing it to be used in applications where a large number of individual light sources has to be detected, such as a card reader in a computer. Another advantage of these components is their speed of operation, a feature that often dictates their use despite the need for amplification of the signal. Figure 9 shows the basic construction and symbol.

**Phototransistors**

A light sensitive transistor is, in effect, a combination of a photodiode and a transistor within the one package resulting in the simplest photodiode-amplifier arrangement. A lens is usually incorporated on the top of the transistor, with three leads extending from the package, identified in the usual manner. Because of the extra gain, the response to light variations is slower than for the photodiode; the package is also larger. These devices, like the photodiode, have a spectral response most sensitive to colours around the red region and making

them suitable for use with filament lamps and red LEDs.

Although all three leads are available for use, most applications only use the collector and emitter leads, with the base lead left open circuit. Often a circuit using a light sensitive transistor is very simple, involving perhaps several other conventional transistors, or maybe an operational amplifier. Sometimes because of their sensitivity, the light source can be routed to the lens by means of optical fibres. This allows the electronics to be relatively remote from the optical action, an advantage where heat and vibration may be likely to cause problems to the phototransistor.

A variation on the basic phototransistor is the photo-darlington device. This package contains, in effect, two photosensitive transistors, coupled as shown in Figure 10. Very high current gains can be achieved, although speed of response falls accordingly. The use of these devices allows the detection of very low light levels, although careful design of the support circuitry is required to minimise the effects of leakage currents within the device.

Another component that is sometimes encountered is the light sensitive SCR. This device uses a photodiode within the SCR package to allow light to trigger the SCR. The classic application for the LASCR is to turn on outdoor lighting when the ambient light falls below a certain level. These devices are mainly low power types, but offer the characteristic of acting like a self-locking relay whereby, once triggered, the SCR remains on until deactivated by some other means.

**Opto-electronic modules**

The combination of a light source and a light sensitive device forms an optocoupler. ▶

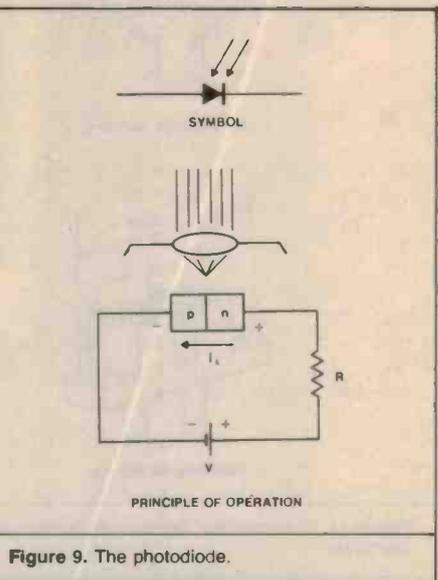
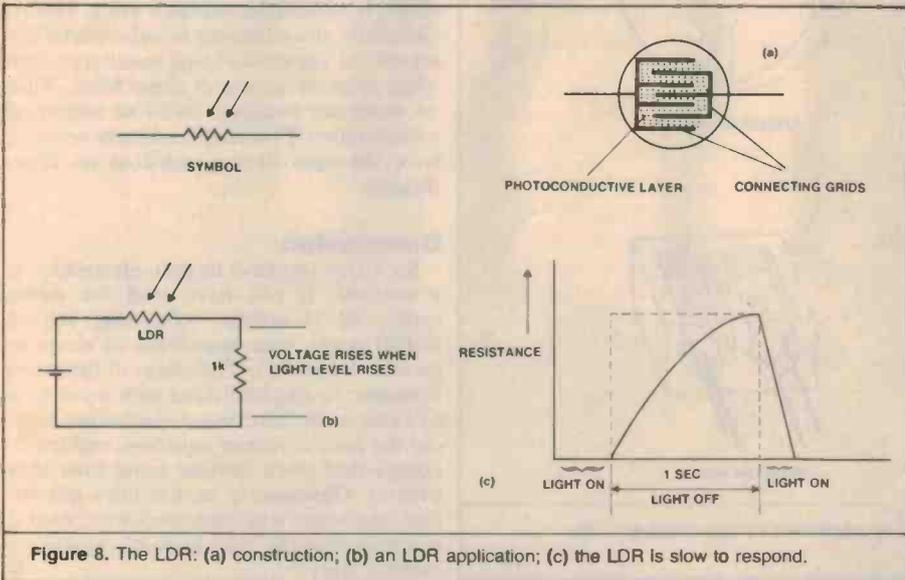


Figure 8. The LDR: (a) construction; (b) an LDR application; (c) the LDR is slow to respond.

Figure 9. The photodiode.

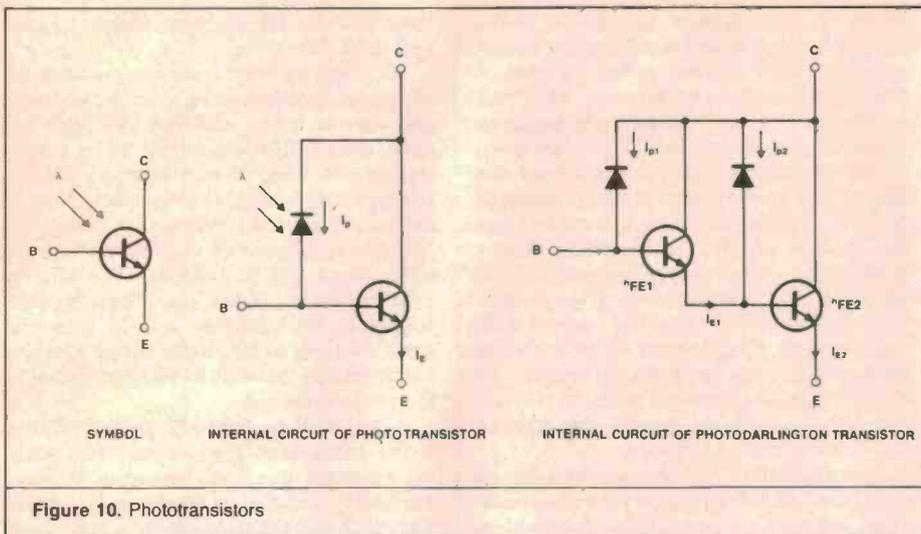


Figure 10. Phototransistors

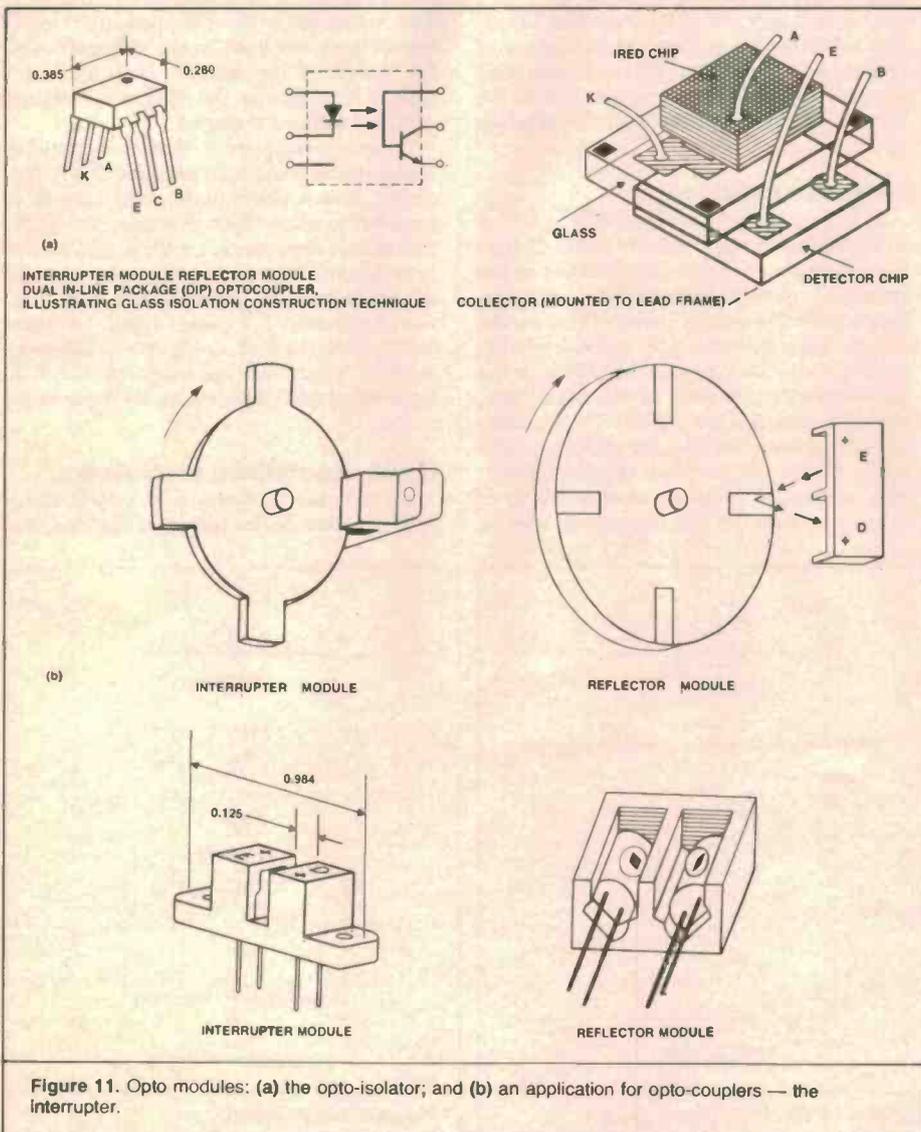


Figure 11. Opto modules: (a) the opto-isolator; and (b) an application for opto-couplers — the interrupter.

If provision is made to interrupt the path of the light an opto-interrupter results. Figure 11 shows some of the devices commonly available. A photocoupler, also known as an opto-isolator, contains in a totally sealed DIL package, an IRED and a phototransistor. The two components are electrically isolated, with an isolation voltage rating measured in kilovolts. Their main use is in interfacing between two circuits that must be electrically independent, such as a low voltage controller acting as a mains operated power device. The control signals are fed to the IRED and the output signal is from the transistor. Coupling between the two is provided by a transparent dielectric housed within the package. The controller needs to provide a current of around 10mA to the IRED, at a voltage of 1 to 2 volts and, as the switching speed of the combination is measured in microseconds, frequencies of many kilohertz can be passed through the unit.

Interrupter modules are very useful components, as the mounting of the devices within the package ensures optimum positioning of the two and means the user need only be concerned with the circuit requirements. As Figure 11 shows, there are two basic module types: the interrupter and the reflector. The first positions the sensor apart from the light source with a gap that can allow a vane to block the light. A good application is in counting the turns of a shaft, or if time is included, as a rev counter. Because the sensor is usually a transistor, support circuitry is simple, usually something to convert the signal to a digital format and the rest of the processing is via a digitally based circuit. These devices are often used instead of a mechanical limit switch, providing increased reliability.

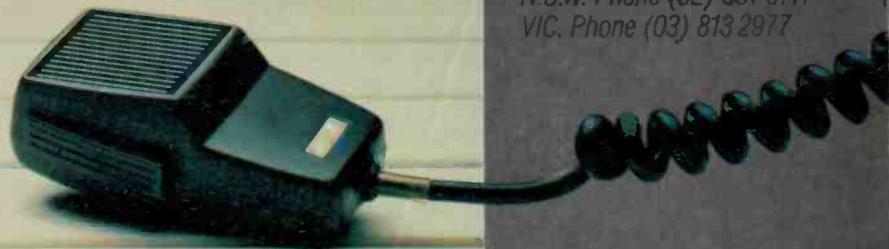
The reflector types use a light beam that is sourced from the package at an angle that allows it to be reflected back to the sensor. Generally, it is sufficient to paint the reflector on the apparatus being monitored with white paint, assuming all else is black. Thus no vanes are required, often an important consideration if existing machinery needs to have the opto device added as an afterthought.

## Conclusion

So, there you have it; opto-electronics in a nutshell. If you have read the entire series, all 15 articles comprising around 50,000 words, your knowledge of electronics must be greater. The intent of the series is simple; to acquaint those with a yearning to know something about electronics without the need to master equations and terminology that often confuse more than they explain. Obviously a lot has been left unsaid; the series was concerned with 'what it is' rather than the 'how to do it'. And that's another story!

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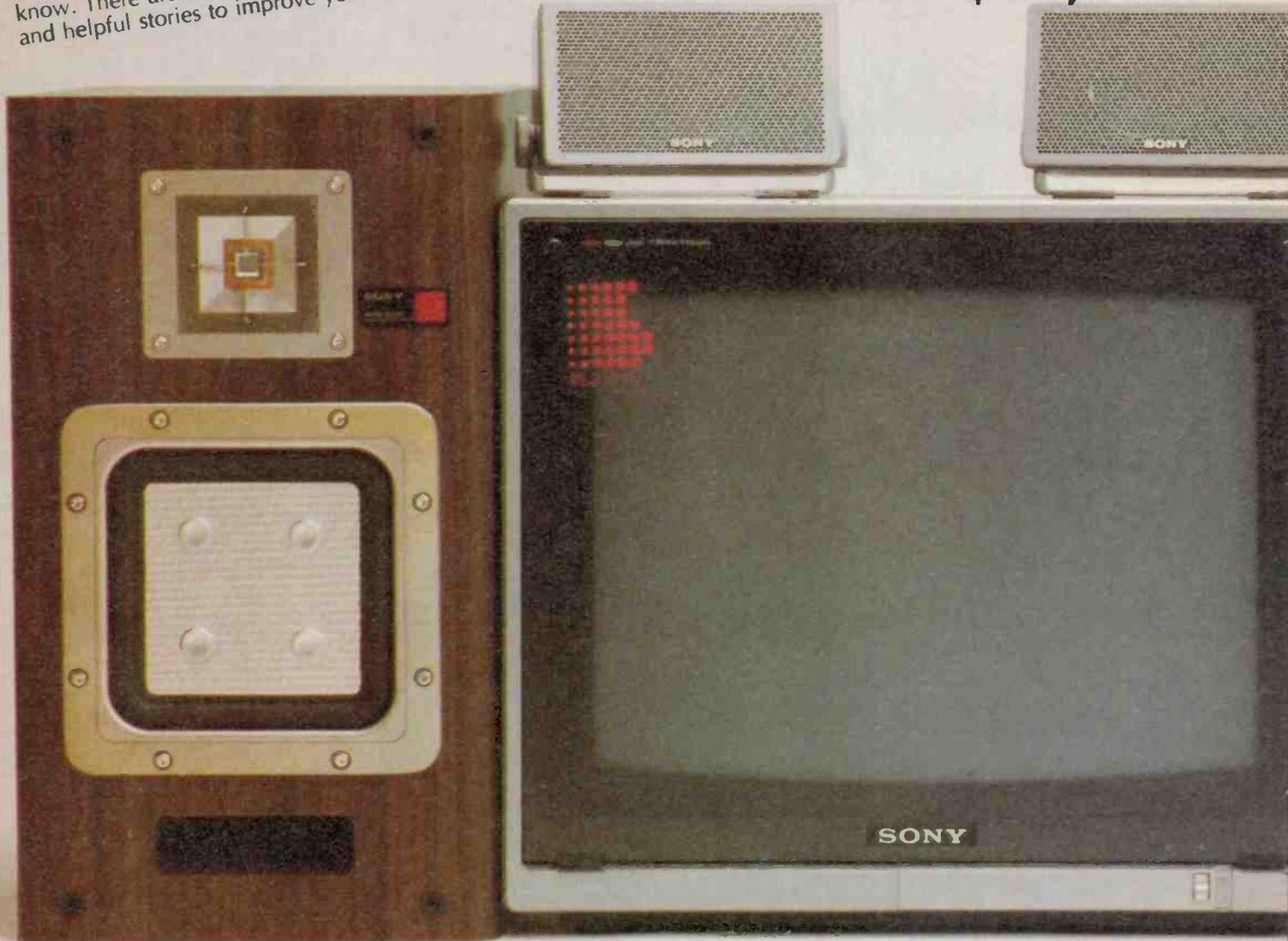
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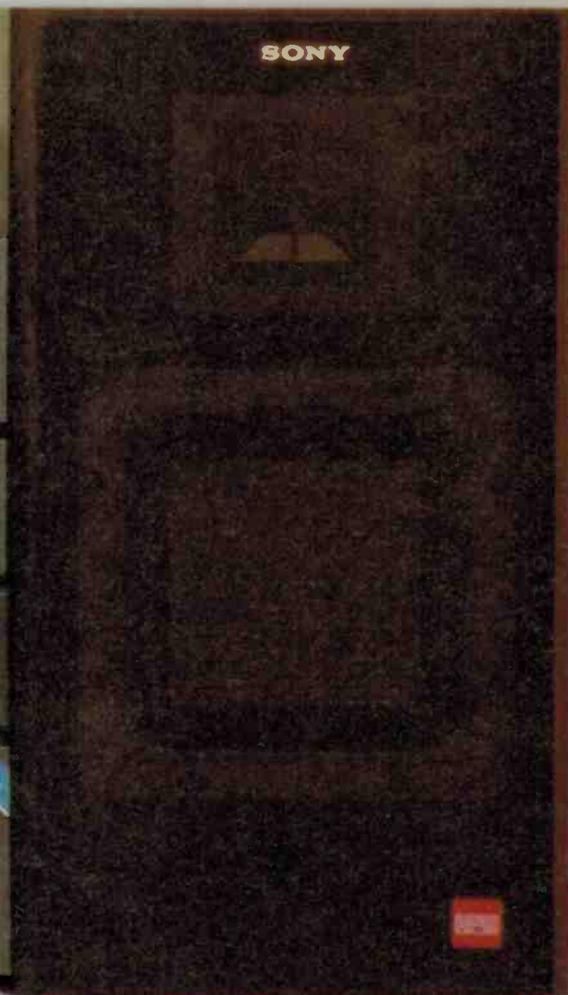
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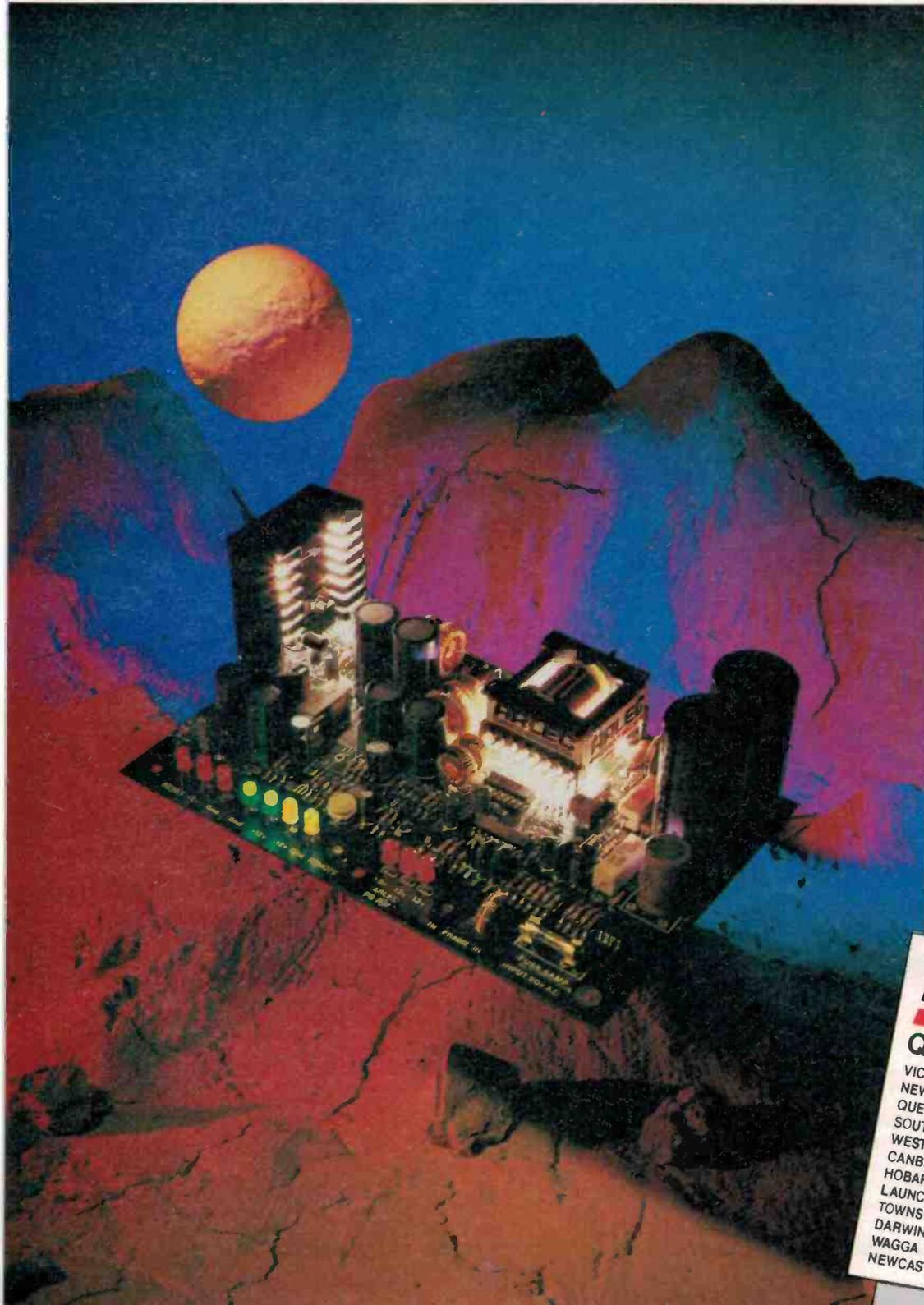
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ETI READER SERVICE 188

# CLEARING THE LAB SHELVES

## — with the Marconi 2955 communications service monitor

**Peter D. Williams**

*Peter Williams is Director of Associated Calibration Laboratories in Melbourne.*

Is test equipment too complicated, too expensive? This new test set says no to both questions but what would Guglielmo say to his company's latest creation? It checks a transceiver in less than three seconds!

meter, etc. All in all six or seven separate, expensive instruments, time consuming to interconnect and evaluate, possibly leading to skimmed work and a tarnished reputation for the repair shop and service industry generally.

From this situation developed the concept of the 'service monitor', which would combine these test functions and add in the feature of portability. In Australia we have had, with varying degrees of success, this type of equipment from Ailtech-Singer, Cushman, IFR, Motorola, Systron Donner, Wavetek, to name a few, and all designed to do more tests while packed into a single instrument.

So what's so special about the Marconi 2955? It's the fresh start approach.

### Different but how?

After doing it's homework, Marconi obviously concluded that technicians wanted less complexity, fewer knobs and less time to learn how to drive it.

What you see on the screen of the Marconi box is transmitter frequency, power output, deviation frequency and modulating frequency with its level. All this information is held on the screen until it is erased with vertical bar charts displaying the dynamic measurements in real time — no meters, no range settings as the box uses auto ranging on all scales.

If you wish to check the receiver of your transceiver, a quick push of the Rx = Tx pushbutton automatically places the 2955 on the same frequency that was transmitted to it and injects the receiver frequency to the radio under test.

If your radio operates on duplex, where receive and transmit frequencies differ, or even cross band transceivers, any of these offsets may be entered into any one of the 38 non-volatile storage areas. Complete in-



MARCONI HAS NOT always been first with the latest technological advance and has been criticised in the past for unimaginative and complacent engineers and marketers. However, in the last few years, sweeping changes in direction and close attention to costs have changed all this.

All this is by way of introduction to one of Marconi's latest efforts in test equipment design — a multi purpose radio service test unit.

The Marconi 2955 is a specialised instrument for use in the test, diagnosis and repair of communication equipment over the frequency range of 0.4 to 1000MHz.

During production, communications equipment is subjected to exacting tests of its frequency accuracy, frequency stability, modulation, distortion, sensitivity, unwanted or spurious outputs from transmitter, power output of transmitter, and encoding and decoding tones.

One would expect these specifications to be checked as part of any radio repair process also, and until a few years ago this required shelves full of test gear. For example, to measure frequency you needed a counter; to generate an rf signal you needed a signal generator; to measure distortion, a distortion meter; power output, a power

## LABORATORY REPORT: MODEL 2955 SERIAL No. 119507/107

In the case of modulation and power indications, most test sets have accuracies ranging from 5% to 20% so a radio that has a nominal 10W output could indicate anywhere from 8W to 12W and still be within the specification of the test set. It is important for any test department to not only calibrate its equipment so that it is within specification, but to know what the tolerances are so that allowance can be made for the readings. It is pleasing to see such a comprehensive range of specifications supplied with the 2955 to enable these allowances to be made.

The Marconi is of first class construction. Modular layout makes servicing, if and when required, a breeze.

To further indicate the tightening and upgrading of specifications, which we believe are required in today's environment, we have shown Marconi's claimed specifications with our results and related these to average current workshop specifications represented by other multipurpose instruments and a representative figure expected of laboratory type instruments.

Lab Results & Manufacturer's Specs	Present W/shop Specs (average)	Lab Equip Specs (average)
<b>rf SIGNAL GENERATOR SECTION</b>		
Frequency Range 400kHz — 1.0GHz		
Output Level		
Measured: $\pm 2$ dB	$\pm 3$ dB	$\pm 1.5$ dB
Spec: $\pm 2$ dB		
Residual FM		
Measured: $< 30$ Hz	$< 100$ Hz	$< 15$ Hz
Spec: $< 30$ Hz		
Harmonics		
Measured: 1.5MHz — 38dBc; 1.5-250MHz — 35dBc; 250-1000MHz — 20dBc	$< 25$ dBc	$< 25$ dBc
Spec: -20dBc; -30dBc; -20dBc		
Spurious (worst case)		
Measured: $< -60$ dBc	$< -60$ dBc	$< -80$ dBc
Spec: $< -45$ dBc 0.4-88MHz $< -60$ dBc to 1000MHz		
<b>MODULATION SECTION</b>		
AM accuracy @ 50% indication		
Measured: better than 3%	$\pm 10\%$	$\pm 5\%$
Spec: $\pm 10\%$		
FM accuracy @ 5kHz deviation		
Measured: better than 3%	$\pm 10\%$	$\pm 5\%$
<b>MASTER OSCILLATOR</b>		
Oven oscillator 10MHz		
Measured: $\pm 1$ part in $10^8$ over 1 hour after warm up		$\pm 2$ parts in $10^7$ over 24 hours
Spec: stability $< 1$ part $10^9$ over 1 second		

### rf FREQ METER SECTION

Accuracy: same as internal standard  $\pm 3\%$

Error resolution:

1Hz/10Hz to 100MHz  
10Hz/100MHz to 1GHz

Sensitivity  
BNC input

Measured: nominal 30mV

12dB SINAD

Spec: 50mV

N type input

Measured: nominal 224mV

12dB SINAD

Spec: 500mV

### rf POWER METER

Accuracy

Measured: better than 5%  $\pm 13\%$   $\pm 1.5\%$

@ 476MHz and  
155MHz 10W

Spec:  $\pm 10\%$

### MODULATION METER

AM/FM on receive

Accuracy over operating range

Measured: better than 5%  $\pm 10\%$   $\pm 1\%$

Spec:  $\pm 8.5\%$  50Hz-10kHz

AM/FM on generate

Accuracy over operating range

Measured: better than 5%

Spec:  $\pm 10\%$  50Hz to 5kHz

### SINAD METER

Accuracy over operating range

Measured: better than  $\pm 1$ dB  $\pm 1$ dB  $\pm 1$ dB

Spec:  $\pm 1$ dB

### DISTORTION METER

Accuracy over operating range

Measured: better than 3%

Spec:  $\pm 5\%$

### AF LEVEL METER

Accuracy over operating range

Measured: better than 5%

Spec:  $\pm 5\%$

### PM/AM/FM ACCURACY

Measured: better than 8% over operating range

Spec:  $\pm 10\%$

Voltage measured 3%

Spec:  $\pm 5\%$  10mV/Div to 20V/div

Sweep rates 100 $\mu$ s/div to 5s/div

locked to internal standard

strument stores of frequency and modulation parameters can be set up at will; a decided convenience for those checking systems using common channels — police, fire, government and the like.

### Functions and features

As befits a pedigreed, self respecting and processor-controlled test box, all the desired functions listed earlier can be initiated: rf power meter, rf frequency counter, modulation meter, rf signal generator, audio signal generator, audio frequency counter, voltmeter, audio distortion meter, SINAD meter, digital oscilloscope, and tones encoder/decoder.

Pushbuttons for function and data entries are colour coded.

The CRT display provides prompts during data entry, guidance during sequences and shows measurement results by means of five auto ranging bar charts. A relatively crude example of bar charts is the loudness

displays on audio gear. The display on the 2955 enables technicians to make precise adjustments to levels. Previously, digital equipment was at a disadvantage for this sort of work as you could not easily see the effect of adjustments approaching or receding from a desired figure as you do with analog meters. The 2955 gives the best of both worlds.

The digital storage scope has an 800kHz sampling rate with a 50kHz bandwidth so you can see the transmitter's or receiver's audio. Repetitive sweep, single sweep and freeze facilities are available. This freeze enables you to observe readings at leisure, especially if you have just keyed in a high-power transmitter and don't want to overload the rf.

Frequency counters can simultaneously show rf and AF frequency readings with either 1Hz or 10Hz resolution for rf and 0.1Hz for AF. Accuracy of the readings is that of the internal frequency standard; if

you are after better accuracy an external standard can be used.

The signal generator can be set up by the keyboard, keying in a transmitter as described earlier or from any of the user programmed sequences. Modulation can be internal or external for AM, FM or phase and is protected against reverse power overloads. Independent tuning for duplex measurements enables cross band operation from say VHF to UHF or vice versa.

Modulation monitoring both on the built-in oscilloscope and from the speaker is possible. Some might question the inability of the monitor to show or provide spectrum analysis. The low receive sensitivity could be criticised too, because an ability to do off air tests of remote transmitters aids in diagnosis. The short answer to these criticisms is that the 2955 was deliberately designed to give automatic frequency tuning with inputs of about 50mV. Obviously greater sensitivity would trigger unwanted responses

and, as the box is billed as service test set, it is expected that equipment under test would be on the bench. Spectrum analysis is best left to the specialised instruments designed for the task.

Radio frequency power can be measured from microwatts to 30W continuously or up to 100W for short periods. Again, the auto ranging bar chart will show the power as well as display it digitally on the screen. The bar charts allow easy tuning of final output stages. The fact that power can be shown down to a milliwatt or better, means that you can use the instrument to show injection levels to oscillators, mixers and the like.

The audio frequency generator operates from 20Hz to 20kHz with a fixed 1kHz tone for distortion measurements. All these internal tones can be used to modulate the rf generator for AM, FM and phase modulation.

Tone encoding/decoding facilities make it a breeze to simulate audible as well as sub-audible tones.

Selective calling systems using four international standards plus any user defined systems are available. In addition, you can send and receive a sequence of up to 10 out of 15 allocated tone frequencies, which can be generated in single step, tone burst or a continuous cycle. For transmitter testing, each received tone is compared with standard frequency allocations held in memory. The read out will give the percentage frequency error.

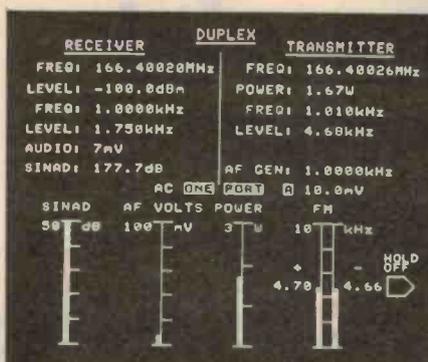
The built-in self-test facility may be called up to enable faults to be identified to a major module level or to group of components. In fact, every time the instrument is turned on, the self-test circuitry goes through three major checks. Failure of any of these tests causes an error message to be displayed and sub tests are initiated so that you can isolate the problem with fault tracing.

Other features include a 'freeze' facility which can hold a displayed value so modulation limiting circuits can be adjusted; auto ranging measurement scales for checking transmitters; an on-screen warning and audible alarm for rf power overload; and a HOLD display key to enable you to freeze all readings once they have stabilised.

A carrier wave form can be seen at the IF socket at the rear. With duplex testing there is no restriction on total frequency offset between receiver and transmitter thus allowing even cross band testing.

A split screen enables you to see transmitter information on the left and receiver information on the right. It can all be copied on to a printer with customer names, serial number, date, etc, for record keeping.

Standard default settings are -100dBm and 1.75kHz deviation at 1kHz modulating frequency for the signal generator.



Duplex testing. Screen display can show major parameters for the transmitter and receiver functions of any VHF or UHF radio. Receive and transmit frequencies can be up to 999.6MHz in difference. Note displayed frequency error for a nominal 166.4MHz signal. HOLD OFF message shows that information is 'frozen' on screen even when radio is not activated. Information may be erased at leisure. Note that some receiver functions are not displayed. If duplex is used, similar information for only receiver or transmitter can be shown. Also note the fast acting bar indicators. The power chart can resolve to 1µW up to 300µW.

Without doing anything else except keying the transmitter into the Marconi to get the receiver frequency, you can get a system check of the radio. Selecting other keys will give you SINAD, distortion or S/N (signal-to-noise). The tuning knob can give you fine control of deviation, tones, etc.

The 2955 has a big seven-inch screen which makes it ideal for displaying a built-in instruction manual. Even during the setting up of a test sequence, help is close at hand by pressing the button labelled HELP! What you see displayed are options, terminology and how to achieve the next step in the sequence. Having sorted yourself out, pressing the same button restores you to the real world of the information display.

This screen is not a conventional phosphor CRT but includes an internal mesh which at normal viewing distances improves sharpness of the lettering.

Two sockets N and BNC are available on the front panel for high and low power inputs. The low signal output is protected against 50 watts reverse, flashing an uncomplimentary signal on the screen and sounding an alarm!

### Performance

Radio frequency power measurement down to better than a milliwatt can enable you to check low rf levels in predriver stages or local oscillators. Although the accuracy of ±20% at low levels isn't lab stuff, remember that rf power meter manufacturers such as Bird don't claim much better than that. Communication power accuracy is around the ±10% for higher powers.

Frequency accuracy using the crystal

oven as standard issue is better than five parts in 10-8. To get this degree of accuracy in other instruments you have to have it optioned up.

Signal generator output needs to have dependable figures. The accuracy approaches that of laboratory instruments and exemplifies the nature of present day requirements. Users of communication equipment are getting the benefit of business and government institutions demanding more exacting technical requirements for equipment.

The lowest reference frequency generated is 400kHz with resolution of 50Hz. If anything below this is wanted, then you have a problem.

"Off air" checks with antenna are not possible unless you are right under/alongside the transmitter. But how much off air testing would you want to do anyway?

The digital oscilloscope is not entirely adequate for 'fine line' analysis, and the lack of spectrum monitor/analyser means you really need a proper spectrum analyser if you want to see limits of spurious outputs with any accuracy.

The audio generator has no usable output below 20Hz. Some users may want to modulate/sweep an oscillator to get response curves of an Rx front end etc.

Apart from unplugging the coax, it is not possible to remove the rf carrier for noise tests.

Output for reference from the internal frequency standard is not available and there is no obvious external adjustment to put the internal frequency standard on frequency, although a 1MHz reference standard can be applied to a BNC socket on the rear panel.

On the ergonomics side, pushbuttons for incrementing up or down must be pressed repeatedly to effect continual change in level or frequency rather than simply pressed while the level steps automatically until released. As it is, a pushbutton can be pressed, click heard but no action, unless pressed dead on centre.

### Conclusion

The Marconi has been correctly billed as a mobile communication test and service unit. With it you can do all the tests required to evaluate any radio. If some older tests such as quietening are not shown then I suggest that a procedure could be devised.

At \$13,600 or thereabouts plus sales tax this unit represents excellent value for the tasks it can perform and at a level of accuracy found in R&D departments, if at all, only a few years ago.

With accessories to handle cellular radio coming up, dc supplies for portable operation, the 2955 must be seriously considered by anyone involved in servicing communication systems. To my mind, it is digital technology usefully employed.

# Interference risk from over-the-horizon radar

Shortwave listeners are familiar with the Russian over-the-horizon radar, informally known as the Russian Woodpecker, and are aware that as it moves up and down shortwave frequencies, it causes considerable interference.

A similar system of over-the-horizon radar is in use in the US for surveillance, and Australia is setting up a similar project in Central Australia. According to Doctor Desmond Ball in a recent Radio Australia interview, funds have been allocated to complete the project.

Traditional radar uses very high frequencies and is based on the line-of-sight which enables excellent definition of an aircraft or whatever object is being surveyed as the signal bounces off the object. But the range of area

under radar supervision is very much restricted. The over-the-horizon radar uses much lower frequencies in the shortwave bands and is functional between 3 and 30MHz. The radar beam is bounced off the ionosphere and depending on power the signal could skip twice across the world 3000 to 5000km.

Over-the-horizon radar suffers in precision object location and identification. Australian authorities believe that as the southern hemisphere has better propagation and there is less air-

craft traffic, identification of unannounced objects is more readily detected. It is on these two assumptions that Australia feels its system is more advanced than the two presently in operation.

The first over-the-horizon radar introduced by the Russians caused protests from shortwave listeners and broadcasters when it was activated from its location at Gomel near Kiev in the Ukraine. The second station, located in the Caucasus, is focused down to the south-east covering China, and the third in Siberia on the Amur River at Nikolaevsk covers the northern region of the globe. The early Russian stations used tremendous



— Arthur Cushen

power, up to 20 or 40 megawatts.

In recent years the Russians have reduced power and become less troublesome, but it is not certain whether that was due to the international protests.

Doctor Ball assured his listeners that the Australian over-the-horizon radar would not cause the same degree of interference due to the much lower power being used (around 50kW).

## DOC news

The first of three transmitting stations for the new ABC shortwave radio service which will blanket the Northern Territory officially began on 20 February, 1986.

John Brown, acting for Communications Minister Michael Duffy, announced the commencement of operations at the Alice Springs high-powered (50,000 W) transmitting station. The other two stations, at Tennant Creek and Katherine, are scheduled to begin transmissions later in the year. Each of the three will have an approximate broadcasting range of 450 km in all directions, and, in combination, will effectively provide radio coverage of the whole of the Northern Territory.

The Alice Springs station (call sign VL8A) will broadcast on frequencies of 4.835 MHz (daytime) and 2.310 MHz (night and early morning). Call signs and frequencies for the other stations will be: Tennant Creek, VL8T, using 4.910 MHz (day-

time) and 2.325 MHz (night and morning); and Katherine, VL8K, using 5.025 MHz (daytime) and 2.485 MHz (night and morning).

Proposals to have commercial entrepreneurs paid an annual fee for rebroadcasting ABC television programs to small, remote communities have proved unacceptable on cost grounds.

Minister Duffy said the government had decided money would be better spent on the regular capital works program under which ABC transmitters and translators were being extended to larger communities round the country. The minister said his department would continue to encourage small communities in remote Australia to invest in self-help broadcasting reception schemes enabling them to get radio and television services much sooner than the government could provide them, given its wider responsibilities across the nation.

SBS's multicultural television

service officially began broadcasting in Hobart and Perth on 16 March 1986.

Originally the SBS was to begin transmissions in both cities by the end of January 1986. However, due to delays in the delivery of transmitters and the installation of time delay equipment to provide Perth with programs in local time, the opening had to be put back to March. Test transmissions were broadcast approximately a fortnight in advance of the official opening to enable installation of UHF antennas.

The DOC launched extensive UHF education programs in both cities, with a pamphlet on UHF reception delivered to every household and a hands-on information stand being set up to handle inquiries from the public.

Over four million Australians in regional areas will receive an extra ABC radio service if draft plans issued last November are successful. The intention is to in-

troduce the service over the next five years, but this is dependent on clearance of television channels from what is known as Band 2 and studio construction in many parts of Australia.

A discussion paper on the subject has been published, entitled *A Second Regional Radio Network for the Australian Broadcasting Corporation*.

The SRRN scheme would involve the establishment of 16 new regional radio studios and upgrading of all existing ones.

Communications Minister Duffy announced that three ABC radio services (Regional Radio 1, Radio 2 and Stereo FM) will shortly be available via the satellite.

The new Secretary to the Department of Communications, Mr Charles Halton, CBE, officially took over from the retiring Secretary, Mr Bob Lansdown, CBE on 1 February, 1986.

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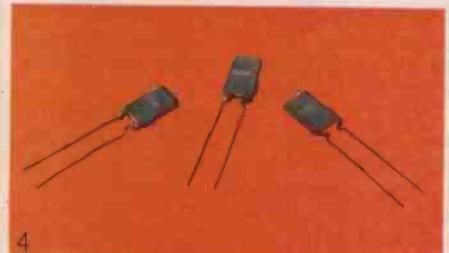
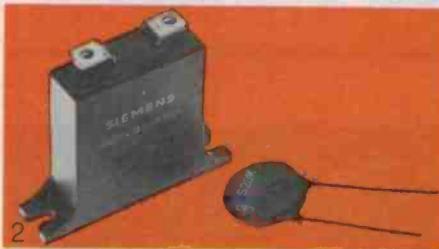
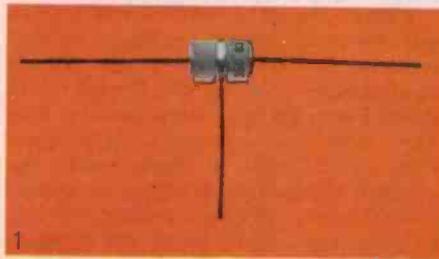
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**Computer terrorism**

A Melbourne academic, Gary Cooper of RMIT, has just completed a study of the nation's computer industry and its attitude to security. He polled the EDP managers of the 700 largest computer companies. Some figures quoted in *Pacific Computer Weekly* magazine: 50% of managers believed they were vulnerable to sabotage; 25% admitted to significant problems with staff threatening to cause machine downtime or sabotage; 7% admitted to discovering a fraud by staff using the machine.

Of those who had discovered problems like this in their installations a quarter said they had not done anything about it and two thirds had not taken legal action.

The same survey found that 14% of managers said they had experienced disasters like floods, 10% had experienced a fire, yet six did not know where their nearest fire brigade was. Forty five per cent had never practised any kind of evacuation drill and 10% allowed smoking, eating and drinking within the installation.

And The Actor thinks he had a problem with Mr Gaddafi?! He should join the computer industry. The good news is that the typically reported staff fraud only involves \$10,000 or less. There are also good openings for technicians skilled in repairing fire damaged computers.

Another piece of paper floating across the desk this week catered, not for the hopelessly laid back, but for the ridiculously paranoid. Netmap, a North Sydney based computer company that would like to get a little bigger has opened a hotline that will advise you on how to overcome your security problems. With an assurance from Michael Hilsden that "doors, locks and passwords are no longer effective barriers to computer intrusion" ringing in your ears, you will be advised to buy an encryptor. This is a device that completely scrambles the signal on the line so no one can understand what you're saying. There are good openings for technicians skilled in installing encryption systems.

Ain't it good to back a winner?

**Missing persons bureau**

Where's the silver lady? Astute readers will remember that back in March we featured her on the front cover with half her head missing. Then we sent her off to the Royal Easter Show to wave the flag, as it were, from the safety and security of the Dick Smith stand — from where she promptly disappeared. If anyone has any information on a lady painted silver, one leg, no arms, half a head, please get in touch. Reward: one week's subscription to ETI.

**Comet Halley**



Spotted: One weekend at Braidwood by the ETI Staff.

**SCOPE TOOLS**

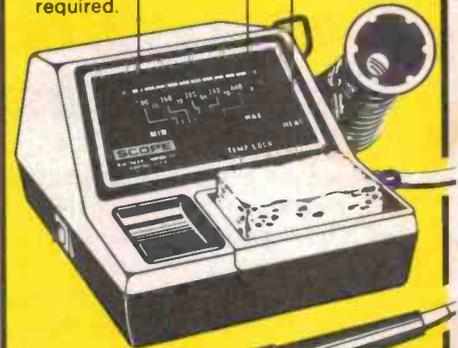
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