eti

Electronics Today INTERNATIONAL

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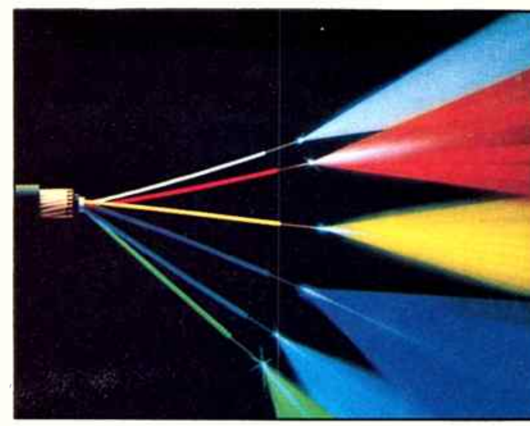

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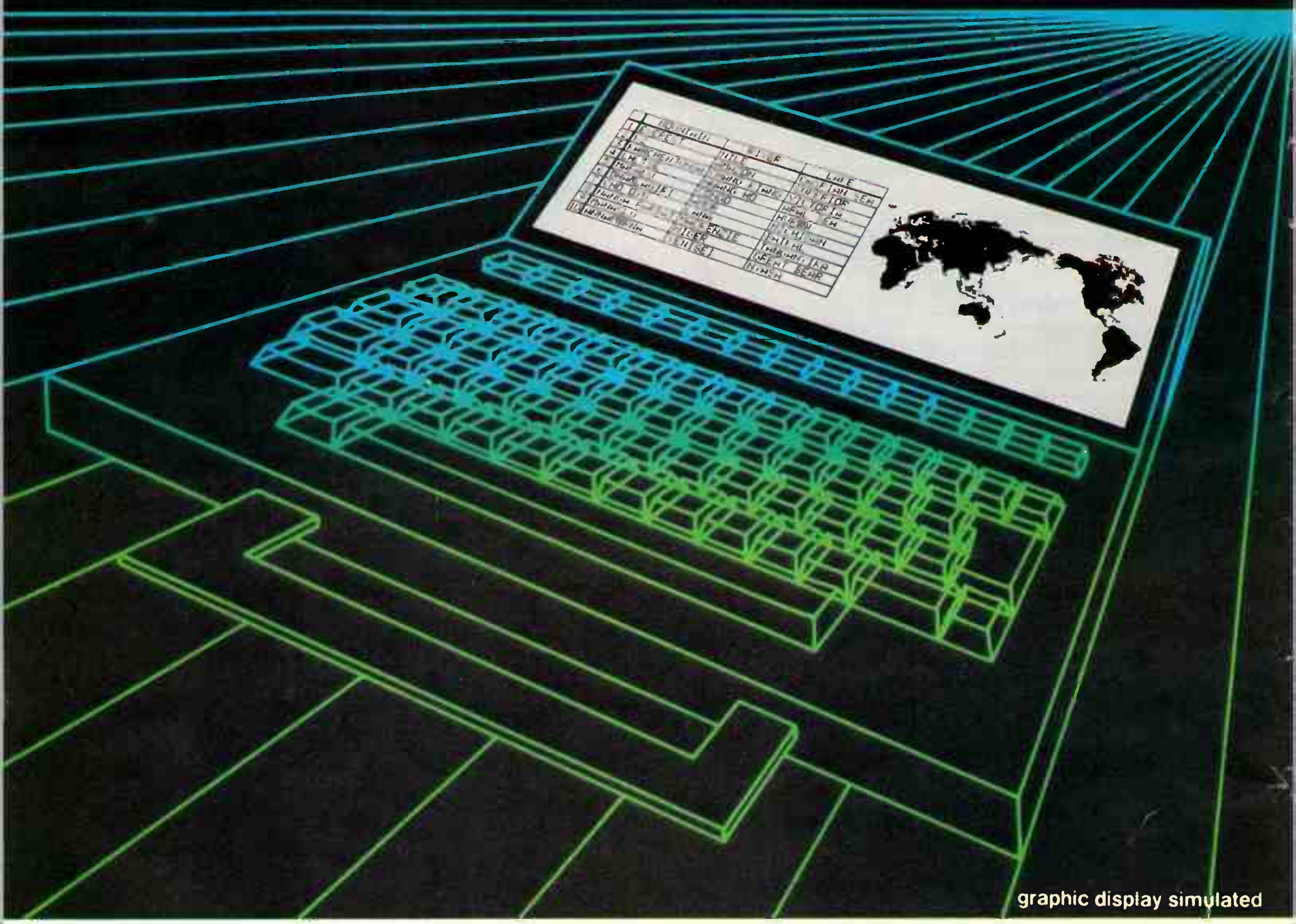

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WELCOME TO THE ETI YEARBOOK; we hope it will be the first of many. We have aimed to include articles on almost every facet of electronics, so in these pages you will find articles on computer aided design, data communications, optical fibres and the latest in engineering techniques. We've included short articles on the latest in hi-fi and video, and in instruments. For those who like our do-it-yourself projects, there's a massive index to all of them.

Because it's somewhat bigger and brighter than usual, we've bumped the price up to $3.50, ($4.50 for the trans-Tasman cousins). The good news is that the price will revert to the old values in February.

The new year

It's become fashionable for commentators to bewail the state of manufacturing industry, particularly the electronics industry, and to make dire predictions about the future. Mr Paul Keating, the Federal Treasurer, won renown with his claim that we were heading for a banana republic. One of the richest and most successful investors in Australia, Mr John Elliot, suggested recently that Australia was the last place on Earth in which to invest.

So it's left to humble commentators like this writer to tell you that 1986 was a great year for the electronics industry in this country, and 1987 promises to be even better. An odd opinion? Perhaps.

In 1986, the dollar was freed from its shackles, oscillated like a yo-yo for a while and then went tumbling through the floor. Cowboys on the land and in the stock exchange, importers and mining czars, all lost heavily. The general media publicized their woes.

Equally prominent in the media, and in this journal, was lament for the lack of research and development in industry. We learned that New Zealand does more than we do; and that our scientists were incapable of translating their considerable competence into hard cash. We also learned that the massive investors of funds, the so-called institutional lenders, were investing heavily off-shore. At the same time, local industry was bemoaning a lack of cash. According to the financiers, Australia lacks investment opportunities. According to the entrepreneurs, local financiers will only invest when the risks have all disappeared.

So, you may ask, what's there to be happy or optimistic about?

The first point to notice, and it may well be the most significant point of all, is that none of this is new. To be sure, we seem to be in the grip of particularly nasty economic times, but our leaders have always belittled our ability, our scientists have never had much honour in their own land (as used to be the case with our artists), and of course, Australians with money have always made it, and invested it, in land or mining.

The great thing about 1986 was that an increasing number of people came to think this might be the wrong way to do things. At long last the nation as a whole is beginning to accept that the world economic order which made us a lucky country is gone. Not temporarily out of alignment, or suspended, but gone.

The falling dollar, portrayed in the media as a national disgrace, was in fact more a measure of national need than national performance. All of a sudden, things became possible that had once been laughable. Big companies started reinvestigating the economics of local manufacturing as opposed to importing; little companies are rapidly shifting their energies into the export market.

In 1986 it became fashionable to look at ways and means of bringing money and ideas together. The venture capital market finally took off, the second boards, notably in Perth, started attracting attention, and the big institutional investors at least had the grace to be embarrassed about their overseas equity.

Meanwhile on campuses, academics have got behind the new ideas about their role to a quite electrifying extent. Almost every university in the country now has a company set up to commercialize inventions by its scientists. Everywhere, academics are working alongside private companies to develop new products.

Finally, the government has accepted that the key to the economic future of Australia is in revitalizing manufacturing, particularly in the booming fields of electronics and genetic engineering. The 1986 budget, which cut virtually every single item of government expenditure, including some sacrosanct items of welfare spending, actually increased the budget for science as well as giving a 150 per cent tax deduction for research and development expenditure. It funded a small but viable space program, and increased the CSIRO's spending.

The climate of public opinion is right for government and business initiatives. The creative and managment skills are demonstrably already in place. The question mark hanging over Australia is, do we have the leadership we need to make fundamental changes to this nation, or will we wait, as we have done in the past, for outside influences to change us first?

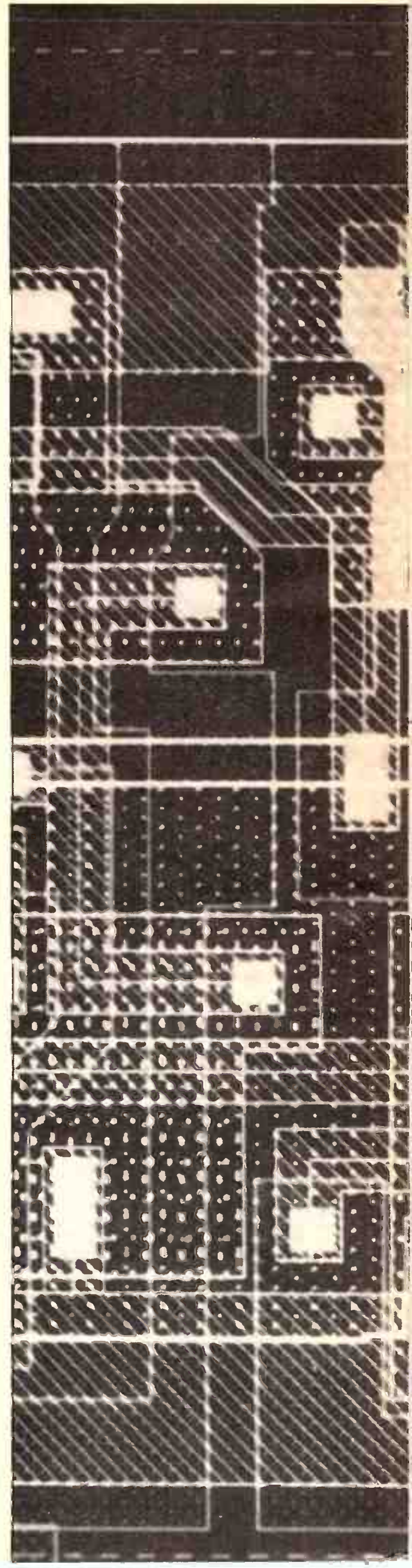
Jon Fairall
Editor

DESIGNING SEMICONDUCTORS

Semicustom cell-based products not only offer the advantages of custom LSI circuits, but also overcome the problems of high costs and long design cycles. It's all come about due to advances in CAD techniques, which have enabled the development of building blocks to make design easier.

Humphrey Leung & David Lloyd

Humphrey Leung is Motorola Product Manager. David Lloyd is Motorola Applications Engineer.



Designing integrated circuits has always been a problem, and it's certainly one of the most important applications of computer aided design (CAD). Now with recent advances in the CAD area, the interface between the design and the designer has become far simpler.

Today the circuit designer is faced with a number of design choices. An IC can be a standard off-the-shelf product, a full custom circuit, or a semicustom array with cell-based logic.

The first approach represents the lowest level of integration, shortest design time and greatest degree of flexibility. Its disadvantages are: difficulty in finding industry standard devices that exactly suit the circuit, higher production costs, and lower performance and reliability.

The second approach provides the designer with exactly the circuit he needs, highest level of performance, and reliability. However, the development time of complex custom circuits is very long, usually because the first and even second pass silicon may not be fully functional. Unless the production volume is very high and the product life cycle is long, then the development cost and cycle time are major disadvantages.

The third approach involves a standard array or cell. It consists of a large number of gate circuits prediffused into a silicon chip. The circuit designer provides the semiconductor manufacturer with interconnecting information that converts these basic gates into functional custom circuits.

Ease-of-use is one of the important reasons for choosing to use gate array, so the design process becomes quite critical to the success of the entire concept. One of the leaders in gate array design techniques has been Motorola.

The key concept in Motorola's technique is the macrocell. Macrocells are groups of cells joined together in a specific way to simulate some logical function.

The CAD approach

The designer uses a CAD system to create a circuit by simply calling upon the predefined library of macrocells and interconnecting them as desired. The designer accesses the library elements in the same way devices are selected from a data book. The selected macrocells appear on the video screen and are manipulated and connected using a CAD mouse tablet, or some other suitable input device. The electrical connections and pinouts are specified via commands resident in the workstation. Initial inconsistencies or incomplete features are flagged. This 'schematic capture' capability allows the engineer to complete the design using video representation rather than by producing a manually drawn schematic.

Initial checks for logic accuracy can then be performed by the designer using logic

simulation programs on the engineering workstation itself. Any problems can be rectified by altering the schematics and testing the logic again until the desired results are obtained.

When checking the circuit it becomes easier to transfer design information to a mainframe with the power to perform more detailed analysis on the circuit. Remote data transfer allows workstations, such as those from Daisy, Mentor and PCAD, to communicate directly with the Motorola CAD mainframe systems consisting of networked IBM 3084s and Amdahi V/8 computers. This transfer allows customers to develop semicustom designs at their sites with their workstations and then use the Motorola CAD system via a 300, 1200 or 2400 baud telephone modem.

Motorola has set up design centres in Sydney and Melbourne, with a regional design centre in Hong Kong. The Hong Kong design centre can also support standard cell design. Any customer can connect into the Motorola CAD system via a 1200 baud telephone modem and a local call to the regional link.

Connected to the mainframe, it is possible to perform more detailed ac simulation to verify proper operation. This can include the effects of internal delays due to the placement of gates and wires. As a result of the more detailed simulation, certain parameters or even circuit design may have to be modified. All these design steps can be completed from the workstation by accessing the mainframe computer via the satellite link.

One very important part of this final simulation is for the customer to supply his test patterns. It is these patterns that will be used by the IC tester to screen for good or bad parts. In some situations it is necessary for the customer to modify his original test patterns during the testing of the devices, or even to modify the device so that it is possible to test some conditions.

The exact configuration of a system like this depends very much on the capabilities of the workstation. At the simplest level this may consist of nothing more than an IBM PC or clone. It is quite practical to consider deriving the initial schematic and even test vectors from something this simple. Information may then be transferred to the mainframe, and the rest of the job accomplished using the IBM as a terminal.

As more money is spent on the workstation its capabilities in a stand-alone mode increase, reducing the amount of time it's necessary to spend communicating with the host. An XT or equivalent will allow schematic capture and logic simulation. Further upmarket, a Mentor or Daisy workstation allows more sophisticated simulation and verification. Both these also communicate via EDIF, the electronic data interchange format, to allow an even greater degree of flexibility in interfacing between workstation and mainframe. ●

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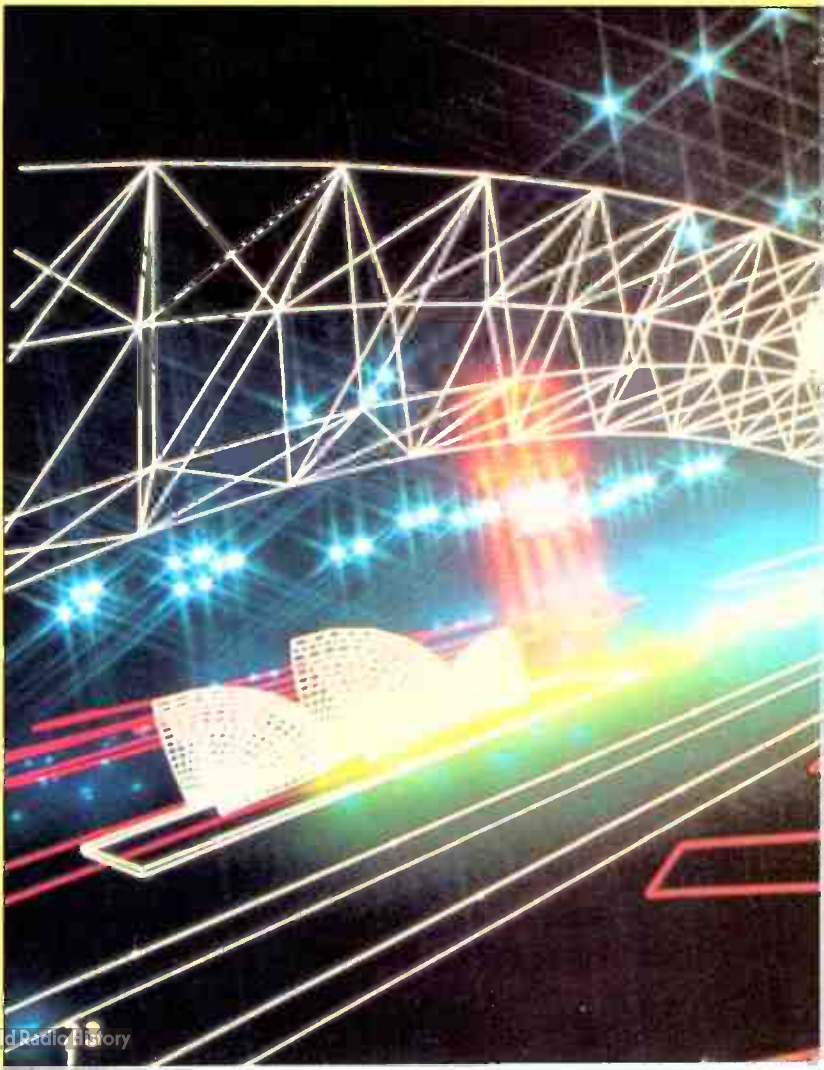
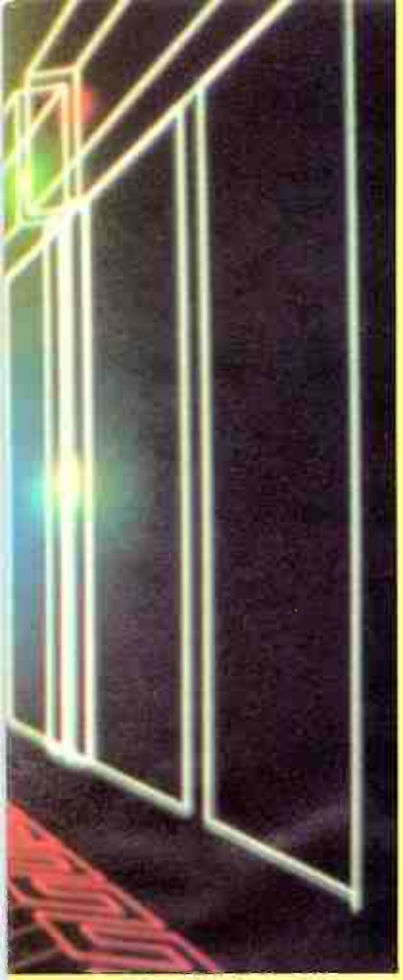
Artist 1 plus

Two frames form XYZAP's New Zealand Insurance ad.

From the Quantel DPB7000 series digital paintbox.



Graphic artists, too, are benefiting from computers. Instead of doing their designs on paper, a process which usually results in waste-paper baskets full of discarded ideas, they are able to draw directly on the screen of a graphic arts system and change it at will until they get the desired result.



A NEW ERA IN COMPUTER GRAPHICS

With rapid advancements in technology, computer graphics is now branching out from the fun field of computer animation into virtually every industry and profession. In Australia applications can be found everywhere from architects' and engineers' offices to mining companies, medical research organizations, mapping authorities and publishing houses. And not only is the use of computer graphics making the work more pleasurable, but it's increasing productivity too.

Robyn Hughes

She opened her eyes slowly, sheltering them from the glare. Above her, in the blue dome, the sun beamed down from its midday peak, so high as to cast no shadows around her. Seagulls were soaring above her head and their calls echoed to her.

All around her was glare, and through the glare she noticed the gently moving shapes of trees, under which three children were lethargically playing with a large red ball, throwing it slowly to each other.

Apart from these figures the place was deserted, and closing her eyes again, she dozed.

Then she felt someone approaching, and looking out from under her eyelids she saw him coming towards her. He was tall, fair and tanned, just the way she'd dreamed he'd be. She could almost feel his warm breath as he came nearer, and nearer . . .

And suddenly there was darkness and the ground under her body was hard and cold. And she heard the voice:

"Your computer-generated Mills and Boon fantasy is completed. Please put 10 dollars in the slot if you wish to select another fantasy from our library of 10,000 disks."

Well, it would be a lot more fun than just sitting, watching TV. And with the current developments in computer graphics technology, such 'real-time' fantasies are not that far away. On a somewhat different level, though not much removed from the realm of fantasy, computer-generated combat simulations are being used in the USA for pilot training.

Combat simulation is achieved by manipulating and distorting graphics on a computer, then rendering them in video for projection on the inside of a 12-metre dome. Surrounded by 360 degrees of graphics, the pilot has the feel of earth and sky zooming past as he pursues his enemy aircraft.

So an island fantasy like our heroine's is quite possible, today. Most of the computer graphics technology in use now was developed from experimentation in military applications, so the 360-degree dome will probably be ready for the mass market any time now. How long before some entrepreneur establishes a chain of 'fantasy parlours' so you can view your dreams? It sounds like a great advancement on going to the movies! Just imagine: no whinging children, no one crunching chips in your ear, no one in front of you with a skyscraper hairdo.

Animation, simulation — a sensation!

Computer animation and simulation is the most publicly visible part of computer graphics, and it's the part which really has the power to excite the imagination. All ▶

NEW HP 9000 GRAPHICS WORKSTATION PROVIDES INTERACTIVE HIGH PERFORMANCE WITH CUSTOM VLSI CHIPS

High-performance solid-rendering graphics at interactive speed are now possible with Hewlett-Packard Company's new HP 9000 Model 320SRX technical workstation.

With Model 320SRX HP believes that solid images now can be rendered 10 to 20 times faster than on other workstations in a similar price range, due to innovative graphics architecture, custom VLSI and capabilities in hardware and microcode.

This new unit provides economical power for computer-aided design (CAD) applications that require high-performance graphics, realistic rendering and interactive design.

To offer these capabilities on a workstation, VLSI expertise was used to build in high-speed performance. The new workstation will be used primarily for mechanical-engineering CAD and 3-D solids.

Other applications that require high-performance graphics, such as molecular modelling, mapping and high-end architectural and engineering construction markets, also can be served by the power of Model 320-SRX for fast generation of realistic graphics images.

For further information contact
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31-41 Joseph Street, Blackburn, Vic 3130.
Telephone (03) 895 2895

HEWLETT PACKARD

ADVERTISING INFO No. 6

those wonderful effects we've seen in *Tron*, *Star Wars*, and *Star Trek*, as well as on TV shows like *Knight Rider* and TV commercials, are showing the public a world of exciting visual effects combined with live action which wasn't conceivable without the technology of computer-generated animation.

And it is a technology which is finally becoming affordable.

In 1984, at the annual Australasian Computer Graphics Association Conference, Ausgraph, we were fortunate to have as guest speaker Dr Alvy Ray Smith of Lucasfilm, who brought with him a 30-second fully computer-animated cartoon called *Andre and Wally B*. This was an amazing little movie which, at the risk of sounding corny, was as good as a Walt Disney original 'in living colour'. However, to produce this film in real-time took the computing power of one four-headed Cray computer, one two-headed Cray (that is, six Cray CPUs!) plus 15 VAX750s. Unfortunately, this puts such a film slightly beyond the budget of anyone wanting to make a TV commercial, or any sort of movie for that matter.

Luckily for everyone, the technology of computer graphics has advanced somewhat in the past two years.

Graphics engines are now available with an enormous amount of power which can perform very computer-intensive tasks, such as real-time graphics, for somewhat less than the cost of six Crays and 15 VAXs.

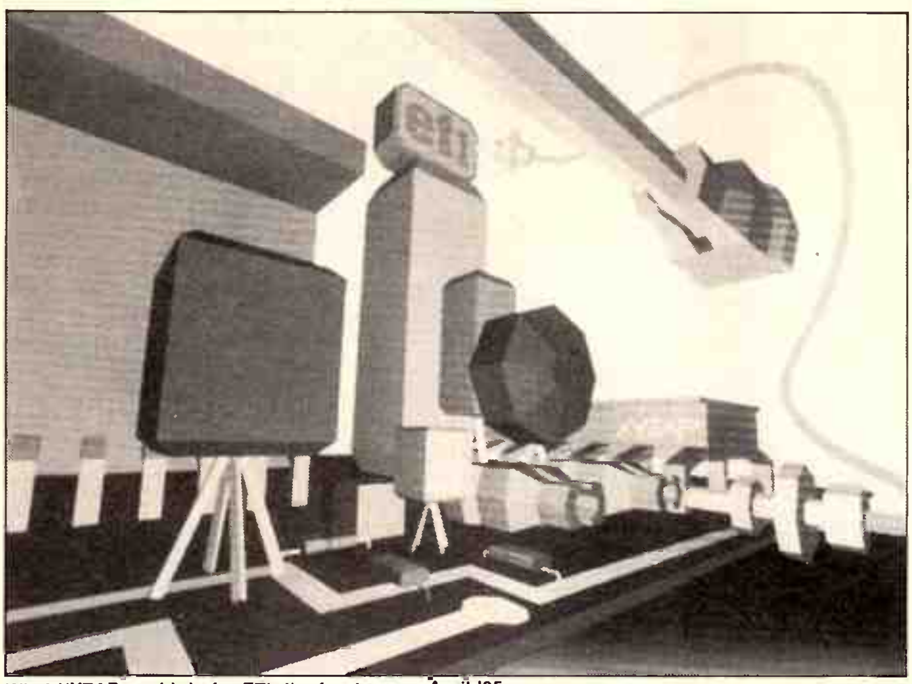
Locally, the company which probably has the lead in computer animation is XYZAP, part of ZAP Productions, a Sydney-based production house. XYZAP was established in 1982, and has written all its own animation software (no mean task) to produce the renowned 2MMM-FM, Sigma and Technics commercials. The company has also won international awards for its 'Network' and 'Wavelength' commercials for Telecom — quite an achievement after starting from scratch only four years ago.

Several other Australian companies are now in the field and producing very exciting work. It's particularly encouraging since the equipment they are using is hardly on the scale of that in the United States production houses.

Outside the field of computer animation (the fun bit), computer graphics is permeating virtually every business and profession today, and can be found everywhere from architects' and engineers' offices to mining companies, medical research organizations, printing and publishing companies.

A colourful gathering

In conjunction with Ausgraph 86 (Sydney Town Hall, 7-11 July), a film and video evening was held to show the state-of-the-art in computer animation from Australian companies, as well as from such well-known United States animation houses as Cranston/Csuri and Pacific Data Images. It was even more mind-boggling than the previous showing, because the technology has advanced so rapidly.



What XYZAP could do for ETI: the front cover, April '85.

Ausgraph itself was divided into industry 'streams' and covered architecture, medical and biological sciences, civil and structural engineering, design and manufacturing, exploration and mining, graphics for management, mapping and cartography, printing and publishing, technical and scientific, and presentation and video. The exhibition featured equipment applicable to all these and more — which gives you an idea of the diverse uses of computer graphics.

The industries listed above all expect sizable increases in productivity through the use of computer graphics. Productivity increases in the range of 200 per cent to 400 per cent have been demonstrated, particularly in CAD (computer aided design) applications, once the users are proficient with the equipment. As an example, a recent story in *Computerworld Australia* quoted sources at the Sydney County Council who claimed productivity increases of 400 per cent from an IBM Cadam CAD system installed in 1984. This gain was achieved on very repetitive tasks, such as drawing circuit diagrams, and it is in this area of repetitive work that computer graphics really comes into its own.

The winds of change — it's drafting in here

Computer aided design and drafting is used by architects, engineers and designers in designing their products on the computer screen, rather than a drawing board. CAD can be used to produce the working drawings necessary to build the office block, bridge, road, circuit or whatever. Production of the working designs by computer produces the biggest time and money savings, both in churning out the original drawings and in making changes. As all design information is kept in a database, changes are simple and flow through to all drawings and specifications produced by the system. Another plus for the designer is that the CAD system can also produce such time-consuming lists of information as materials required for use in construction work.

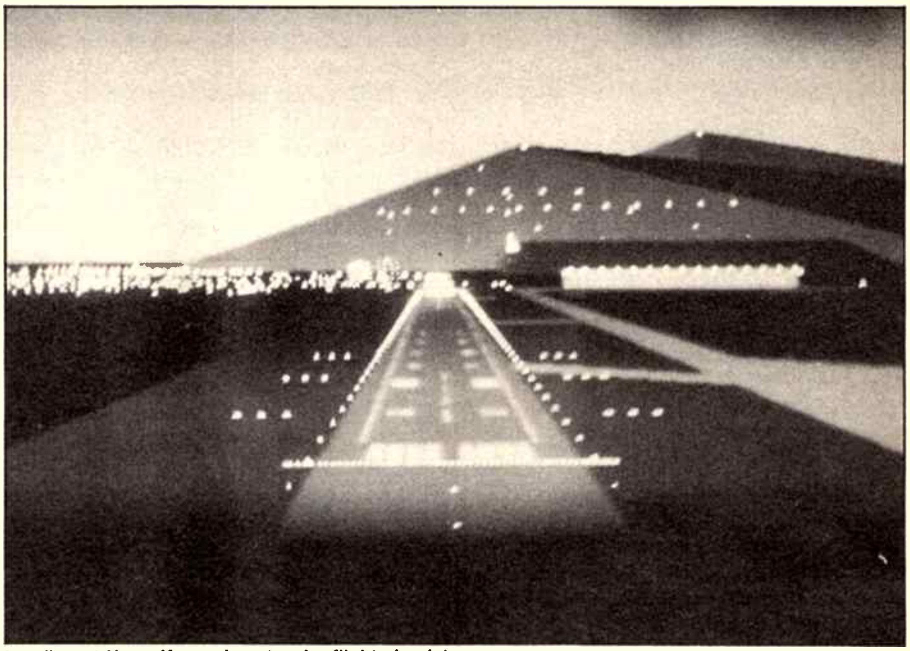
And if you have ever worked in a drawing office, as I did in my youth, and had to produce cross-hatching for a full-sized perspective drawing using a T-square, set-square and Rapidograph pen, I can tell you the joy of watching a fast plotter turn out the same thing is almost overwhelming.

The same benefits also apply to the use of computer graphics in the manufacturing environment. Design engineers enjoy the added advantage of producing work-flow diagrams and a diverse range of other information necessary for efficient production. And to take this process one step ▶

further, CAM, (computer aided manufacturing) techniques can be added to the CAD system (if they are not already inherent), which will run the machine tools on the factory floor.

Computer graphics is also being used in medicine to eliminate the need for surgery as a diagnostic aid, which in itself should prove life-saving in many cases. Doctors are able to use information from computerized body scans and process it on an imaging system to get an accurate picture of internal conditions. This is an incredible breakthrough in medical diagnostic techniques and is possibly one of the most important scientific uses of computer graphics to date.

Another exciting use of computer graphics, particularly in Australia, is in the mining and exploration industries. Computer graphics are being used by mining companies to locate mineral deposits from photographs taken by satellites, and for many others uses — from analyzing bore hole information to designing the mines and mining equipment.



Landing at Hong Kong airport — by flight simulator.

Putting Australia on the map

And in cartography, Australia is one of the world leaders in research. In particular, the Australian Army is involved in a long-term project to map an enormous area of Australia, again using satellite photographs and a technique called photogrammetry. The Army has refined the technique by developing a voice-recognition unit for the system, which enables the operator to work without having to take his or her eyes off the maps. The Army is also using scanning techniques to get the many existing maps onto the computer system.

Another application of mapping which is gaining prominence in Australia is that of the Land Information System. Most Australian States are now working on the development of a system, which combines existing maps from public utilities such as electricity and gas authorities, telecommunications authorities, local councils, road authorities, and so on, to provide a complete database of all information relating to areas of land. This is a mammoth task which would be inconceivable without computers and computer graphics.

Use graphics or be damned

The use of computer graphics enables publishing houses to lay out a whole page complete with graphics, text and advertisements on a terminal screen, and to turn this layout directly into a ready-to-print format. This has enabled the industry to come a long way from the days when all the text was set in galleys, proof-read, sent back for corrections read again, then cut up and pasted down by a layout artist; the separately processed photographs were put in some time later. Many publishing houses in Australia have adopted these techniques and they are beginning to be used by some large companies in their in-house printing facilities, particularly for technical documentation.

Graphic artists too, are benefiting from computers. Instead of doing their design on paper, a process which usually results in waste-paper baskets full of discarded ideas, they are able to draw directly on the screen of a graphic arts system and change it at will until they get the desired result. Most manual effects, such as air brushing, colour filling and so on, can be handled by these systems and most artists who have tried them are delighted by the results. In many cases, these machines can actually enhance the artists' creativity by enabling them to try out more ideas in less time than would be possible with manual methods.

> **66** *Computer graphics is also being used in medicine to eliminate the need for surgery as a diagnostic aid, which in itself should prove life-saving in many cases. Doctors are able to use information from computerized body scans and process it on an imaging system to get an accurate picture of internal conditions.* **99**

Another area of computer graphics which has an exciting future is that of holograms. Combining holographics and computer animation could lead to all sorts of possibilities.

Hollo, graphics!

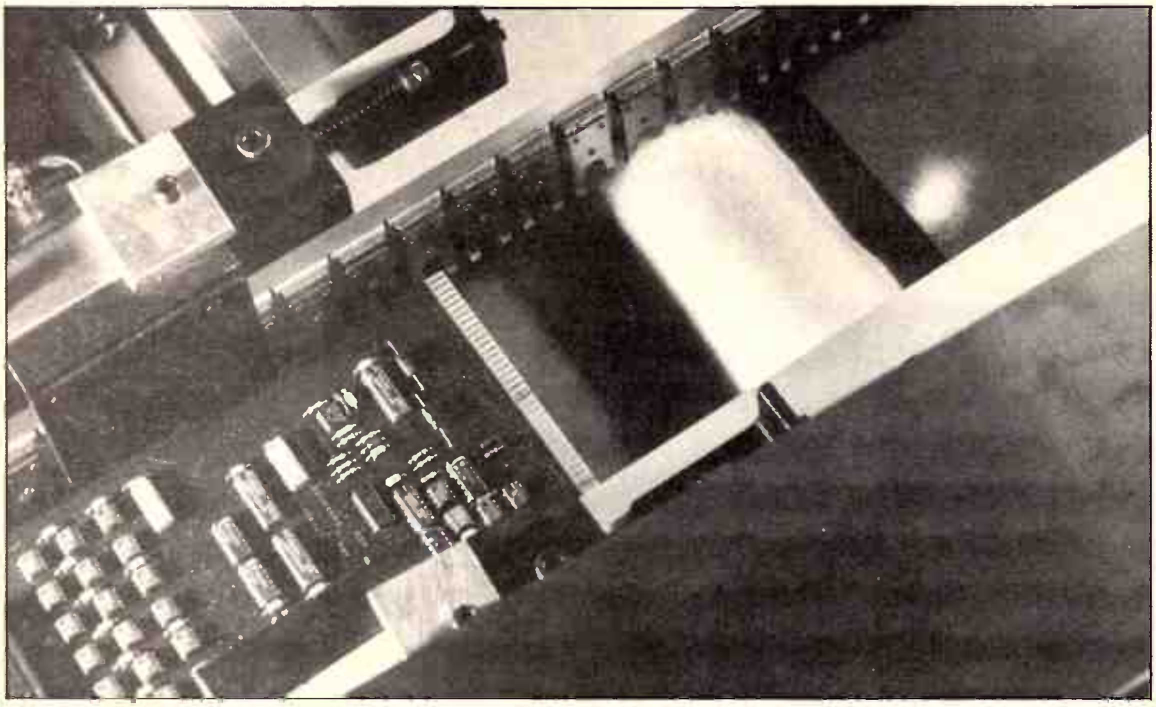
Picture a kid's toy farm where the animals all move around the farm buildings, neighing, bleating, clucking and quacking. What about a fashion parade where there are no live models, just holograms whose clothes change before your eyes. What about an enormous hologram of a forest in the middle of a city so we can remember what lots of trees look like. We could even produce a massive hologram of World War III for President Reagan so he could have a lot of fun and get it out of his system.

All of which leads to another important thing about computer graphics. Apart from fulfilling all those useful functions like increasing productivity and saving lives, they are also a lot of fun, whatever field you're in. Even producing your own pie-chart allows you some creative input and you'll probably find the whole thing is very habit forming.

So if you have a microcomputer, go and buy yourself a cheap little graphics package and get started. ●

MANUFACTURING TECHNIQUES

An amalgam of new technologies is changing the methods and economics of electronic manufacturing. Dragged forward by the demands of economics, pushed by the demands of technology, the factories of the twenty-first century are already here.



A bath in wave solder.

Many of the wonderful products of modern electronics — a CD player or miniature radio, integrated circuit or optical fibre — depend as much on specialized manufacturing techniques as on any purely theoretical advances in science. Very often, the advent of a new method of manufacturing makes products possible that previously were either impossible or uneconomic.

Here in Australia, new manufacturing techniques hold out the promise of a new international competitiveness. At the core of these new technologies is the economic concept of productivity; making one worker produce more. By and large this translates into automation; making it possible for one person to produce 10 gizmos, instead of having 10 people make one. Probably the most visible manifestation of this, certainly the one causing the most concern in the general community, is the robot.

However, robots come in many shapes and sizes. Few are the moving arm type, still fewer are humanoid. Most are just boxes that sit and hum. But inside the boxes, all kinds of clever things happen.

New techniques

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. The output from CAD machines is used to control 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 0.5 mm, 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

Meanwhile, increasing board packing density (the number of components per square centimetre) is prompting designers to demand narrower tracks.

which acts as a resist. According to Michael Brinsden, managing director of Printronics, a Sydney based board shop, these techniques allow track widths of 0.18 mm. 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 DuPont company, which makes many of the photographic polymers used in imaging circuit boards, the practical limit of photographic techniques is about 0.1 mm. 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 0.25 mm hole in the copper, for instance, is insignificant at millimetre technology but will cut narrow tracks. Cleanliness 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.

The limit to line resolution is caused by the physics of the situation. For instance, in the imaging process, it is necessary to shine ▶

MORRIS IS KEEPING COMPANY WITH SOME VERY HIGH FLYERS.

Morris Productions have been producing high quality circuit boards for over 20 years and setting new standards in this demanding, high technology industry. Australia's leading professional, commercial and defence manufacturers have specified Morris Printed Circuit Boards for quality and performance. This reflects the ability to accommodate complex and varied designs from single sided, double sided and multi-layered configurations.

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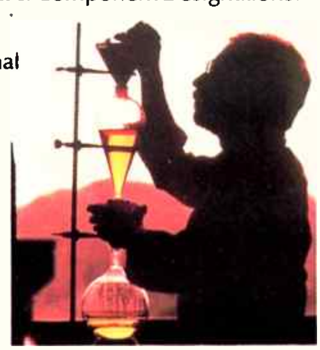
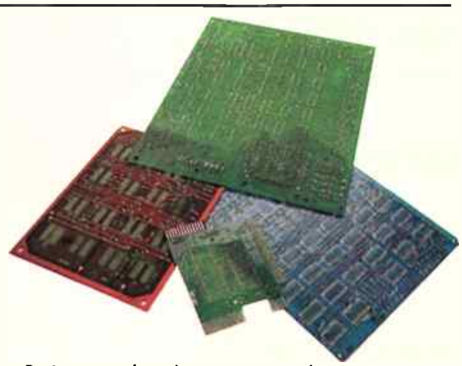
Morris has earned an international reputation for producing highly complex multi-layered circuit boards, up to an incredible 18 layers.





Stringent development work and impeccable quality control, governed by Morris's own fully approved National Association Testing Authority laboratory, has made Morris a most highly respected supplier of multi-layer PCB's. This level of quality is evident, with the contract to supply U.S. Military Standard circuit boards for the Radar Systems fitted to the RAAF's new F/A 18 Hornet.

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ADVERTISING INFO No. 10

A pick 'n place machine in action.

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. DuPont's technical marketing specialist, Don 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 happening at a greater rate than in the board part of the industry. Here stuffing automation is 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.

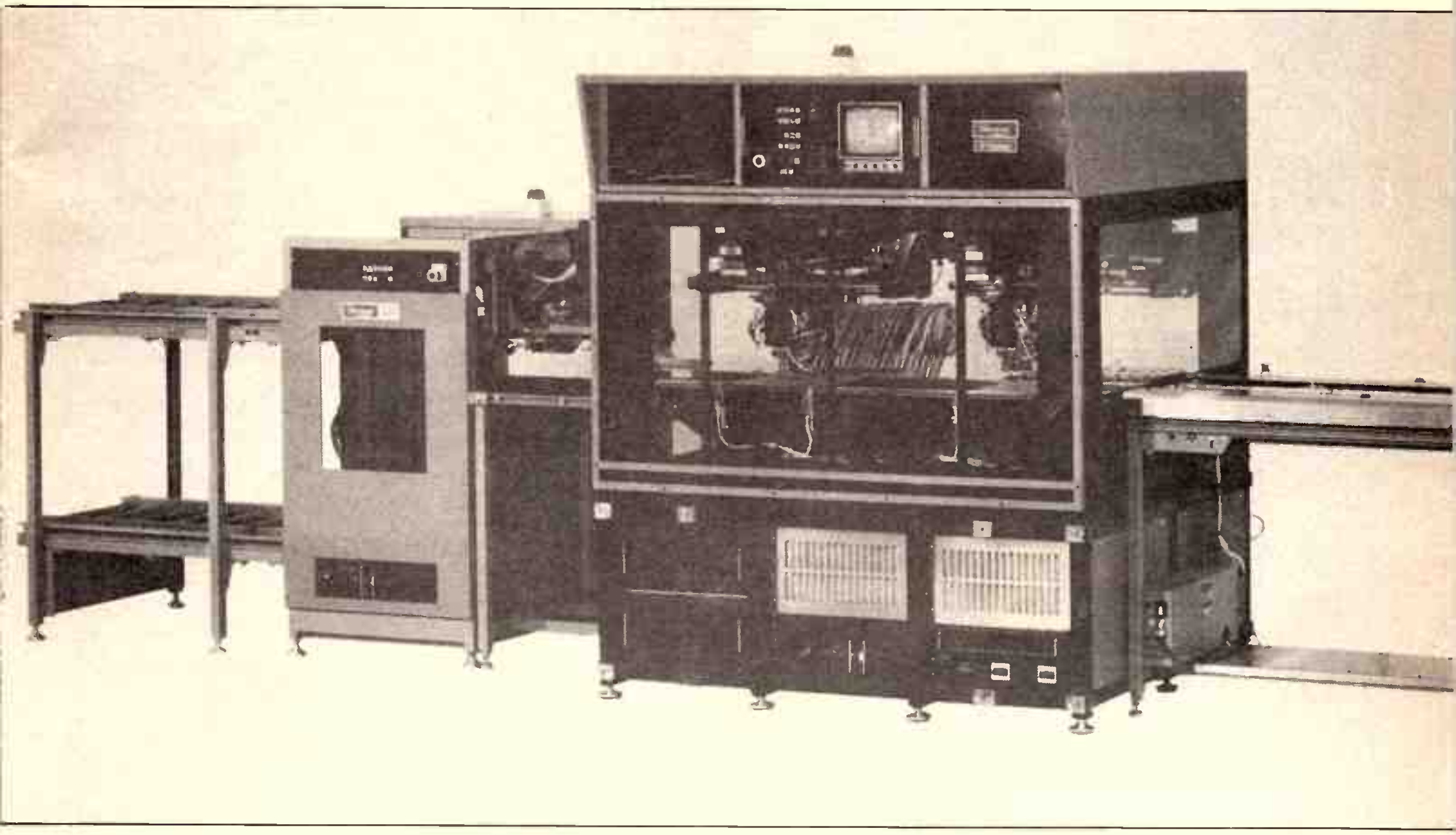
There are large numbers of these machines already in service in Australia. Indeed, most board shops seem to have made some concession to this level of technology. However, even before it is fully in place, it is being overtaken by surface mounting.

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.

These supply problems are rapidly disappearing however, Philips and Siemens, in particular, now have a wide range of product available in both discrete components and monolithics. Most of the IC makers can now supply their products in SOIC (small outline integrated circuit) packages.

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 dragging 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 Eian 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 is 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, computerization 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 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 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 manufac-

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turing 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, 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 are required and to make any sort of measurement. At the moment Richardson is working 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, computerized 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 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 were 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.●

THE AIR KNIFE EXPERIMENT

Soldering is a tricky business at the best of times, leading to all kinds of frustrations. In a mass production situation, soldering errors can cause major economic problems as well. One of the main weapons in the fight against the bad joint is the airknife.

Leo Lambert

Leo Lambert is with Digital Equipment Corporation.

Few radical changes have been made in wave soldering techniques since the process was first used some 30 years ago. It was a major advance, enabling the use of the assembly line in board stuffing for the first time.

In this technique, molten solder is placed in a bath. The wave is then created by pumping the molten solder over a ridge in the bottom of the bath. The board, loaded with components, is pulled over the wave in such a way that the solder adheres to the copper tracks of the board and to the legs of the components.

Among changes that have been significant are the inclined conveyor, the introduction of oil into the wave, and the reshaping of the wave. As a consequence of these changes, solder drainage has been improved and bridging between component leads and etched lines has been drastically reduced.

Always, the objective of such changes has been to improve solder joint reliability.

Over the years, researchers have identified the characteristics of the wave that makes for better joints. For instance, the angle at which the wave falls, ie, the trailing edge, turns out to be quite critical for the number of fillets and bridges left behind on the board. Sophistications of the basic idea have included rough waves, in which the surface of the wave is very turbulent, and double waves, in which the board is passed over two waves in rapid succession.

In recent years, however, wave soldering techniques have not kept pace with the soldering demands of the newer printed wiring modules. Increasing pin densities have magnified bridging problems. A realistic estimate, industry-wide, of solder shorts on the newer boards is 1 to 20 shorts per 1000 with standard component leads and 10 to 50 shorts per 1000 joints for micro-sockets.

In addition to the problems brought about by increasing board densities, the wave soldering machines are also under attack from other directions. New soldering techniques are proving at least as satisfactory as the old methods and, allied with new solder formulations, are very useful on dense boards.

Against this background, the US-based Hollis company announced the development of an 'air knife' machine in 1977. It has taken a while to get it right, but now the old soldering machines are coming back into contention.

So, what is the significance of the air knife, and how does it work? It needs to be understood that the problem for wave soldering is in the residue left after the soldering process has been completed. Fillets of solder might be longer than necessary, forming bridges between adjacent tracks. Alternatively, the result from a soldering machine might be a badly formed fillet, without strength.

> *“. . . the air knife-equipped machine reduced defects/1000 joints by 72 per cent.”*

So the question becomes, how can the solder be treated to ensure these problems don't happen?

It had been considered a grave mistake to disturb a solder joint during solidification. Several papers had warned against outside forces, for these were expected to remove the strength member of the joint — the fillet — before it was hard enough to resist the pressure. However, liquid solder has no memory. Therefore, if an external force could be designed to act upon the still-molten solder prior to solidification, solder defects such as bridges could be forcibly removed. In 1977, an air knife system was developed to handle this task.

Later work indicated that solder exhibits great tenacity in adhering to a properly wetted interface. In practice it was found that solder could easily be removed from non-wetted interfaces. Therefore, sound joints would be improved by shaping their fillets but non-wetted joints would be exposed immediately.

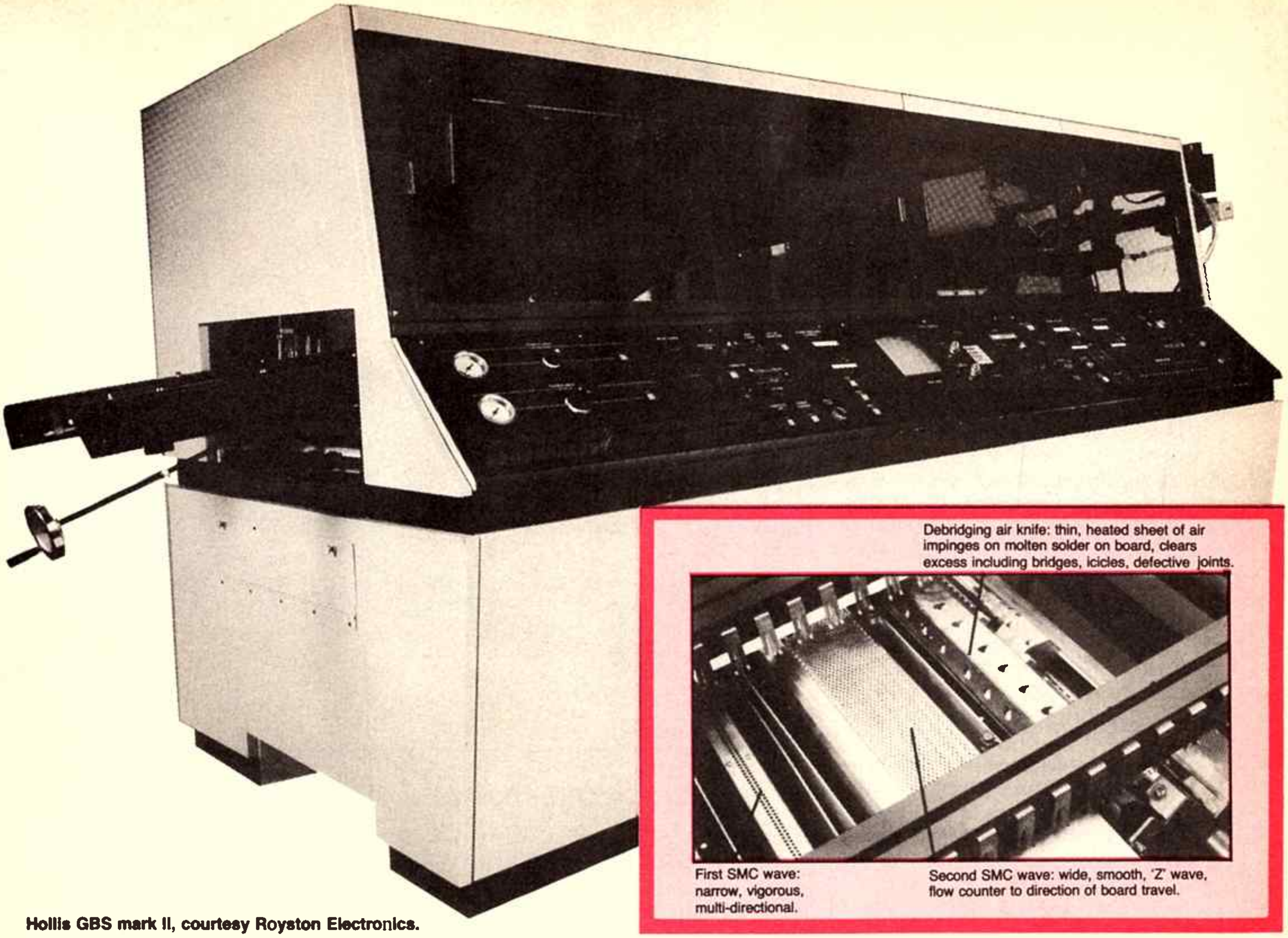
As a soldered module exited the solder wave, a fine jet stream of high-velocity hot air swept the bottom of the module. According to Comerford and O'Rourke, co-developers of the air knife, "The energy in the gas jet is intended to disrupt any bridges that have formed between supporting end points, such as leads or conductors, and to remove icicles as well".

The air knife is adjustable in angular relationship to the printed circuit panel. Other parameters such as distance from the solder pot and from the board, air pressure, air temperature, and synchronization with panel passage are adjustable, aided by a microprocessor control.

The experiment

In 1982 an experiment was conducted at Digital Equipment Corporation (DEC) to determine the value, if any, of adding an air knife immediately after the solder wave used in module assembly. The experiment was prompted by the need to reduce the expense due to soldering defects and by the commercial availability of air knife-equipped wave soldering systems.

Digital Equipment Corporation selected one of its assembly plants which was then experiencing an average of 3.5 solder shorts



Hollis GBS mark II, courtesy Royston Electronics.

per 1000 joints at the test facility. The boards manufactured there had no solder mask and component leads were left long and straight. Large ground plane areas with no solder drain capability, plus the absence of protective solder masking, created another defect: icicles. Taken altogether, the number of defects averaged 4.9/1000 joints.

As a company, Digital wave solders over five billion connections annually. Thus, at the outset of the experiment it was apparent that a significant reduction in defects could save millions of dollars in re-work costs.

A regulator and a digital circuit module were selected for the experiment.

The experiment compared the soldering results between the standard Digital Equipment soldering system and the air knife-equipped soldering system.

Process settings for both the DEC soldering system and the Hollis GBS soldering system with air knife were the same with respect to flux type, flux density, preheat temperature, conveyor speed and angle of incline, solder and solder pot temperature, and oil-intermix quantity.

The air knife was mounted ¼ inch to ⅜ inch from the lower side of the module as it passed on the conveyor from the solder pot. The air knife orifice was angled upward 45 degrees from the horizontal.

The results

In the experiment, a total of 1050 modules were wave soldered on the Digital Equipment wave soldering system. During the test, 543,785 joints were soldered. Of these, 2642 were defective, for a defect/1000 joints average of 4.9. The average number of defects per module was 2.5.

Throughout the test, 1040 modules containing 605,260 joints were wave soldered and passed over the air knife on the GBS machine. Of these, 1072 were defective, for an average of 1.8 defects/1000 joints. The average number of defects per module was 1.0. Thus, the air knife-equipped machine reduced defects/1000 joints by 72 per cent.

Air knife performance was directly dependent upon the proximity of the knife to the module immediately as it left the solder pot. The closer the air knife can be brought to the module while solder is still molten, the fewer defects will remain. Because the regulator module had many hand-inserted parts of different lead lengths, more clearance was required than for the digital module. Therefore, the knife was set at ⅜ inch from the passing regulator modules. So that the air knife may be set closer, it is recommended that leads be trimmed or formed to a clearance length.

Icicles and excess solder were significantly reduced by the air knife. However, some problems were still apparent around pads which receive mechanical hardware during final assembly. Although not considered defects, some solder buildup was observed on ground planes etched 90 degrees to the direction of wave flow. In the same sense, a solder buildup also occurred behind thick leads on ground planes and large etch areas. Both conditions would be eliminated if the air knife were brought closer to the passing modules.

Solder shorts were significantly reduced by the air knife. Remaining shorts tended to appear in the same location on the boards. The reasons that some shorts still exist are:

- irregular etch layout,
- long leads bent close to the board surface, and
- that air knife distance from module lower surface was set at ⅜ inch instead of closer due to requirement for lead clearance.

Also, it was found that the air knife was not as effective on lead-to-lead shorts perpendicular to the air knife flow pattern. This discovery highlighted design problems in the board layout process.

For digital modules, the air knife was set closer to the module; ¼ inch instead of the ⅜ inch used when processing the regulator module. This change was sufficient to ▶

eliminate solder shorts except in design-related cases.

During set-up, solder was blown through the plated through-hole by the air knife which was set at 52 degrees. This problem was corrected by lowering air pressure from 60 psi to 45 psi. This event demonstrated that air pressure is important and should be correctly specified for each particular module type. However, there was no observed peeling or displacement of the solder mask as a result of the air knife.

After the experiment it was concluded that the hot air knife would improve wave soldering quality, removing shorts and excess solder when these cannot be removed by adjustments to the DEC wave soldering system. Furthermore, it appears that the hot air knife did not induce any defects into the wave soldering process. It was observed, however, that the airknife must be properly adjusted to prevent blowing solder through to the topside of the module. Also, a degree of technical ability is required to optimize air knife operation.

Both power supply regulator digital modules showed great improvement in wave soldering quality as a result of the air knife. Correcting one design-related short on the

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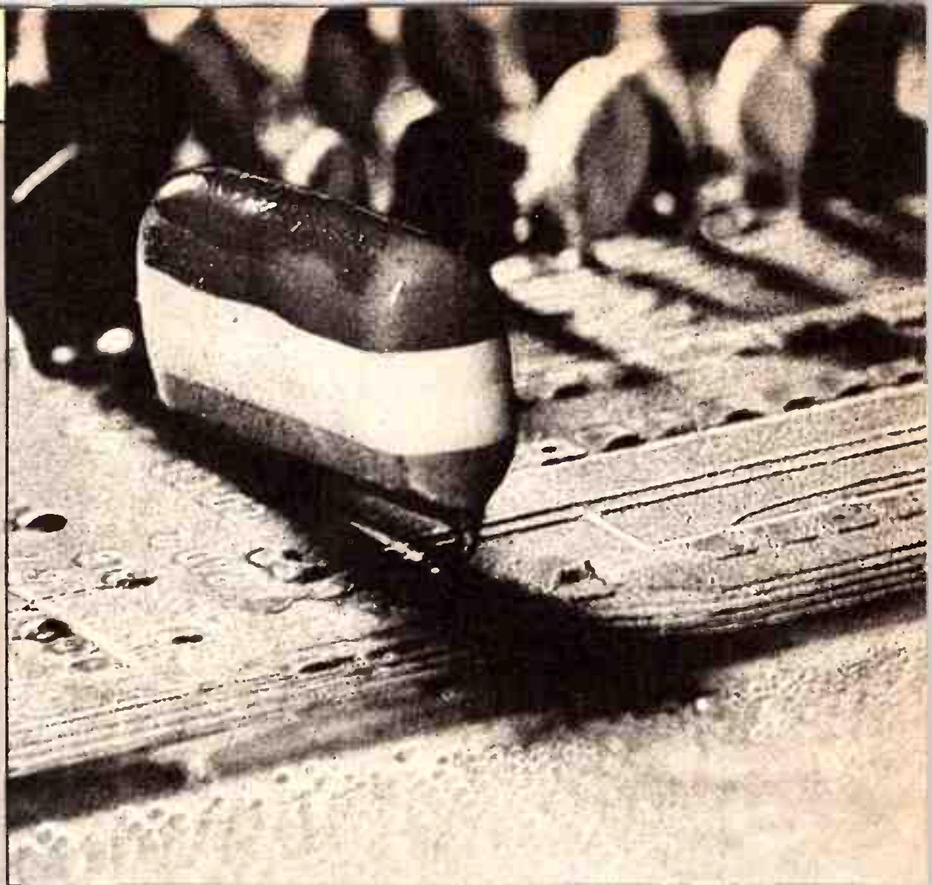
digital modules should reduce post-air knife defects to 3.9/100k joints for shorts and icicles.

A 'no solder' condition was repeatedly detected, module after module, on the same component lead. The lead frequently appeared contaminated. Lab tests later confirmed this condition and corrections were made.

Other problems detected by the air knife operation were included; some related to poor etch layout design. For example, two leads which are clinched towards each other to form a line parallel with the direction of air flow sometimes bridge together, and the bridge is not always eliminated by the stream of air. ●



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AN INTRODUCTION TO FIBRE OPTICS

The idea of optical communications was established more than a century ago, but recently advances in fibre optics technology have skyrocketed. It's become the bright new hope in the development of communications systems for the future.

Bruno Baras

Bruno Baras is marketing manager with Integral Fibre Systems Pty Ltd, Chatswood, NSW.

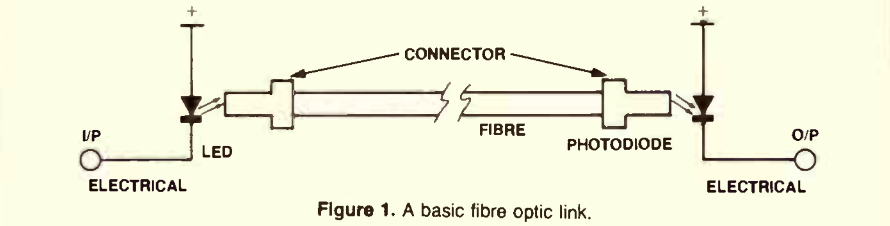


Figure 1. A basic fibre optic link.

In a communications sense, fibre optics is the transmission of information by means of optical energy confined and guided by optical waveguides.

The basic schematic of a fibre optic link is shown in Figure 1. In essence, an electrical input signal modulates an optical source, and the resulting light energy is coupled into the fibre and confined there. At the far end of the fibre the light is directed onto a photodiode that converts the optical energy back to an electrical signal.

Fibre optics can be a viable alternative to copper and electrical signalling for a number of very good reasons. It has very large bandwidth capability (much wider than most coaxial cable) as well as low losses, which means longer cable lengths can be used before repeaters are required. Other advantages include excellent electrical noise immunity, security against crosstalk and tapping, significantly lighter cables (reducing installation costs), and cost advantages over coax systems.

However, despite all the advantages that fibre optics can offer, it does not represent a total replacement for coax type systems. Each application is different and needs to be examined in the light of its own economic and performance requirements.

Historical background

The year is 1880, Graham Bell patents his photophone. It is an embryonic system: sunlight focused onto a diaphragm is modulated by speech, the resulting beam is collected at the receiver, a selenium cell produces a change in resistance, and an earpiece converts electrical current back into sound waves (see Figure 2).

All very well, but it did have its problems and didn't quite catch on. The transmitter and receiver required accurate alignment; the sun was not always shining, particularly at night; and obstacles to the light path presented severe problems. However, the idea of optical communications was established even though the technology of the day did not allow its full exploitation.

Prior to that date, the phenomenon of total internal reflection had been placed on a firm analytical footing with the advent of Snell's Law. Snell quantified the way in which light bends when it crosses a boundary between different materials, such as air and water, or air and glass. He discovered that at a certain angle light travelling in a medium will experience 'total internal reflection' if it hits the medium boundary below a critical angle (see Figure 3).

Extrapolating the concept of total internal reflection leads to the concept of the light pipe. A light ray, once correctly launched into the pipe, will make repeated total internal reflections from the walls of the pipe until it strikes some obstruction or emerges at the far end. Early experimenters demonstrated light pipes using both solids and liquids. However, losses were generally too large to allow for practical application of the concept.

Eventually, theorists realized that silica glass could yield very low attenuation fig-

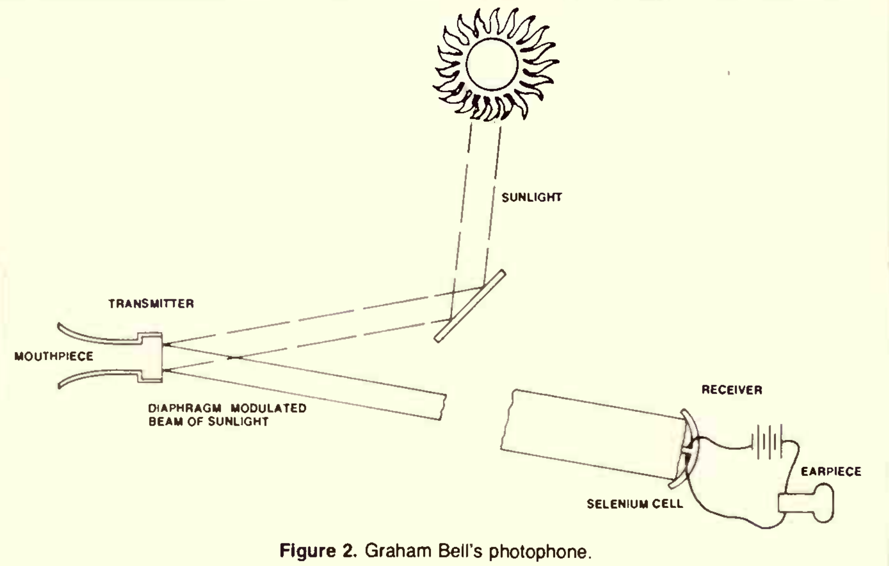


Figure 2. Graham Bell's photophone.

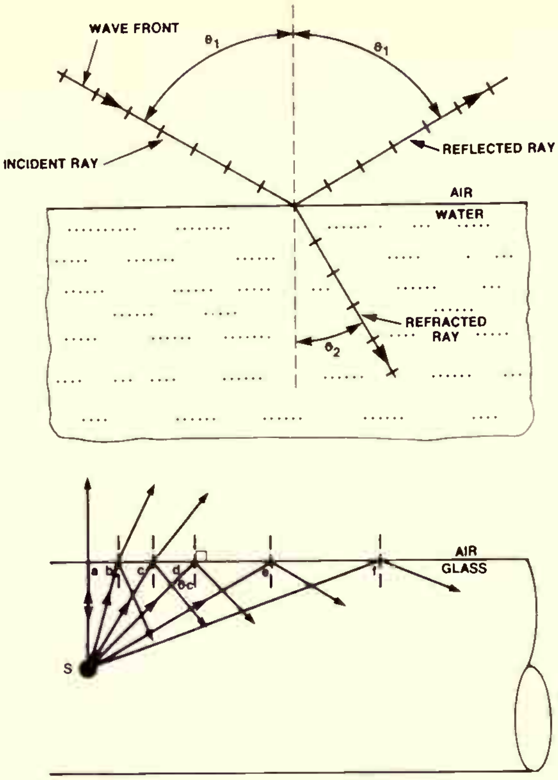
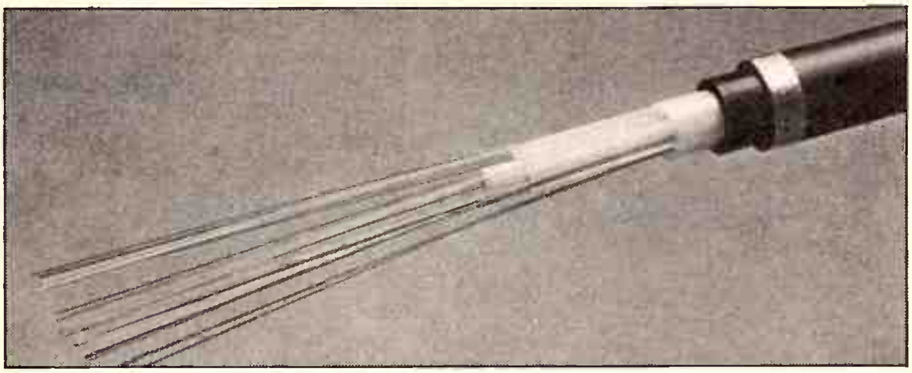


Figure 3. Total internal reflection.



A sample of Olex optical fibre cable.

ures if it was sufficiently pure. In the 1960s technology advanced to the point of being able to make such a glass. Other materials have been tried before and since but, at least for the next several years, glass appears to offer the best overall characteristics (see Figure 4).

At around the same time that the glass was being developed, considerable work was being done in the field of semiconductor light sources and detectors. During the 1970s, fibre losses had been reduced to the point where communication systems became viable using fibre optics. Telecommunications, defence, and industrial applications were all investigated.

Today, fibre optics represents a very fast growth area in communications systems. Significant mileage of fibre has been installed and much more is planned. As well, the technology is now safe; ie, all the characteristics of the system have been fully investigated and are thoroughly understood. Commercial availability of components and even full systems are commonplace. Although fibre optic technology may be new, it is by no means experimental.

What does one need to get a fibre optic system going?

The essential ingredients are a transmitter, a medium and a receiver. The transmitters are usually light emitting diodes (LEDs) or solid state lasers, the medium for communications is glass fibre and the receiver is a solid state semiconductor photodiode.

Optical fibres

Optical fibre is made from an inorganic glass with a high silica content. The outside diameter of a typical communications grade fibre is 125 μm, ie, 0.125 mm or about the thickness of a human hair. The light is confined to the central core region, which has a higher refractive index than the outer cladding, thus making possible total internal reflection. The core is typically 50 μm in diameter, or 0.05 mm. Another common fibre size is 140 μm outer diameter with a core diameter of 100 μm.

Despite these apparently tiny dimensions, the optical fibre is very strong in tension and its high elasticity allows it to be readily bent. Some care must be exercized when handling bare fibre as needle-sharp pieces can break off and become embedded in the skin. They may be very difficult to remove.

The fibre is fabricated using a chemical deposition technique to achieve the required purity and composition differences. A silica glass tube, known as the preform, has various mixtures of gases passed through it. Localized heating causes high purity glass to form on the inside surfaces. The preform is then put into a drawing machine where the tube is collapsed and fibre is drawn from the end. The fibre is ▶

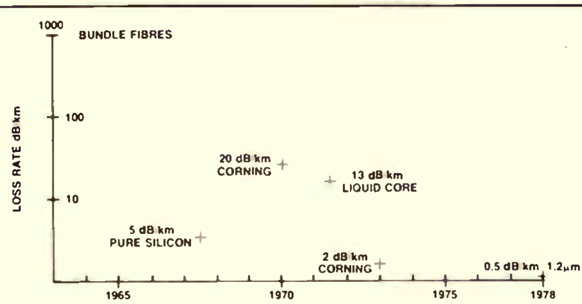


Figure 4. Milestones in fibre development.

immediately coated in a resin compound to preserve the surface properties of the glass. It then passes through a series of proof tests that show up any mechanical deficiencies in the material. A nylon sheath is often added to provide further mechanical protection. The sheath also provides a means of identifying particular fibres in a cable by way of their different colours.

Raw fibre is seldom used 'as is'. Despite its strength, it still needs to be protected against every day wear and tear. Depending upon the application that a particular fibre is intended for, it may be provided with a simple PVC outer covering or it could be incorporated into a fully armoured telecommunications grade cable.

Cable lengths vary depending upon the process used, but eventually it will become necessary to join two fibres together. This is usually done by welding the fibres under a microscope, taking particular care with cleanliness and fibre alignment. Some different cable types are shown in Figure 5.

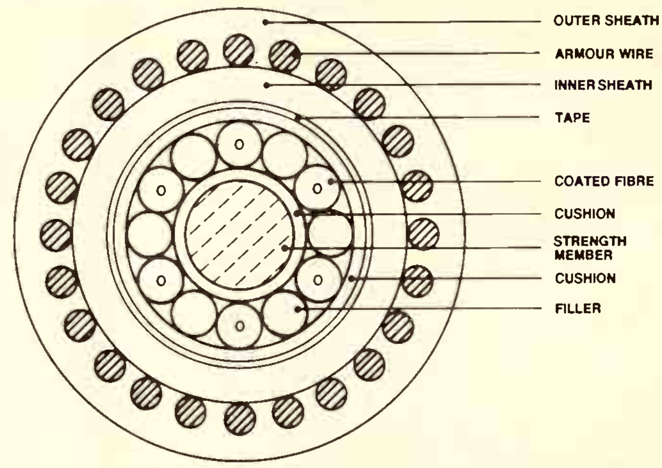


Figure 5. Generalized structure of a concentric optical cable.

Before proceeding, it is worth mentioning that although almost all high quality optical fibre is made from silica glass, some variations do exist. These are the all plastic and the plastic clad silica fibres. Generally confined to the low data rate, short run applications, they still provide adequate performance at an acceptable price.

Fibre characteristics

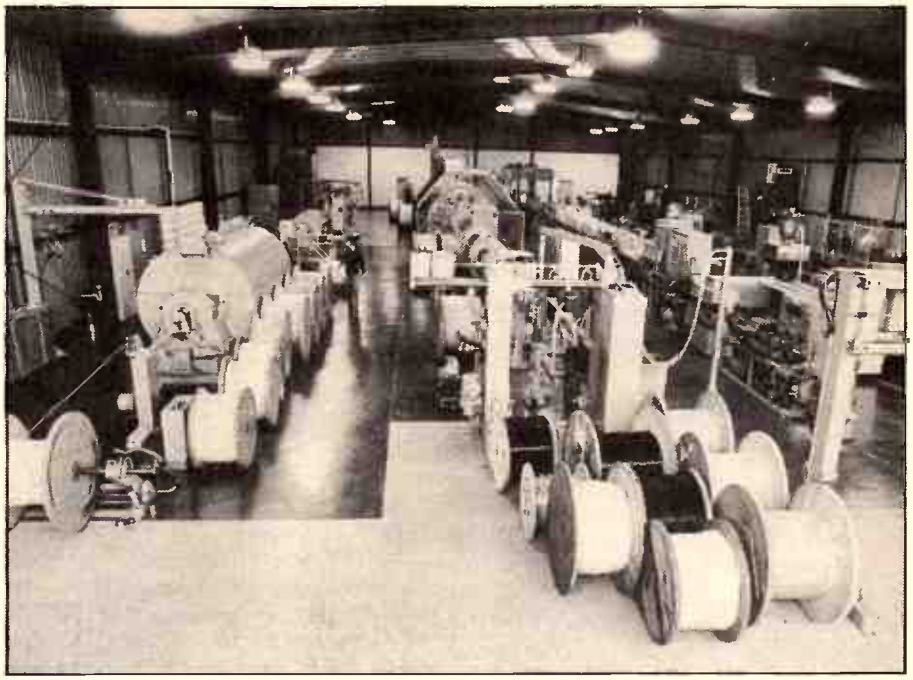
One of the most important characteristics of an optical fibre is attenuation of the light passing through it. Losses are due to absorption, scattering and boundary effects. For a given fibre composition, the losses are dependent upon the frequency of the light being transmitted. There is a theoretical limit of attenuation due to Raleigh Scattering, and this limit is heavily dependent on wavelength.

Rayleigh Scattering is the phenomenon responsible for the Earth having a blue sky. As incident light from the sun collides with small optical discontinuities in the atmosphere, the shorter wavelengths of blue light are scattered in all directions. Thus we see a blue sky regardless of which way we look. At sunset the sunlight travels a greater distance through the lower reaches of the atmosphere where larger particles are present. These cause scattering of the longer wavelengths and further attenuation of the shorter ones. Thus the shorter wavelengths are lost and the longer red wavelengths are scattered.

A similar thing happens within optical fibres. The optical discontinuities created by the glass molecules are of such sizes to cause large attenuations at shorter wavelengths. For this reason, among others, fibre optics is used at infrared wavelengths. The attenuation curve shows a steady dropping-off of attenuation with increasing wavelength. However, there are some notable peaks in the response.

These peaks are due, in the main, to absorption peaks caused by resonances at the molecular level of materials within the glass. The major absorptions are due to OH ions present in the glass, particularly as a result of water ingress. The peaks then define 'windows' in which the infrared spectrum is most useful to fibre opticians. Systems today typically run at a wavelength of 850 nm, with newer releases at 1300 nm. Research is still being carried out at 1550 nm which, being a longer wavelength again, offers significant improvement over the other two.

Other loss mechanisms associated with fibre are the boundary effects. These include numerical aperture (NA) effects, leaky rays and fresnel reflection. Numerical aperture refers to the angle at which rays are launched into the fibre, a launch angle that exceeds the NA of the fibre will result in some of the applied light being lost into the cladding layer. Microbends within the fibre can cause losses by directing light out of the core to be lost. Fresnel reflection is the reflection that occurs from the end of the fibre when correct index matching has not been implemented. It is,



The manufacture of fibre optic cable at Olex, Melbourne.

FIBRE OPTICS — A THREAT TO THE SWITCH MAKERS?

The introduction of optical fibre into the telephone network may lead to a decline in the public switch market according to the US-based research company, IRD.

This report, which forecasts developments in fibre optic telecommunications over the next 10 years, points out that network design always involves a trade-off between the cost of switching and the cost of transmission facilities. According to the IRD research team, the economics of this trade-off have been 'radically altered' by the arrival of fibre optics.

With optical transmission systems that can operate at several gigabits per second just about to hit the market, nothing else will be able to touch fibre optics for cheap wideband transmission. This abundance will eventually lead to a reduction in the cost of point-to-point transmission so that in some cases switches may not be required where they once would have been. The result? Fewer switches will be bought by the big carriers.

The IRD report predicts an era of more centralized switching and a move away from the present complex switching hierarchy of local and regional exchanges. This will mean that 'backhauling' will become increasingly common. (Backhauling is the switching of circuits over apparently geographically irrational routes — going from Sydney to Melbourne via Perth, for example.) With the cost of transmission falling, backhauling may make more economic sense than putting in expensive local exchanges.

if you like, the SWR of fibre optics. A typical value for glass terminated in air is about four per cent return.

Due to the very high frequency of the optical carrier employed in fibre optics, wide bandwidth of transmitted data is possible. A fairly ordinary communications fibre has a bandwidth of 200 MHz/km. This amounts to approximately 28 TV channels (7 MHz spacing) over a distance of 1 km. But the full bandwidth capability of the fibre is seldom used, as other factors generally dominate.

Sources and detectors

The main optical sources used in communications are the light emitting diode (LED) and the solid state laser.

Silicon photodiode detectors and GaAlAs lasers and LED sources can be used to best effect at the wavelength of 850 nm. However, it is not simply adequate that the spectral responses of the devices line up. Adequate means of coupling power into and out of the devices must also be provided.

Light emitting diode (LED)

The light emitting diode is a forward biased pn junction that emits light from the junction region with the passage of current across that junction. The emitted wavelength depends upon the band gap energy of the material used. For example: GaAlAs emits between 750 nm and 900 nm, depending upon doping; GaInAsP emits between 1000 nm and 1500 nm; GaAsP emits 640 nm for red, 590 nm for yellow and 560nm for green; and SiC emits 480 nm for blue LEDs. The simplest LED is shown in Figure 6.

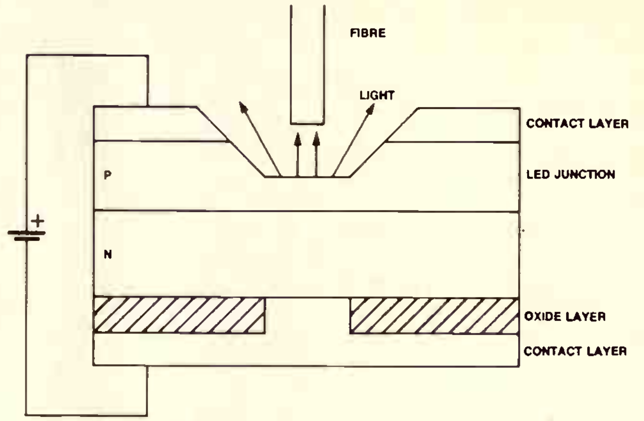


Figure 6. A simple LED structure.

As with most simple things there are problems, foremost of which is that the light has difficulty getting out of the junction area. Reabsorption of the light by the overlaying material makes it necessary to use a heterojunction configuration (see Figure 7).

In the heterojunction LED an extra layer of material is grown over the light emitting junction. This allows higher current densities in the junction areas and thus a higher optical output. In addition, the overlaying material is almost transparent to the wavelengths being emitted thus forming a window to the junction. Most LEDs are made using this structure.

Solid state laser

The word 'laser' is an acronym for Light Amplification by Stimulated Emission of Radiation.

In the semiconductor laser, the laser 'cavity' is formed between two semiconductor regions. High current densities are created within the junction by means of a double heterojunction structure allowing stimulated emissions to take place. The two parallel edges of the crystal create the ends of the resonant 'cavity' with light being emitted from the edge of the structure.

Injection lasers produce a fine spectral line of approximately 1 nm width. This is compared with 40-50 nm for a typical LED. Output powers are significantly higher for lasers and modulation frequencies are also much improved. An LED may be modulated at rates up to about 100 MHz whereas a laser is usually good to 1 GHz or more. The difference is due to the shorter recombination time constants under stimulated emission conditions versus the spontaneous recombinations in an LED junction.

However, injection lasers are much more delicate and expensive to fabricate. Depending upon the application they may require threshold stabilization, current limiting, temperature compensation or cooling. These extra overheads can make laser sources less attractive unless their advantages can be put to good use to outweigh these difficulties.

PIN diode

Although there are a number of different mechanisms that can be used to convert light into an electrical signal such as photoemissive and photoconductive techniques, it is the photovoltaic mechanism that best suits fibre optics applications.

In the photovoltaic mechanism, incident photons are absorbed within the material to produce hole-electron pairs. By arranging the photons to fall on the depletion region of a pn junction the holes and electrons are separated and produce a voltage across the junction.

TYPES OF OPTICAL FIBRE

Optical fibres fall into a number of different type categories: multimode, single mode, step index and graded index.

Multimode fibres are able to support a number of different ray paths through the core material. Due to different path lengths not all rays arrive at the end at the same time, causing pulse dispersion. A standard grade multimode fibre has a diameter of 125 μm and a core of 50 μm.

A single mode fibre is only able to support a single ray path through the core. Therefore the optical pulses do not become blurred due to the different propagation times. Single mode fibres have the highest bandwidth and are used on long haul Telecom applications. They are also the most difficult to splice, with core diameters down around 5 to 10 μm.

Step index fibres are the classical light pipe construction with a sharp change in refractive index between the core and the cladding. They are usually confined to short haul, low bandwidth applications as the multiplicity of propagation paths and the resulting pulse distortion limits the bandwidth.

To overcome some of the problems of pulse mode dispersion, the graded index fibre was developed. The refractive index of the core material is closely controlled in such a fashion that the speed of light in different parts of the core diameter is different. Towards the outer edge of the core the light travels faster than at the centre. The end result is that rays that are continually bouncing back and forth from outer edge to outer edge travel a longer distance than those going straight down the centre, but they travel faster. At the far end, all the rays from a pulse edge will arrive at the same time. This increases the bandwidth over step index fibres without having to go to the single mode format. Most medium haul communictions grade fibre today is graded index.

In order to improve the overall response of the photodiode, a large intrinsic region is placed between the p and n junctions. A reverse bias voltage decreases the transit time of the electron-holes and accordingly increases the frequency response of the device. The addition of the intrinsic region gives the device its name of PIN diode, P+I+N. Typical PIN diodes can have a quantum efficiency of greater than 70 per cent and response times better than 1 ns. Quantum efficiency is a measure of the number of incident photons that generate electrons.

Avalanche photodiode

To achieve a more sensitive photodiode, the reverse bias voltage can be increased to the point where internal gain takes place due to electron avalanche multiplication. Electron avalanche multiplication occurs when an electron, freed by an incident photon, is accelerated towards the positive bias and collides with other electrons on the way. These are in turn knocked free of the lattice and are accelerated towards the bias, knocking others out as they proceed. The result is a gain within the device generally in the order of x100. The major drawback is that a high voltage supply is required in the region of 150 V to 400 Vdc. A special semiconductor structure is required to support this high voltage and at the same time ensure stable low noise multiplication. Temperature compensation of the operating point may be required.

Despite these problems, the APD sees considerable service due to its ability to amplify very weak signals with good frequency response.

LASER SAFETY

Movies such as the James Bond stories and Star Wars have fuelled a lot of hysteria about lasers. They represent them as dangerous 'zapping' machines wielded by heroes and villains. But, of course, there are lasers and lasers. The low-powered helium neon type, which is used in an increasing array of products, is safe. In fact, there is not one documented case of damage caused by these lasers, despite many millions of hours of unsupervised use throughout the world.

Helium neon lasers produce visible red (632.8 Nm) light. Because the light rays all travel in one direction, a low powered laser of say two milliwatts is highly visible on all but the sunniest of days.

Compared to other types, helium neon lasers are economical and very reliable. They are used wherever a stable source of visible red light is required. Products such as bar code scanners, alignment systems used in construction, medical acupuncture lasers, laser pointers, guides for sawmills and patient positioners all use them. As well, the high powered invisible lasers which are used for cutting have a visible red helium neon laser to spot the beam.

Unfortunately, because of a very complex and conservative Australian Standard on laser safety, the words 'laser radiation' instead of 'laser light' are used on laser safety warning labels. Technically the terminology is not incorrect, since the light emitted by visible lasers is part of the electromagnetic spectrum and thus a form of radiation — but it *is* only light. Contrary to common misconception, lasers are not radioactive.

Visible helium neon lasers even over 10 milliwatts will not harm skin, set fire to paper, or do anything else untoward. As with all bright sources of light though, you should never look directly back down the beam of any laser. There is a level at which, if you look back down the beam and suppress the urge to blink so that the pupil becomes fully dilated, you could burn the retina of the eye. Under the Australian Standards, this level is 1 mW through the dilated pupil for more than 0.25 of a second (which is the blink reflex). In experiments, it has been found that the power required to damage a retina is 10 milliwatts — so there is a 10 times safety factor built in to the Standards.

The particular Standard that stipulates this 1 mW safety factor is AS2211, and it covers class 2 and class 3A lasers. With class 2, total power must be no more than 1 mW. A class 3A allows only 1 mW into the pupils, thus the total power for a 1 mW laser can be up to 5.0 mW but with a large diameter beam. Lasers over 5 mW are generally restricted to laboratory use, however you should always refer to the label to check the power before using any laser device.

To be sure of safety, lasers should be set up so that the beam is not at eye level or in such a location that the beam could be bounced off reflective surfaces such as mirrors, back towards eyes.

One safety area that is not covered by laser Standards is the electrical aspect. Even small tubes require more than 1 kV for operation and have starting voltages up to 6 kV. These can give a nasty jolt. Unless you are very well set up, you should not work with high voltage laser power supplies.

— Jeff Lacey

Jeff Lacey is managing director of Laser Systems Pty Ltd, Mulgrave, Vic.

Fibre optic measurement

Fibre optic measurement is a very broad field covering all aspects of the fibre, fibre-electrical interface, splices, cable performance, modal dispersion. Outside the fibre manufacturing plant or the research lab, however, one instrument stands out as being most useful. This is the optical time domain reflectometer (OTDR).

With a good OTDR it is possible to accurately measure the length of a fibre, locate cable breaks, measure the fibre attenuation, and measure splice or connector losses *in situ*.

In operation the OTDR launches a narrow pulse of light into the fibre under test. Typically, the pulse is derived from an injection laser. As the light travels down the fibre it is subject to Rayleigh Scattering and some of the light will reflect back up the fibre to the instrument. Connectors ▶

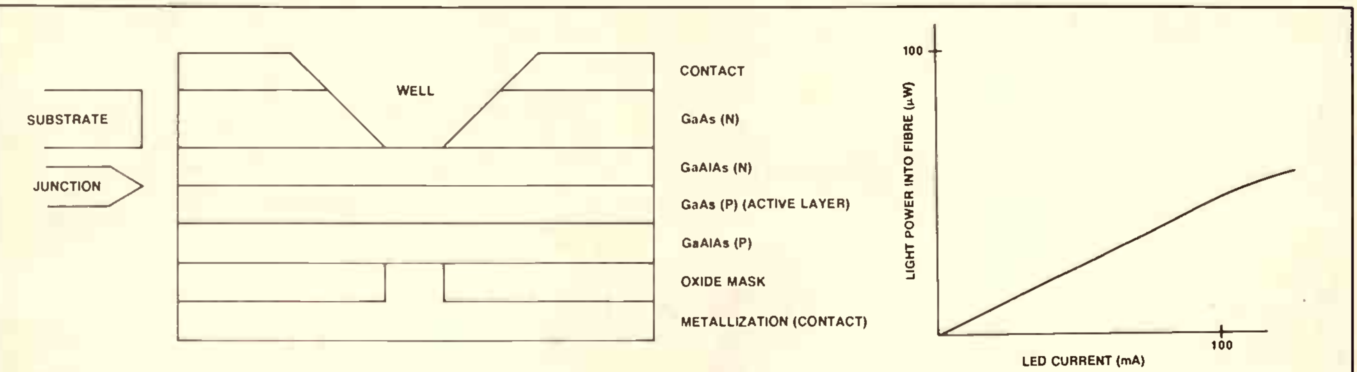


Figure 7. The heterojunction LED structure.

An Anritsu optical time domain reflectometer.

and fibre ends can produce quite strong reflections.

An optical receiver in the OTDR monitors these reflections and displays them on the vertical axis of a CRO screen. As reflections from far objects take longer to return than near-end reflections, it is possible to calibrate the horizontal trace of the display in distance (see Figure 8).

On the ODTR trace, the Rayleigh backscattering reflections show up as an exponential curve. Passing this through a log amplifier will produce a straight line whose slope is proportional to the attenuation of the fibre. Splices and connectors will show up as steps in the trace, the magnitude of a step being proportional to the splice loss. The OTDR is therefore, a powerful instrument for establishing the well-being of a fibre link, particularly as all the measurements are done from one end of the cable.

One way in which the OTDR can be put to good use is to take the signature of a particular installation noting attenuation and splice losses. This can then be compared with future signatures when a problem in the system may be suspected (see Figure 9).

The OTDR is certainly the most versatile fibre optic test instrument, but during cable installation and checking a simple infrared source and optical power meter can be used to good effect. This combination is generally employed as a continuity checker but with care can also be used for attenuation measurements. It has the supreme advantage of being inexpensive and rugged.

In principle, the measurement of fibre attenuation is quite simple. Given a length of fibre to be tested, for example 1 km, couple the infrared source into the fibre and measure the power coming out the other end. Now all we need to know is the level of the power going in. Unfortunately this is where the difficulties occur. A simple approach is to cut the fibre one or two

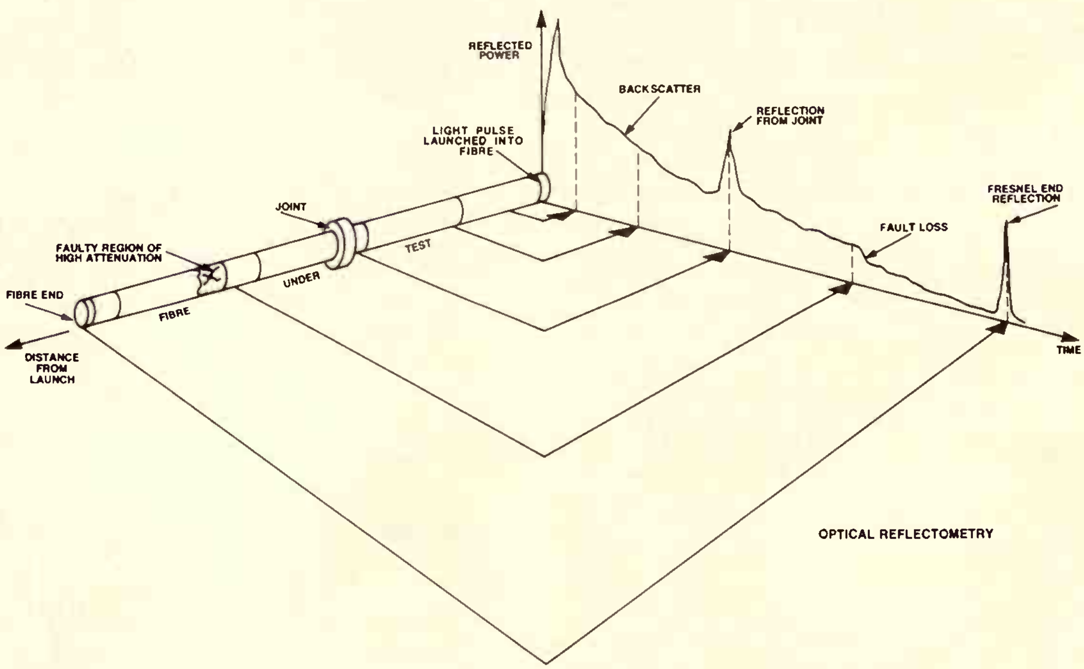


Figure 8. A typical OTDR trace for a length of fibre cable.

metres from the source and measure the power at that point. Loss in dB is then given by the equation:

$$\text{Loss} = 10 \log \frac{\text{power in}}{\text{power out}} \text{ dB}$$

The problem arises due to the fact that close to the source not all the light is travelling in the core of the fibre. Some is travelling in the cladding and although this will not reach the end of the long fibre it will get to the end of the short length. Thus the power meter reads a higher value at the short length than is truly the case. Likewise, some of the modes in the core region will not reach the far end because of their excessive launching angles. These modes are very susceptible to fibre loss mechanisms such as microbending.

To do a true attenuation measurement it is necessary to inject power into the fibre in such a fashion as to closely approximate the equilibrium conditions of that fibre. This removes extraneous modes that may otherwise cause erroneous results.

In the technique used to do this, light is coupled into the fibre from a source and then sent to a mode scrambler. This ensures that the optical power is distributed across all the propagation modes of the fibre. Following that stage, a Mandrel Wrap filters out all the core modes that are not equilibrium modes. It is, in effect, a simulated long fibre. Then a cladding mode stripper removes any light travelling in the cladding by placing the fibre in a bath of material with a refractive index greater than that of the cladding. This causes cladding rays to be refracted out of the fibre rather than back into it. Finally, a splice is used to join up to the fibre under test. The 'cut and measure' technique can now be used with a much more realistic and reproducible result.

Other test instruments exist for fibre optic measurements but these are generally confined to use by manufacturers or research labs and have limited field applicability except in all but the most demanding situations. ●

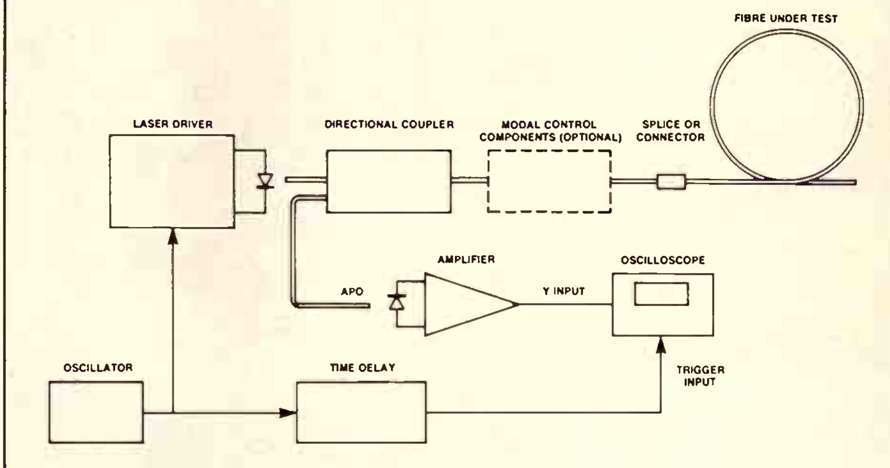


Figure 9. Basic block schematic of an OTDR.

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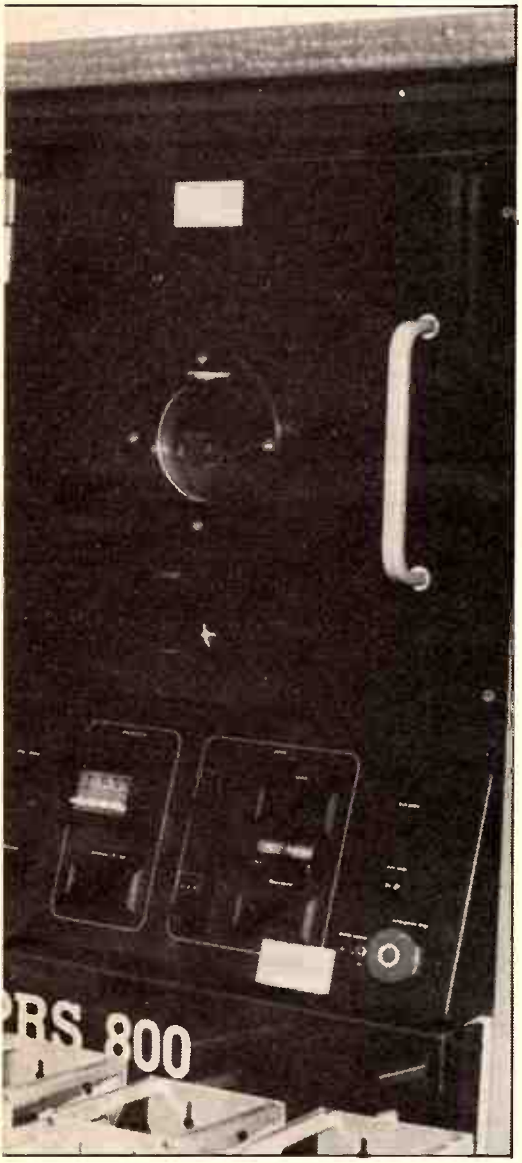
PLASMA PROCESSING

It is predicted that by 1990 plasma processing will have superseded wet etching in the production of all ICs. Not surprisingly, considerable research work is currently underway to perfect techniques for various applications.

Brian Dance

Plasma Technology's PRS800 photoresist stripper.



Traditional wet etching techniques are no longer suitable for semiconductor device fabrication, since the line resolution is no longer good enough. The problem is especially critical with modern high density circuits.

The alternative technique, plasma wafer processing, is used in the fabrication of over half of the integrated circuits being produced at the present time; by 1990 it is expected that plasma processing will be used in the production of all ICs.

Primitive plasma techniques have been available since the 1970s. Recently much effort has gone into research, to try to perfect techniques for various applications.

Plasma processing involves exposing the surface of a wafer to ions. These are produced by an electrical discharge in a gas mixture. The ions bombard the surface, etching it in the process.

The three main purposes for which plasma techniques are employed are: etching the fine patterns (via a suitable mask) that are required to produce circuits on chips; stripping off the remains of photoresist materials; and depositing thin films of materials onto surfaces.

Plasma stripping

The basic reaction involved in the stripping of resists from semiconductor wafers is the oxidation of the organic hydrocarbon resist material to carbon monoxide, water vapour, etc, in an oxygen plasma. First used in the early 1970s, this technique offers the advantage of leaving a clean surface free from ash. The process can be speeded up by using a maximum concentration of reactive oxygen in the plasma. Pure oxygen can be used if the plasma is excited at about 13.56 MHz. If the plasma is excited at low frequencies, say a few hundred kHz, the addition of a fluorine compound is necessary to obtain a satisfactory stripping rate. This results in silicon and other materials being attacked, so high frequency discharge in pure oxygen is therefore usually preferred.

The etching rate can be increased by raising the temperature of the wafer. This can be done by heating the outside of the reaction chamber to about 80°C and allowing the heat from the plasma to further raise the temperature of the wafer surface to nearly 200°C.

Various techniques are available for monitoring the etching rate. One of the most widely used methods detects the photons emitted by the carbon monoxide evolved during the etching process using an optical filter or a monochromator and a photodiode. It also provides an indication as to when all of the photoresist has been removed (the 'end point').

A microprocessor control system has been developed by Plasma Technology in the UK to automatically adjust the gas flow and the gas pressure so as to obtain maximum plasma activity at all times. The optimum values of these parameters may vary with the thickness of the remaining resist but the microprocessor can be programmed to automatically adjust the parameters for minimum processing time.

These principles have been adopted for Plasma Technology's PRS800 system which is claimed to be the fastest available photoresist stripper. A typical stripping time for 1.2 µm AZ positive resist on 100 x 100 mm wafers is 18 minutes. An aluminium chamber pre-heated to 80°C is employed to eliminate warm up delays and to stabilize process conditions. A 650 W, 13.56 MHz power source is used. The throughput can reach 300 x 125 mm wafers/hour.

> ***The problem with RIE is that it's too slow for use on production lines. Typical etching rates are only 40 to 50 nm/minute.***

The latest barrel stripping system from Electrotech, the Plasmafab PE508, employs an aluminium process chamber with a load capacity of 100 x 100 mm wafers, 50 x 125 mm wafers, 50 x 150 mm wafers or 25 x 200 mm wafers with a capability of stripping 1 µm resists from up to 200 wafers/hour. It incorporates a 600 W 13.56 MHz power unit.

Plasma etching

Plasma etching employs fluorine or chlorine-based vapours instead of oxygen to etch the very fine patterns required in the insulating and conducting layers of microelectronic devices. Many materials such as semiconductors, aluminium interconnects and silicon dioxide can be successfully etched at reasonable rates by gas plasmas. The use of chlorine causes more problems (such as contamination of the pump oil) than the use of fluorine compounds.

The products created by the reaction must be volatile in order to leave a clean surface. Fluorocarbon gases are best for etching because of this. They are absorbed on the surface where they provide both fluorine atoms to produce a volatile silicon compound and carbon atoms to react with the oxygen of the film.

The chemistry of the plasma is very complex. Among the things to consider is selectivity, ie, plasma must only attack the desired material with a minimum effect on the underlying silicon, etc. CF_4 is best for etching silicon dioxide whereas fluorine atoms etch silicon; thus the best selectivity for the etching of silicon dioxide is usually obtained with vapours containing relatively few fluorine atoms (such as CF_4 which can provide a 10:1 selectivity).

The first plasma etching techniques used low energy ions (less than 100 eV) to bombard the surface of the wafer. In such a ▶

planar electrode system the ions come from all directions and, like the wet processes, etch away the material equally in the vertical and horizontal directions. Thus the features on the chip are 'undercut' as the etching takes place on the sides or walls of the features as well as at the top. This means walls which are not perpendicular, so the minimum packing density cannot be achieved.

One solution is reactive ion etching (RIE), in which ions of higher energy are used to bombard the surface. Electric fields enable the ions to be directed almost normally at the surface so that no appreciable undercutting occurs. However, the process is not simply a physical bombardment. It also enhances chemical reactions taking place on the surface, and avoids the formation of fluorocarbon polymers which inhibit etching. This combination of physical and chemical etching has been found to offer the best results for many applications.

The problem with RIE is that it's too slow for use on production lines. Typical etching rates are only 40 to 50 nm/minute. The main reason why the rates are so low is that very low pressures have to be employed. At such pressures the concentration of ions in the plasma is very low. One way around it is to etch batches of wafers together. Success then depends on all the wafers etching uniformly at the same rate.

The other major problem of current RIE processing is the damage produced by the ion bombardment of the surface. Fairly energetic ions (about 500 eV) must be employed to obtain perpendicular incidence on the wafer surface, but these ions cause more damage than those of lower energies. Planar etching is a purely chemical action, but RIE is partly mechanical and partly chemical.

New techniques

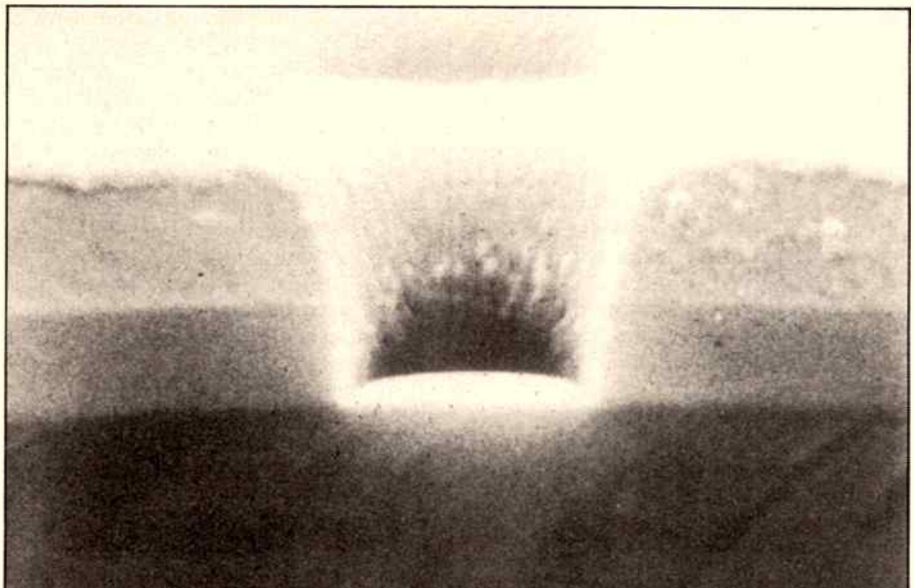
Plasma Technology is attacking these problems in two ways which will probably be used together in new plasma processing equipment in due course. Basically the idea is to generate a high concentration of the ionized species only just above the wafer surface. This should enable perpendicular incidence to be obtained at relatively low ion energies with a consequent reduction in the amount of surface damage. Very high ion densities are required to obtain the desired increase in the etching rates which will enable a wafer to be etched to a depth of 1 µm in about one minute.

One technique being evaluated involves the use of a microwave discharge feeding a resonant cavity to generate the plasma instead of the conventional radio frequency power system. This is already giving good results. Etching rates of 2 to 2.5 µm/m have been obtained with an input of only 200 W. This is four to five times faster than in previous RIE systems. The microwave frequency results in better ionization efficiencies, so damage may be minimized.

The second method involves the use of magnetic confinement of the electrons so that they create more ions instead of rapidly moving to the electrodes. It seems probable that electromagnets will be used so that the field strength can be varied over the range of about 0.1 to 0.5 T. Plasma Technology is currently having the electromagnets designed and hopes to obtain etching rates of about 4 µm/m for silicon dioxide (other materials etch more rapidly).

Most of the work up to the present time has been devoted to optimizing the position of the microwave resonant cavity in the equipment. The distance between the cavity and the bottom electrode which supports the wafers has a considerable effect on the uniformity of the discharge and on the etching rate. Plasma Technology plans to deliver an R&D version of the microwave equipment by the end of 1986 so that feedback from users can be considered before a single wafer production version is launched by the middle of 1987.

For some applications totally vertical profiles in silicon dioxide are very undesirable. The most frequent example being the etching of contact holes which must then be coated with a metal layer. A range of hole profiles and a variety of wall angles may be required. Controlled photoresist erosion is one of the most reliable techniques for producing sloped walls. An RIE process based on fluorine chemistry enables the wall angle to be varied over a wide range (20° to 90°) with high reproducibility.



Contact hole in SiO_2 showing sloped walls using controlled photoresist erosion (Plasma Technology).

Other materials

Plasma techniques can be employed for etching many materials besides silicon and its oxide. Chlorine-based plasmas are required for gallium arsenide surface etching, since gallium trifluoride is involatile.

Work in the Department of Electrical Engineering at the University of Glasgow has shown that submicron features can be routinely etched in the surface of gallium arsenide. Low rf power densities are used to minimize radiation and ion bombardment damage with low pressures to provide anisotrophy and reduce polymer contamination. Etching rates in the 50 to 250 nm/m range have been obtained by Plasma Technology with typical selectivities to type AZ photoresist of up to 100:1. Applications include recessed gate FETs and optical structures such as wave guides. Work at Sheffield University has shown that completely anisotropic etching is possible in this material.

Collaborative work between the Royal Signals and Radar Establishment (RSRE) in Malvern, UK, and Plasma Technology has enabled via holes to be etched through gallium arsenide substrates. Via holes, metallized completely through the wafer are required for low impedance connections to ▶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a rear surface gold ground plan in high frequency devices. They can be circular or square in cross section, 20 to 200 µm across, and 400 µm in depth. A fairly steep wall slope of 70° to 80° is required without an overhang which could impede the subsequent metallization.

Indium antimonide has been etched by a plasma process developed by Plasma Technology in collaboration with the North China Research Institute on Electro-Optics, Beijing, China. Apparently this is the first plasma etching of this material which is of considerable interest for possible future semiconductor injection laser use.

The process was developed in response to specific device requirements. It is based on chlorine chemistry, using 13.56 MHz plasma excitation, and provides a reasonable etching rate without serious degradation of the photoresist mask. A turbopump (360 L/s capacity) was used to provide the required base pressure in the chamber and a nitrogen-purged glovebox was considered essential to avoid contamination of the chamber. The 170 mm diameter electrodes and the chamber itself were anodized to prevent attack by the plasma. Water cooling was employed to enhance the resist lifetime.

Plasma Technology has also carried out an investigation into the plasma etching of indium phosphide. Very precise etching is required for the fabrication of some structures, such as MOSFETs for operation at frequencies of up to 100 GHz. An optimized process based on chlorine chemistry has been developed for use at very low pressures; a turbopump is said to be essential for this RIE process to achieve the excellent base pressure of less than 10^{-5} bar which is required for highly reproducible processing. The electrodes and the chamber were anodized. Features up to 5 µm in depth have been fabricated using metal film masks with etching rates of up to 300 nm/m and a high selectivity against etching the oxide mask.

Other new etching targets are inspired by the needs of electro-optics. In order to be able to make structures such as waveguides in lithium niobate for integrated optics applications, it is essential to be able to etch structures with vertical walls. This has proved very difficult, but recent work has led to the development of a plasma etching process specifically for this material.

The process employs a chlorine-based plasma to etch structures up to a few micrometres in depth using a conventional photoresist as a mask. Alternatively, deeper structures can be formed using a metal mask (usually aluminium). The plasma is generated by 13.56 MHz power using 170 mm electrodes. It was found necessary

One hundred nanometre optical structures in semi-insulating gallium arsenide with gold/platinum mask using silicon tetrachloride chemistry (Plasma Technology).

to pay careful attention to all of the materials used in the chamber, only anodized components being employed. Some tolerance in the process parameters, especially when photoresist masks were employed, was obtained by controlling the electrode temperature with a closed circuit water temperature control unit. A turbopump is essential to avoid contamination by water vapour.

Plasma deposition

The gases employed in plasma deposition systems are chosen so that they combine in the plasma state to form solid deposits. This offers a method of producing thin film deposits during the manufacture of semiconductor devices; it usually produces better quality films than those produced by thermal oxidation and has the advantage that a lower temperature can be used. Applications include the deposition of thin films of silicon dioxide for diffusion masks, dielectric and passivation layers or silicon nitride to act as a barrier to sodium and other ions. Silicon nitride can also be deposited as a cap to prevent the loss of volatile material during the post implantation annealing of gallium arsenide devices.

The development of plasma deposited films has made it feasible to deposit thin film transistors on to inexpensive substrates, such as glass. This material allows logic circuits to be integrated onto liquid crystal displays, etc, and has applications for high speed memory devices.

As multi-layer metallizaton becomes more common in microelectronic devices, requirements arise for the deposition of metals such as tungsten. This metal can also be deposited on polysilicon as part of the increasingly used 'polycide' process for VLSI devices and is used to form the Schottky barrier metal layer on III-V compound semiconductors. A typical plasma enhanced chemical vapour deposition (PECVD) process starts with tungsten hexafluoride (together with film-stabilizing gases) to deposit pure tungsten at a temperature not exceeding 300°C. Special gas handling is required to avoid the deposition of tungsten in unwanted places.

Equipment has been designed to produce uniform films at high deposition rates so as to obtain maximum throughput. For example, the new Electrotech ND8200 low temperature plasma enhanced chemical vapour deposition (PECVD) system can deposit silicon nitride at typically 70 nm/m or silicon dioxide at 107 nm/m, both at 300°C, on 200 mm wafers using a cassette wafer handling system.

An interesting use of these techniques is in large area applications, such as on solar cells. Other deposition methods involve high temperatures which cannot be used for plastic or glass substrates or for large areas.

Current state-of-the-art in plasma technology seems to enable the production of thin films on substrates up to A4 size. A typical amorphous silicon film of this size has a thickness of 60 nm and appears to have a gold tinge caused by transmitted light, but thicker 2 µm films look like aluminium reflectors. PIN structures can be fabricated *in situ* for such applications as solar cells. The intrinsic centre layer (typically 1 µm in thickness) is amorphous silicon and the other two thinner layers are doped amorphous silicon. One of the difficulties in the deposition of such films is the problem of avoiding contamination from the dopants used for the two outer layers from reaching the inner layer. Amorphous silicon carbide has also been deposited; it can be employed as the p-layer in PIN photocells instead of doped amorphous silicon.

Amorphous silicon may be used not only for solar cells, but also for flat VDU/TV screens, large area memory devices or large area detectors such as document readers. If any of these suddenly became widely adopted, very high volume production would be required very quickly. As Plasma Technology would be unable to meet such a demand, it decided to collaborate with Edwards High Vacuum on the development of the equipment. There has also been collaboration in this work with Solems (France), Messerschmitt-Bölkow-Blohm (West Germany) and a consortium of Benelux universities, including the Inter-University Microelectronics Centre at Leuven, Belgium. ●

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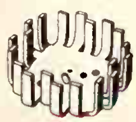

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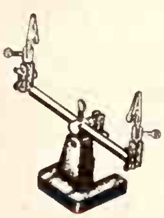

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Harmonic Distortion Factor: Less than 0.4%
Contact Pressure: Approx. 3 N
Weight: Approx. 250g
Length of lead: 3 metres

Cat. A10519 .... $199

OMNI-DIRECTIONAL WIRELESS MICROPHONE

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

Cat. A10450 .... $19.95

RECHARGEABLE ELECTRIC SCREWDRIVER

The perfect tool for professional or handyman!

- Long lasting NiCad battery
- Forward/Reverse Modes
- Detachable pistol grip
- Simple to use chuck
- 2 Flat tips
- 2 Philips tips
- Includes AC/DC charger

PERFORMANCE DATA:
Gears Ratio: 1:50
Max. R.P.M.: 150
Max. Torque: 3.2 (Newton Metre)
Screwing Capacity: 4 x 8/300, 5 x 8/220

T12200 .... $99.50

Something for everyone during the holidays!

"IBM XT TYPE" COMPUTER CASING

Give your kit computer a totally professional appearance with one of these "IBM type" casings, includes room for 2 x 5 1/4 inch disk drives, connection ports and mounting accessories etc.
Dimensions: 490 x 390 x 140mm.

Cat. X11090 .... Normally $119

SPECIAL, ONLY $99

"IBM AT STYLE" COMPUTER CASING

Our latest computer casing, featuring security key switch, 8 slots, and mounting accessories etc.
Size: 490(W) x 145(H) x 400(D)

Cat. X11091 .... Normally $139

SPECIAL, $119

KEYBOARD AND CASE

A stylistic low profile case to give your system the professional look it deserves. Comes with an attached encoded, parallel output keyboard and provisions for 2 x 5 1/4" slimline disk drives.

Cat. X11080 .... Normally $249

SPECIAL, ONLY $199

ELECTRET MIC INSERTS

With pins for easy board insertion.
Cat. C10170

1-9	10+	100+
$2.50	$2.25	$2.00

CRYSTAL LOCKED WIRELESS MICROPHONE AND RECIEVER

MICROPHONE SPECIFICATIONS:
Transmitting Frequency: 37.1MHz
Transmitting System: crystal oscillation
Microphone: Electret condenser
Power Supply: 9V battery
Range: 300 feet in open field
Dimensions: 185 x 27 x 38mm
Weight: 160 grams

RECIEVER SPECIFICATIONS:
Recieving Freq: 37.1MHz
Output Level: 30mV (maximum)
Recieving System: Super heterodyne crystal oscillation
Power Supply: 9V Battery or 9V DC power adapter
Volume control
Tuning LED
Dimensions: 115 x 32 x 44mm
Weight: 220 grams

Cat. A10452 .... R.R.P. $113

Our price $99

MINIATURE HEATSINK!

A great little fellow if you are short of space. Great price too, because we import direct so you save!

Cat.		1-9	10+
H10606		$0.40	$0.35

DB STAND OFFS

At incredible prices! No need to pay absurd prices because we import them direct and pass on the savings to you!

2 Pack P10930	$1.00
10 Pack P10932	$3.95
100 Pack P10934	$20.00

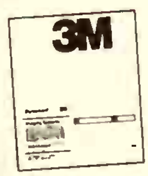
DIGITAL SPEEDO/ DIGITAL TACHO/ SPEED ALERT

- Digital readout (LED) for both tacho and speedo.
- 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
- Speedo: 0 - 199kph
- Tachometer: 0 - 9900kph
- Speed alert: 40 - 120kph
- Complete with mounting hardware

Cat. A15064 .... R.R.P. $89.95

OUR PRICE $74.95

MAIL ORDER HOTLINE (03) 543 7877 (2 lines)



3M SCOTCHCAL PHOTOSENSITIVE

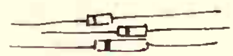
All prices per box of 10 sheets and include sales tax!

8007 REVERSAL FILM	
250 x 300mm	$39.95
300 x 600mm	$54.95
8005 BLACK ALUMINIUM	
250 x 300mm	$69.95
300 x 600mm	$79.95
8009 BLUE ALUMINIUM	
250 x 300mm	$69.95
300 x 600mm	$79.95
8011 RED/WHITE	
250 x 300mm	$64.95
300 x 600mm	$74.95
8013 BLACK/YELLOW	
250 x 300mm	$64.95
300 x 600mm	$74.95
8015 BLACK/WHITE	
250 x 300mm	$64.95
300 x 600mm	$74.95
8016 BLUE/WHITE	
250 x 300mm	$64.95
300 x 600mm	$74.95
8018 GREEN/WHITE	
250 x 300mm	$64.95
300 x 600mm	$74.95

DESOLDERING BRAID

1.5 metres at direct import prices!

Cat.No.	1-9	10+
T?????	$1.75	$1.50



DIODE SPECIALS

We have millions of diodes

	1-99	100+	1000+
IN4148 Small signal Cat. Z10135	3¢	2 1/2¢	2¢
IN4004 400V 1A Cat.Z10107	4¢	3 1/2¢	3¢

1/2" HIGH INTENSITY RED LED DISPLAYS

(Available in Common Cathode and Common Anode)

Dimensions:
Overall: 12.7mm across, 19mm high
Display: 12.7mm(H) x 7.3mm(W)
Segment Width: 1.2mm
Brightness: 3400 ucd I_F = 10mA

COMMON CATHODE:

Pin 1 Segment E	Pin 6 Segment B
Pin 2 Segment D	Pin 7 Segment A
Pin 3 CC	Pin 8 CC
Pin 4 Segment C	Pin 9 Segment F
Pin 5 Segment Dp	Pin 10 Segment G

Cat No.	1-9	10+
Z10190	$1.95	$1.75

COMMON ANODE:

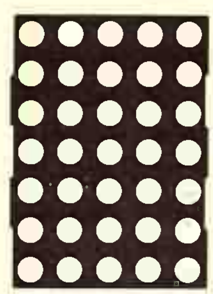
Pin 1 Segment E	Pin 6 Segment B
Pin 2 Segment D	Pin 7 Segment A
Pin 3 CA	Pin 8 CA
Pin 4 Segment C	Pin 9 Segment F
Pin 5 Segment Dp	Pin 10 Segment G

Cat.No.	1-9	10+
Z10191	$1.95	$1.75

HIGH INTENSITY RED LED BAR GRAPH

Dimensions:
Overall: 63mm across, 5mm high.
LEDs 10 x 5mm x 1mm

Cat No.	1-9	10+
Z10180	$2.95	$2.75



HIGH INTENSITY ALPHANUMERIC RED DISPLAY

Interlockable 2" display module with 35 high intensity, 5mm pixels per module allowing vast scope for custom displays

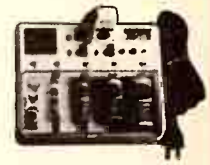
Brightness: 3000 ucd, I_F = 10mA

PIN 1 Row 5A	PIN 8 Row 3A
PIN 2 Row 7A	PIN 9 Row 1A
PIN 3 Col. 2C	PIN 10 Col. 4C
PIN 4 Col. 3C	PIN 11 Col. 3C
PIN 5 Row 4A	PIN 12 Row 4A
PIN 6 Col. 5C	PIN 13 Col. 1C
PIN 7 Row 6A	PIN 14 Row 2A

Cat.No.	1-9	10+
Z10196	$7.95	$6.95

NICADS!

Size	Desc.	1-9	10+	100+
AA	0.5 A.H.	$2.95	$2.75	$2.25
C	1.2 A.H.	$7.95	$6.50	$6.25
D	1.2 A.H.	$7.95	$6.50	$6.25



UNIVERSAL BATTERY CHARGER AND TESTER

Save money on expensive batteries with this universal battery charger. Features include meter tester, and provisions for D, C, AA, AAA, N, button and cell batteries, 9V and 6V (square types). Comes complete with detailed instructions.

Cat. M23533 .... $29.95

RECHARGEABLE 12V GELL BATTERIES

Leakproof and in 3 convenient sizes, these long service life batteries are ideal for burglar systems, emergency lighting or as a computer backup power supply. Ideal for many power needs.

Cat. S15029	12V 1.2 AH	$17.50
Cat. S15031	12V 2.6 AH	$32.50
Cat. S15033	12V 4.5 AH	$39.50

rie

Rod Irving Electronics

48 A'Beckett St, MELBOURNE
Phone (03) 663 6151
425 High St, NORTHCOTE
Phone (03) 489 8866
Mail Order and Correspondence: P.O. Box 620, CLAYTON 3168
Telex: AA 151938

MAIL ORDER HOTLINE
008 335757
(TOLL FREE)
(STRICTLY ORDERS ONLY)

LOCAL ORDERS & INQUIRIES
(03) 543 7877

POSTAGE RATES:

$1 - $9.99	$2.00
$10 - $24.99	$3.00
$25 - $49.99	$4.00
$50 - $99.99	$5.00
$100 - $199	$7.50
$200 - $499	$10.00
$500 plus	$12.50

FREE POSTAGE FOR ORDERS OVER $75 & UNDER 3KG!!

The above postage rates are for basic postage only. Road Freight, bulky and fragile items will be charged at different rates.

Certified Post for orders over $100 included free!
Registered Post for orders over $200 included free!

All sales tax exempt orders and wholesale inquiries to: RITRONICS WHOLESALE, 56 Renver Rd, Clayton. Ph. (03) 543 2166 (3 lines)

Errors and omissions excepted

*Apple and IBM are registered trade names

MasterCard VISA

FREE POSTAGE FOR ALL ORDERS OVER $75 & UNDER 3KG!!

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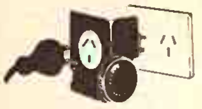
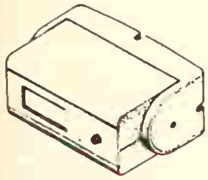
FREE POSTAGE FOR ALL ORDERS OVER $75 & UNDER 3KG!!



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, waking you, even making the coffee! lights etc for security while you're away from home!
- Bargain Price!

Cat M22002 **only $19.95**



PASSIVE INFRA RED DETECTOR

Compact P.I.R. with adjustable corner or wall mounting bracket, dual pyroelectric infra red sensing element gives a coverage 2 x 14 zones 2m high and 10m wide

- Sensitivity adjustment control
- Detecting range 12-15 metres at 90 degrees
- Detecting zones 9 long (up), 5 short (down)
- LED indicator for walk test (can be disabled)
- Shielded against RF interference
- Relay output NC or NO at 30V (AC-DC) 0.5A max
- Integral NC tamper switch
- Operating voltage 10.5 - 16V DC
- Current 20mA with LED 25mA

Cat S????? **$145**

10W HORN SPEAKERS

White durable plastic, 8 ohms

Cat C12010 Normally $11.95

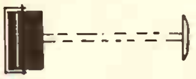
SPECIAL, ONLY $9.95

CODE KEY PAD

- Telephone type digital keypad
- Four digit, changeable code
- Over 5000 possible combinations
- Power consumption: 5mA standby, 50mA alarm
- Two sector LED and 1 arm LED
- Wrong number lockout
- 12V DC operation
- Relay output
- Panic button
- Normally open tamper switch
- Dimensions 145 x 100 x 37mm
- ACP3 compatible

Cat A13014 .... R.R.P. $79.95

SPECIAL, ONLY $69.95



ARLEC SECURITY BEAM

This compact security system transmits an invisible, modulated beam of infrared light which can be directed across a doorway, path or any other to be monitored. Anyone walking through the beam immediately causes an audible warning to sound. Suitable for shops, homes, factories etc.

FEATURES:

- Small compact design
- Infrared modulated beam
- Prismatic reflector allows up to 10% misalignment
- Effective range is 2 - 8 metres
- Low voltage (9V) operation via S.E.C. approved adaptor
- Negligible power consumption
- Simplified wiring
- Solid state electronic circuitry
- Produces audible warning
- Easy installation
- 12 months guarantee

Cat A15060 .... **$89.95**

RITRON KEYLESS CAR ALARM

The first shipment sold out immediately to the trade. They didn'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

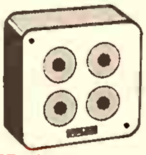
Cat S15054 Normally $39.95

NOW $29.95

ELECTRONIC DOOR ALARM AND CHIME

Electronic control system with powerful in-built 100dB alarm. Changeable 3 digit, push button, secret code controller that is tamper proof. 3 function switch provides off position, chime and 7 seconds delay entry. Emergency panic button. Suitable for left or right hand door opening. Simple installation, no wiring required. Low current 15mA at 9V. Operates on 9V battery.

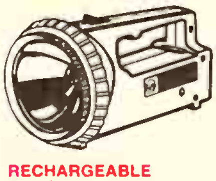
Cat S????? **$44.95**



PIEZO SIREN

- 4 piezo units in a 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

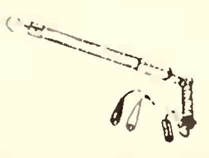
Cat S15071 **$23.95**



RECHARGEABLE LANTERN

- Up to 1,000 recharges
- No more expensive batteries
- Beam length 1,050 feet
- Cannot be over charged
- Shoulder strap included
- 240V charge lead connects direct
- 12V Car lighter recharging lead (ideal for camping, travel, boating etc)
- Red safety shade cover

Cat A15053 **only $29.95**



FLUORESCENT WORK & EMERGENCY LIGHT

- Suits cars, boating, caravan, camping etc
- Shatterproof, glare free
- Cigarette lighter plug and alligator clips
- 12V DC, 8 watt, transistorised

Cat A15052 **$25.95**

RACK MOUNTING CABINETS

These superbly crafted rack cabinets will give your projects a real professional appearance.

- All dimensions conform to the International Standard.
- Aluminium construction.
- Removeable upper and lower panels.
- Ventilated lid.
- Choice of Natural or Black finish.
- Quality brushed finish anodised front panel.

A = Internal Height mm
B = Rear Width mm
C = Depth mm

A	B	C	Finish	Cat.No.	Price
38	430	254	Natural	H10401	$49.50
82	430	254	Natural	H10402	$59.50
126	430	254	Natural	H10403	$69.50
38	430	254	Black	H10411	$59.95
82	430	254	Black	H10412	$69.95
126	430	254	Black	H10413	$79.95

"SNAP TOGETHER" PLASTIC CASE

Top and bottom simply snap together (no screws required), removable front and back panels. Size: 186(W) x 125(D) x 50(H)mm

Cat H10116 .... **$7.95**

HORWOOD ALUMINIUM CASES

H10382	3 x 4 x 2 inches	$ 5.50
H10383	3 x 4 x 3 inches	$ 6.50
H10384	3 x 4 x 4 inches	$ 7.50
H10385	3 x 4 x 5 inches	$ 7.95
H10386	3 x 4 x 6 inches	$ 8.50
H10387	3 x 4 x 7 inches	$ 9.50
H10388	3 x 4 x 8 inches	$10.50
H10389	3 x 4 x 9 inches	$10.95
H10390	3 x 4 x 10 inches	$11.95

SPECTROL MULTIDIALS

Model 16-1-11 (.9")
Cat.R14400 **$21.95**

Model 18-1-11 (1" x 1.75" Rect.)
Cat.R14405 **$38.50**

Model 21-1-11 (1.82")
Cat R14410 **$37.50**

AEROSOLVE SPRAYPACKS

PCB Coating '201'
Cat N11040 **$6.95**

Freezing Spray '202'
Cat N11042 **$6.95**

Insulating Varnish '203'
Cat N11043 **$7.95**

Electric Motor Cleaner '204'
Cat N11044 **$6.95**

Electronic Super Clean (Freon) '205'
Cat N11047 **$7.50**

Flux Remover '206'
Cat N11049 **$6.95**

Elec Contact Cleaner & Lube '207'
Cat N11051 **$5.95**

Silver Cote '208'
Cat N11054 **$6.95**

Formula "66" '535'
Cat N11057 **$5.95**

Clear Coat Plastic Spray '540'
Cat N11059 **$6.95**

SOLDER ROLLS

Absolutely top quality, unlike our opposition's!
60/40 Resin cored.

Cat.No.	Description	Price
T31000	.71mm 250gm	$8.95
T31002	.71mm 500gm	$15.95
T31010	.91mm 250gm	$7.95
T31012	.91mm 500gm	$14.95
T31020	1.6mm 250gm	$7.50
T31022	1.6mm 500gm	$13.95
T31030	.71mm 1 metre	$1.50
T31032	.91mm 1 metre	$1.25
T31034	1.6mm 1 metre	$1.00

BREADBOARD SPECIALS

Why pay more?

Cat.P11000	100 holes	$2.75
Cat.P11005	640 holes	$10.75
Cat.P11007	640+100 holes	$13.00
Cat.P11009	840+200 holes	$17.50
Cat.P11010	1280+100 holes	$19.95
Cat.P11011	1280+300 holes	$32.50
Cat.P11012	1280+400 holes	$36.75
Cat.P11015	1920+500 holes	$57.50
Cat.P11018	2560+700 holes	$64.95

PUSH BUTTON DIALLERS

Tired of old fashion dialling and re-dialling engaged numbers? These convenient push button diallers include last number redial (up to 16 digits) and instructions for an easy changeover.

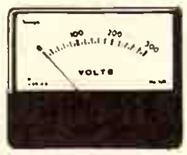
Cat. A12030 NORMALLY $19.95

SPECIAL, ONLY $14.95

IC SOCKETS (LOW PROFILE)

How cheap can they go?

	1+	10+	100+	1000+
8 Pin Cat.	15c	14c	12c	09c
14 Pin Cat.	16c	15c	14c	10c
16 Pin Cat.	17c	16c	15c	11c
18 Pin Cat.	18c	17c	16c	13c
20 Pin Cat.	29c	28c	27c	26c
24 Pin Cat.	35c	33c	32c	28c
40 Pin Cat.	45c	40c	35c	30c



PANEL METERS GALORE!

We have a great range of panel meters at great prices!

Cat.No.	Description	Price
Q10500	MU45 0-1mA	12.50
Q10502	MU45 50-0-50uA	12.50
Q10504	MU45 0-100uA	12.50
Q10510	MU45 0-5A	12.50
Q10518	MU45 0-1A	12.50
Q10520	MU45 0-1A	12.50
Q10525	MU45 0-20V	12.50
Q10530	MU52E 0-1A	14.50
Q10533	MU52E 0-5A	14.50
Q10535	MU45 VU PMetre	14.95
Q10538	MU65 0-50uA	16.95
Q10540	MU65 0-1mA	16.95
Q10550	MU65 0-100uA	16.95
Q10560	MU65 0-20V	16.95

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. $149

SPECIAL, ONLY $129

ARLEC 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
- Instruction sheets

Cat. T12300 .... **$59.95**

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 **$3.75**
Socket Cat. P10150 **$2.95**

CANNON TYPE CONNECTORS

	1-9	10+
P10960 3 PIN LINE MALE	$3.90	$3.50
P10962 3 PIN CHASIS MALE	$3.00	$2.50
P10964 3 PIN LINE FEMALE	$4.50	$3.90
P10966 3 PIN CHASIS FEMALE	$4.95	$3.95

FREE STANDING, FOLD UP MAGNIFIER

An econonomically 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 **$14.95**

ANTISTATIC SOLDER SUCKER

- Light weight
- Sturdy construction
- Easy to remove tip
- Excellent value for money!

Cat T11281 **$13.95**

METEX MULTIMETERS

These instruments are compact, rugged, battery operated, hand held 3 1/2 digit multimeters. Dual-slope A-D converters use C-MOS technology for auto-zeroing, polarity selection and over-range indication. Full overload is provided.

METEX 3800 MULTIMETER

This instrument is a compact, rugged, battery operated, hand held 3 1/2 digit multimeter for measuring DC and AC voltage, DC and AC current, Resistance and Diode, for testing Audible continuity and transistor hFE. The Dual-slope A-D Converter uses C-MOS technology for auto-zeroing, polarity selection and over-range indication. Full overload is provided. It is an ideal instrument for use in the field, laboratory, workshop, hobby and home applications.

Features...

- Push-button ON/OFF power switch
- 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.
- Diode testing with 1 mA fixed current.
- Audible Continuity Test.
- Transistor hFE Test.

SPECIFICATIONS

Maximum Display: 1999 counts 3 1/2 digit type with automatic polarity indication.

Indication Method: LCD display.

Measuring Method: Dual-slope in A-D converter system.

Over-range Indication: "1" Figure only in the display.

Temperature Ranges: Operating 0-C to +40-C

Power Supply: one 9 volt battery (006P or FC-1 type of equivalent)

Cat. Q91530 Normally $109

SPECIAL $99

METEX 3530 MULTIMETER

This instrument is a compact, rugged, battery operated, hand held 3 1/2 digit multimeter for measuring DC and AC voltage, DC and AC current, Resistance and Diode, Capacitance, Transistor hFE and Continuity Test. The Dual-slope A-D Converter uses C-MOS technology for auto-zeroing, polarity selection and over-range indication. Full overload is provided. It is an ideal instrument for use in the field, laboratory, workshop, hobby and home applications.

Features...

- Push-button ON/OFF power switch
- 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
- Audible Continuity Test
- Transistor hFE Test

SPECIFICATIONS

Maximum Display: 1999 counts 3 1/2 digit type with automatic polarity indication

Indication Method: LCD display

Measuring Method: Dual-slope in A-D converter system

Over-range Indication: "1" Figure only in the display

Temperature Ranges: Operating 0-C to +40-C

Power Supply: one 9 volt battery (006P or FC-1 type of equivalent)

Cat Q91540 Normally $139

SPECIAL $129

POSTAGE FOR ORDERS OVER $75 & UNDER 3kg!!

JUMBO 5¼" DISK STORAGE
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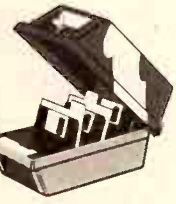

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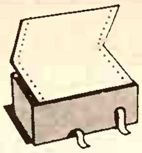

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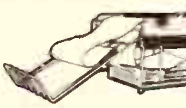

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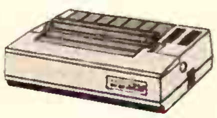

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Resolution:
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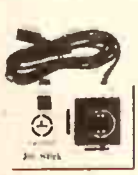

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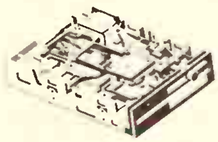

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A Guide to IC Numbering

An attempt to unravel the mystery behind the numbering systems used on ICs and other semiconductors.

John Linsley Hood

TABLE 1. THE CODES USED IN THE MANUFACTURERS PREFIX.

Prefix	Manufacturer
AD	Analog Devices
AM	Advanced Micro Devices
CA	RCA
DS, LM, LF, LH	National Semiconductor
DG	Siliconix
H, HA, HI	Harris
HA	Hitachi
ICL, ICM	Intersil
IR	International Rectifier
MC	Motorola
OP, MP	Precision Monolithics
N, NE, SE	Signetics (Mullard)
RC, RM	Raytheon
SG	Silicon General
SL, SP	Plessey
SN, TL	Texas Instruments
µA	Fairchild
UCN, UDN, ULN	Sprague
XR	Exar
Z, ZD	Ferranti

These form the first group of letters in an IC type number, appearing before the number itself.

Integrated circuits are the easy route to circuit design. Many clever engineers have thought of ways of achieving the desired end in conveniently packaged and often quite inexpensive circuit blocks. However, there are two main snags. The first of these is knowing which is the right IC to use, and the second is to decide which version of the IC in question is the device that you want.

The circuit diagram may show a 741, but the catalogue lists a whole range of these from MC1741SCG to LM1741CJ-14. What does this mean? And the problem doesn't stop here either; there are all the digital ICs as well.

To start with, the first two letters in the specification refer to the maker of the device. MC, for example, refers to Motorola, µA to Fairchild, and so on. The letters at the end of the specification refer to the packaging, the temperature range for permitted operation, or the reliability guarantee.

Transistor type designations are a bit simpler since they don't usually have a prefix identifying the maker or a suffix specifying one of a range of package forms. The package is usually implied by the actual type number of the transistor. Unless they are very popular devices, like a 2N930 or a 2N6015, a particular transistor will only be available from one or maybe two manufacturers.

TABLE 2. PERMITTED TERMPERATURE RANGE.

Suffix	Temperature range
1 (Harris only)	−55°C to +200°C
M (2 for Harris, 54 for TTL)	−55°C to +125°C
I	−25°C to +85°C
C (5 for Harris, 74 for TTL)	0°C to 70°C

One of these letters (or numbers in the case of Harris ICs and TTL) will usually appear immediately after the IC number.

TABLE 3. IC PACKAGE DESCRIPTION

Manufacturer	Metal can TO99 TO100 8-pin-10-pin	Plastic DIL 8-pin	Plastic DIL 14-pin	Plastic DIL 16-pin	Ceramic DIL 8-pin	Ceramic DIL 14-pin	Ceramic DIL 16-pin	Power plastic TO92	Power plastic TO220
Advanced Micro Devices		P	P	P	D	D	D		
Analog Devices	J								
Fairchild	H	T	P	P	R	D	D	W	U
Intersil	K								
ITT		N	N	N	D,J	D,J	D,J		
Harris (H, HA, HI)	2*	3*	3*	3*	1*	1*	1*		
Motorola	H,G	P	P	P	V	L	L	P	T
National Semiconductor	H,G	N	N	N	J	J	J	Z	T
Precision Monolithics	J	P	P	P	Z	Y	Q		
Raytheon	H	DN	DB	MP	DE	DC	DD	S	U
Signetics	H	N,V,N,E	F,A,N,H	B,NJ	FE	FH	FJ		
Siliconix	A	J	J	J	K	K	K		
Sprague	H	M	A	A	H	H	H	Y	Z
RCA	T								
Texas Instruments	H	P	N	N	JG	J	J	LP	KC
	mainly linear ICs	mainly commercial or industrial types			mainly military or industrial types			transistor types	

One or more letters will usually be placed immediately after the temperature code letter, except in the case of Harris ICs where numbers are used (marked with an asterisk) and placed before the type number.

TABLE 4. LETTER CODES USED IN THE MIDDLE OF 7400 SERIES TTL TYPE.

Family type	Description	Propagation delay (per gate)	Average Power (per gate)
74ALS..	Advanced Low-power Schottky	3-4ns	1-2 mW
74LS..	Low-power Schottky	10ns	2 mW
74..	Standard TTL	10ns	10 mW
74S..	Schottky TTL	3ns	20 mW
74L..	Low-power TTL	33ns	1 mW
74C or CD	CMOS	50ns	<1 μW

The USA JEDEC listing, 1N-, 2N-, 3N-, only refers to the time at which that particular device was registered with the US military authorities, so a 2N5068 is a much more recent device than a 2N697. There is, however, a small measure of type identification in that 1N- refers to diodes, 2N- refers to bipolar or junction field-effect transistors, and 3N- means MOSFETS.

The European type designation actually gives a description of the general type of the device in its letters. The letters at the end of the type number, for small signal devices, usually denote the current gain range or the pin configuration. Table 5 outlines the classification system used to describe these types of discrete semiconductors.

North American sourced transistors (and ICs) are usually second-sourced (meaning that there are at least two manufacturers), whereas the European devices may come from one manufacturer alone. This is awkward if a designer specifies a favourite device which is not stocked by a particular store, although that same store might have been able to supply a substitute, which at a pinch, could have done the same job.

With digital ICs, the device classification, if it isn't standard TTL or CMOS, is tucked into the middle of the part number. The LS in 74LS68 indicates a low power Schottky device, while the HC in 74HC160 refers to high speed CMOS.

As a general rule, plastic encapsulations are cheaper than metal can or ceramic dual-in-line packages, and commercial temperature range devices are cheaper than the industrial or military versions. Although I have my favourite brands, my experience is that most modern devices from Western Europe, Japan, or the United States (including *off-shore* factory sites such as Taiwan and San Salvador) are reliable in performance and packaging. The companies in question would have gone bust in this competitive age if this were not the case.

Finally, while there are very few magic differences between one device and another for a given voltage, power and current range, an npn small signal transistor tends to be much the same as the next. Nevertheless, it is fairer to the designer if you try to use the particular device specified; there *may* be a good reason for the choice. ●

TABLE 5. THE EUROPEAN PROELECTRON CLASSIFICATION SYSTEM.

First letter	Second letter	Third letter (if any)	Number	Final letters
A = germanium	A = small signal diode			lead-out arrangement: (pin view)
B = silicon	B – varicap or rectifier diode			
C = gallium arsenide	C = small signal transistor			
	D = power transistor	not usually significant	manufacturer's catalogue number	L = B C E
	E = point contact diode			
	F, G, L = high frequency transistor			
	R = special purpose device			NO LETTER = E B C
	S = switching diode or transistor			
	T = thyristor or triac			
	U = high voltage transistor			
	X = same as B			
	Y = power rectifier			
	Z = zener diode			

current gain at 1 mA:
A = 40-120
B = 150-460
C = 270-800

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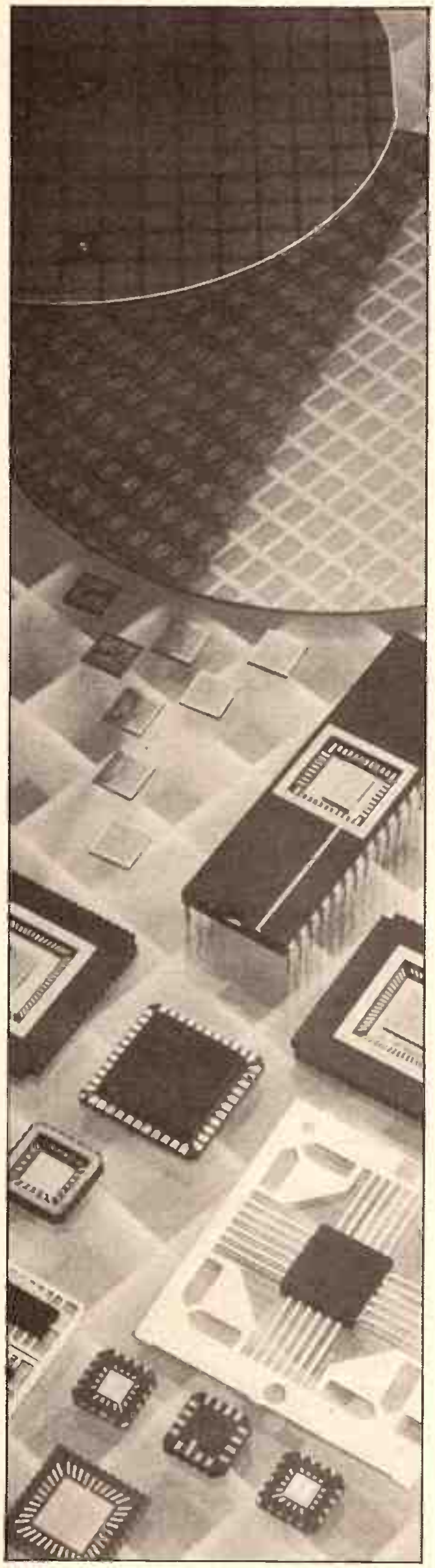

Courtesy Plessey.

ASICs: SEMICONDUCTOR GROWTH LEADERS

Application specific integrated circuits (ASICs) are taking the semiconductor world by storm. Here a senior executive with one of the main players discusses the advantages of the new way of integrating circuits.

Dev Chakravarty

Dev Chakravarty is product planning manager at Motorola's ASIC division in Phoenix, Arizona.

Custom chips, or application specific integrated circuits have been around for a number of years. In the last year or so they have really taken off, with market leaders predicting that some 30 per cent or so of all ICs will be of this type within the next few years.

They have a number of advantages. A single chip can replace up to 30 standard chips, resulting in considerable savings in board space, as well as in manufacturing costs. Additionally, designs using ASICs are much more difficult to plagiarize than ones using standard ICs. Performance is often enhanced because on-off pin delays are reduced.

There are three different types of ASIC: gate array, standard cell or full custom. Gate arrays have a series of logic gates etched into them, and rely on interconnections between these gates to achieve some specialized function. Standard cells are fully implemented functional blocks which may be joined together in any configuration to provide the overall function. Finally, fully custom chips are just that; designed from the ground up for a particular application.

Each has its own set of advantages and disadvantages. Exactly what these are can sometimes be a little difficult to say in precise terms, but the general trends are clear enough.

Gate arrays, for example, have a substantial processing advantage. Instead of the 11 to 13 mask layers required to produce a complete IC from a blank chip, gate arrays are on preprocessed wafers with up to 10 fabricated layers, which are routinely produced in batch quantities. The preprocessed wafers are subsequently customized with the addition of metal interconnects in the last 1 to 3 mask layers. The result is a speedy turnaround time, now in the 7 to 10 week range, thereby lowering prototyping costs — *but not volume production costs.*

Therein lies the reason for the great popularity of standard cells. They represent one of the fastest growing segments of the ASIC market. According to the market research company, Dataquest, the market for standard cells is expected to increase from a paltry $US120m in 1984 to a

> **"To help in the crossover between gate-array and standard-cell designs for a particular system, the ability to map a gate-array, when needed, into a standard cell would be ideal."**

sizable $US2400m in 1989, representing a compound average growth rate of 81.2 per cent.

Standard cell integrated circuits are essentially circuits that are built using standard cell libraries. Standard cell libraries contain a range of SSI and MSI functions. These functions include primitive devices such as NAND, NOR and XOR gates and JK type flipflops. More complex functions include mircoprocessor cores, configurable memory (both ROM and RAM), PLAs for random control logic and timers. Also included are analogue functions such as op-amps, comparators, analogue switches and A-D converters.

A vast range of functions thus exists in a standard cell library. Using the library is akin to creating systems-level designs from a data book. If required functions such as counters or shift registers in a particular configuration are not available, these may be easily created using the exhaustive set of primitive gates and flipflops.

The standard cell area on the silicon is surrounded by pads which can be dedicated to input or output only, input/output, or power. Standard cell designs can be both pad- or gate-limited. For example, if the number of logic gates used is very small, say around 100 while comparatively the number of I/O pads is large, say 20 pads, the resulting die can be pad-limited. Vice versa, when the number of gates is large and there is little need for I/O, the design is likely to be gate limited.

Standard-cell trends

IC designers have used standard cells in their handcrafted designs for many years. However, an important reason for the recent popularity of standard cells and their emergence as distinct ASIC products is the maturation of computer aided design (see elsehwere in this issue).

The other trend is in manufacturing technology. The majority of standard cells are being designed in 3 μm CMOS. This allows operation up to about 25 MHz and gate densities up to 6000 gates. Although experimental processes are routinely reported with very much greater sophistication than this, the next realistic step appears to be a move to 2 μm CMOS, which will increase both complexity and performance, although not by very large amounts.

So, when does one use the various types of customized chip?

In the *Semicustom IC Yearbook 1985*, D. Stanley Hurst and Stan Mask revealed the results of their study of empirical evidence from various manufacturers. They found that standard cells become a better choice than gate arrays when the volume exceeds 10,000 units. But when the volume exceeds 100,000 units, handcrafted full-custom products become preferable.

This gradient reflects costs, of course, but also some more subtle technical advantages. Standard cells, for instance, require that 11 to 13 mask layers must be uniquely fabricated; there are no preprocessed wafers. This costs, and it also requires longer turnaround time.

On the other hand, because standard cells can be further customized, substantial cost savings can be realized in the volume-production stage. With standard cells, the designer is not forced to pick a preconfigured I/O structure as with gate arrays. This flexibility can lead to die-size savings in pad-limited designs, which translate into the lower volume-production costs.

> **“ *According to the market research company, Dataquest, the market for standard cells is expected to increase from a paltry $US120m in 1984 to a sizable $US2400m in 1989, representing a compound average growth rate of 81.2 per cent.* ”**

Another vital point in favour of standard cell technology is that the designer is not restricted by a fixed amount of gates.

Only the silicon area actually required is used: no unused or unusable circuits need exist. For example, a gate-array designer with a logic circuit requiring 910 gates might have to use a 1200-gate array, should that be the nearest gate-array configuration that is available from the manufacturer.

Indeed, because of routing problems, many manufacturers recommend the use of just 80 per cent of the gates. Accordingly, the 1200-gate array could then be used just for a 960-gate logic design.

Costs

The total cost of ASICs is a function of two factors: *nonrecurring engineering* charges — the engineering cost for prototyping — and the production costs. The nonrecurring engineering charge is highest for full-custom products, somewhat lower for standard cells, and least of all for gate arrays. Production cost per unit is exactly the opposite, being least for handcrafted custom ICs, somewhat higher for standard cells, and much higher for gate arrays, because of the factors mentioned earlier.

The cost of an ASIC is the sum of nonrecurring charges and the production cost divided by the number of units. Once these set-up costs, production costs per unit, and number of units are available, the choice within the ASIC product spectrum can be easily made. The major variable is the number of units produced — and here is where the choice of ASIC type could be critical.

Mapping

There is another factor that needs to be added to this equation, and that is 'mapping', the technique of crossing over from one of these ASIC types to the other.

The trend is towards designing the original prototype as a gate array, so as to incur minimal set up costs. This allows the complete product to be prototyped, and perhaps even put on the market. If it's successful, continued high production costs can be avoided by redesigning as a standard cell chip. This means a system designer with an appealing idea but unsure of the market will not box himself into an unsatisfactory solution.

In today's highly volatile electronics marketplace, where demand forecasting is akin to crystal-ball gazing, systems houses are understandably hesitant to make optimistic projections about production volume. To help in the crossover between gate-array and standard-cell designs for a particular system, the ability to map a gate array, when needed, into a standard cell would be ideal.

Another reason the designer might choose gate arrays as the vehicle for a prototype is that the faster prototyping turnaround time would help send the product to market more quickly. Speedy marketing is useful in today's world of shrinking product life cycles. Later, when the demand picks up and the product cost must be reduced, the mappability feature permits translating the gate-array design into a standard cell device with minimal effort.

Essentially, mappability is a CAD concept. It depends on the ability of a CAD system to take data originally designed for a gate array and turn it into something suitable for a custom cell with minimal, or no, design effort. ●

EEPROMs: A TECHNOLOGY WHOSE TIME HAS COME

Although the advantages of EEPROMs have been duly acknowledged by the electronics community, there has been resistance to them notably because of their low density. But new processes are fixing that.

Elizabeth Mullins

Although ROMs and EPROMs have played a vital part in memory design for many years, system flexibility has been limited by the difficulty of reprogramming these devices in many applications. The information stored in ROMs is programmed during the manufacturing process and cannot be reprogrammed. EPROMs have to be removed from the system and reprocessed before they can be reused.

Traditionally, the search for non-volatility has led to the use of RAM and battery back-up. However, there have been limitations with this approach in environments where high temperature and space are factors.

The need for a non-volatile memory that could be erased and reprogrammed in-circuit became apparent as applications developed requiring reprogramming in remote locations. The first electrically erasable programmable read-only memory (EEPROM), Intel's 2816, was introduced in 1980. With in-circuit alterability and non-volatility, EEPROMs were seen as a solution for a standard storage program medium.

Many predicted the EEPROM market would explode into a billion-dollar business by 1990, but those forecasts turned out to be premature. The EEPROM market has suffered from a lack of standardization when compared with other technologies. And it has suffered from an absence of commitment from major semiconductor suppliers which would otherwise add credibility to the EEPROM concept.

Now, however, it seems the market is finally ready to boom. There is significant interest developing among major customers of electronic components as EEPROM devices reach the 64K-bit level. EEPROM technology is recognized as strategically important as its applications give new capabilities to other product areas.

Design options

Early EEPROMs used an extension of EPROM technology, first introduced by Intel in 1971. An EPROM is a read-only memory with a special feature: its program can be erased by ultraviolet light and reprogrammed in a PROM programmer. EEPROMs take this feature to the next degree, engineers can reprogram them in the field without interrupting in-service equipment operation. Remote reprogramming is possible via telecommunications or datacommunications links, thus saving the labour and system down-time costs usually incurred when changing code in the field. Each byte can be rewritten up to 10,000 times, leading to simpler, more flexible systems. And reprogramming is fast: a single-byte program edit takes only 10 milliseconds.

> *"EEPROMs take this feature to the next degree; engineers can reprogram them in the field without interrupting in-service equipment in operation. Remote programming is possible via telecommunications or datacommunications links, thus saving the labour and system down-time costs usually incurred when changing code in the field."*

The potential for convenient, low-cost system reconfiguration is enormous for OEMs and end-users. EEPROMs are currently finding a home in industrial process control applications where equipment can be self-calibrating. In military and commercial aircraft, on-board and diagnostic programming can be changed remotely. In retail stores, point-of-sale terminals can have pricing tables updated instantly. In harsh industrial and manufacturing environments, programmable robots can make use of self-diagnostic/self-correction feedback loops.

And the promise of EEPROM technology is not limited merely to memory chips. The industry is developing microcontrollers with on-chip EEPROMs that users can program for particular jobs, as well as developing EEPROM-based logic chips, which are circuits that perform calculations in computers.

The density barrier

A few challenges had to be met in order to make EEPROM technology viable. To date, density has been the big issue with EEPROMs when competing with other memory devices; EEPROMs now lag behind EPROMs by several density levels.

But that gap is narrowing. There are programs in place to escalate product development over the next few years from the current 64K level. One such program is the partnership between Intel and Xicor, a joint development agreement entered into in July 1985 to pursue high density devices. The agreement covers shared development of technology and is based on the expertise of both companies. Xicor's cell concepts will be coupled with Intel's CHMOS processing capability and fine line lithography. The benefits of the program are twofold: both companies will be able to accelerate the time-to-market of devices sooner than either could on its own. Second, the agreement promotes mutual second sourcing, since both companies will be manufacturing the new EEPROMs.

Pioneering a new process

The first process used with EEPROMs

evolved from the process Intel pioneered for EPROMs, termed 'floating gate tunnel oxide' — or 'FLOTOX'. The oxide region is thinned in a certain area, promoting the programming of the device electrically. But Intel is now changing the technology path at the 64K-bit level. The new process, a triple poly-silicon floating gate technology, differs from the previous processes in that the electrical charge is conducted from one poly layer to the second poly layer for programming, and from the second to the third for erasing.

FLOTOX has proven a highly reliable technology for lower densities. But the triple poly process allows the cell to be scaled to a greater degree than FLOTOX. The FLOTOX process can't be scaled any further without either making a much thinner oxide, which has reliability implications, or by using a very small tunnel area. The area defined by lithography is much more rigid with FLOTOX.

By using the triple poly process, design rules can be more relaxed and the lithography process less complex. Another advantage is that unlike FLOTOX — which uses two transistors — the addition of extra poly integrates the second transistor into the sturcture in the triple poly process, yielding a 1.5 transistor-type cell. This creates a much denser structure.

Competition

Although EEPROMs are not the ideal memory for all applications, they offer distinct advantages when compared to other memories. They hold the edge over byte-wide static RAMs in that they are an all-silicon solution to non-volatile memory, whereas static RAMs need a battery to operate, rendering them less desirable for military and high-temperature environments. EEPROMs will be able to capitalize on the fact that their memory cells are smaller than those of SRAMs, which use four transistors to the EEPROM's one and a half. EEPROMs will soon surpass SRAMs in density, improving their cost-effectiveness.

EEPROMs will also be considered in applications now calling for bubble memories, where access time is a factor. Bubble memories have a much higher density but on average take 44 ms to read or write, since all information is processed serially. In contrast, the write speed of EEPROMs is currently 10 ms and read speed is 200 ns.

Because EEPROMs offer the flexibility to alter information in-system, they possess certain advantages over EPROMs, which must be programmed outside the system. Intel estimates the need for in-circuit reprogramming to represent 10 per cent of the EPROM market. ●

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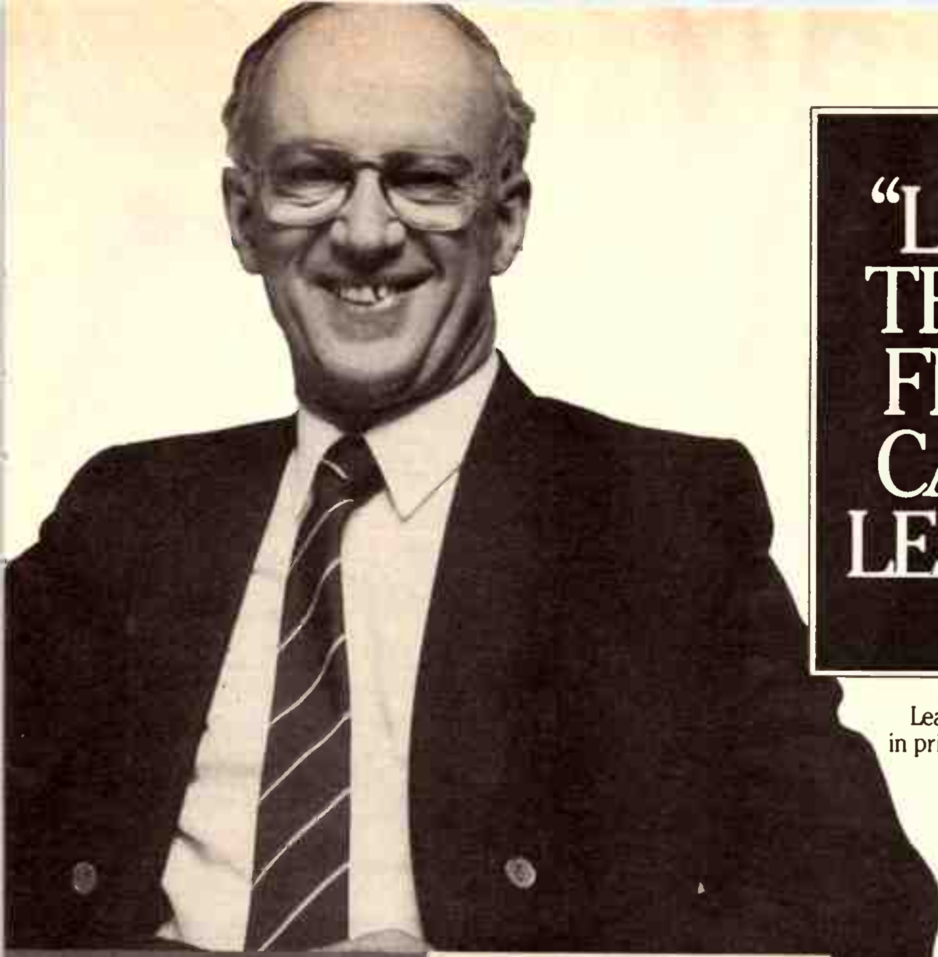

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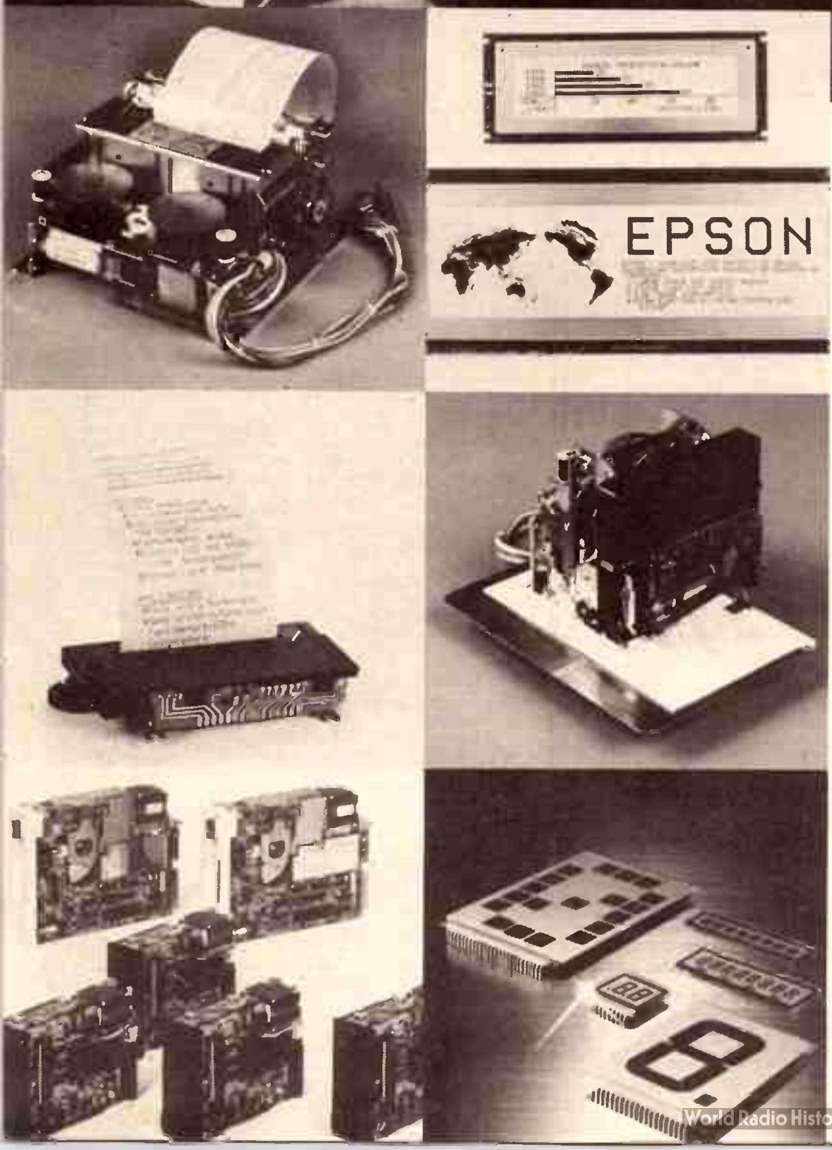

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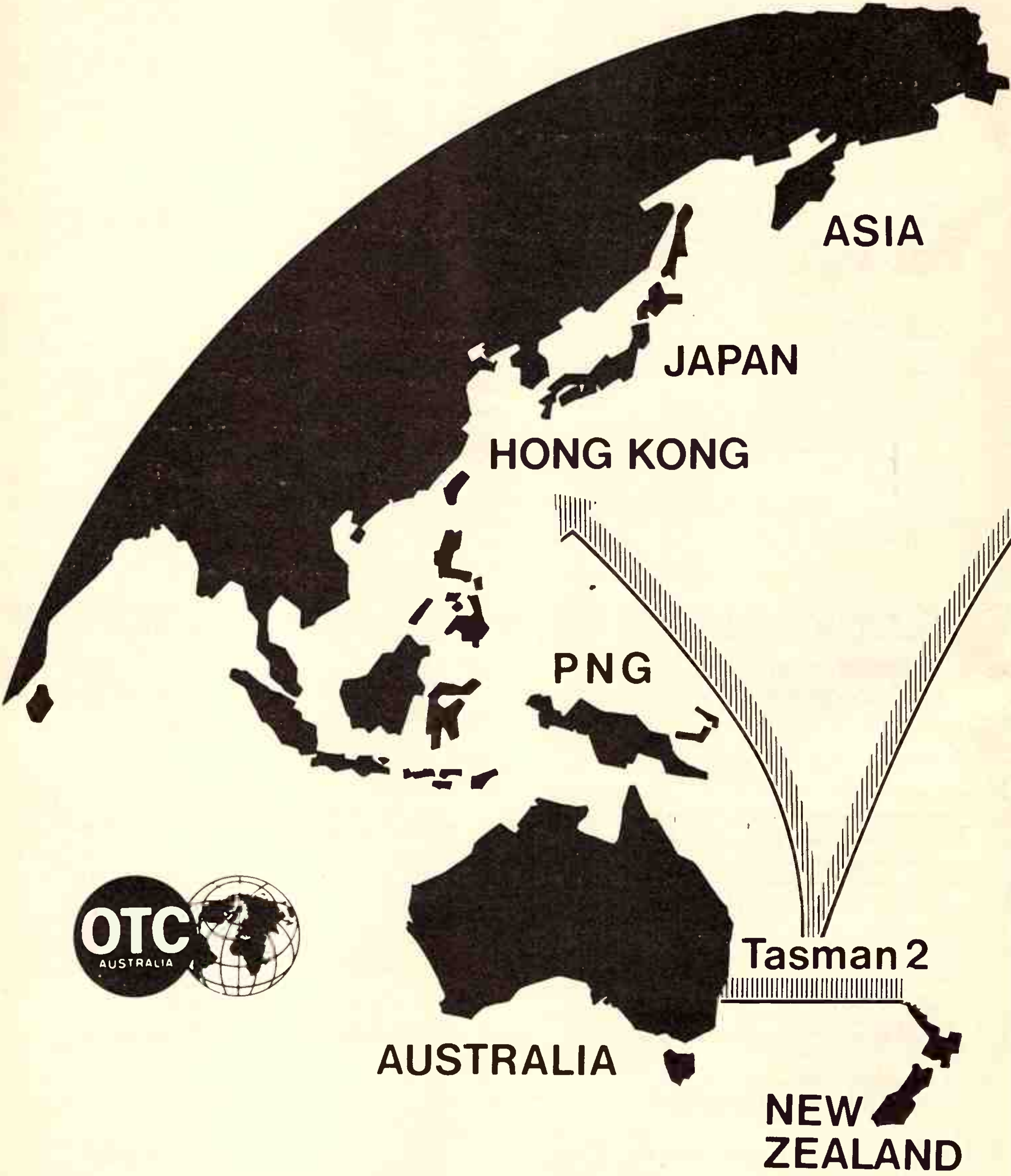
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COMMUNICATION ADVANCES HELPING THE ECONOMY

The trend towards globalization of business is necessitating greatly improved telecommunications facilities. Now Australia's OTC is planning for a 50 per cent stake in a new digital fibre optic submarine cable network that will link Pacific-rim countries.

George F. Maltby

George Maltby is Managing Director, OTC Australia.

Talking about communications is talking about the future: the future of regions' economies, and the future of the businesses that make up those economies. Both depend on the establishment of information and data communications networks. They also depend on the close co-operation of communications carriers, high technology corporations and major users, in the planning and construction of the facilities necessary to support the emergence of a high-level information society.

There are, I believe, three key elements impacting on the development of telecommunications services at this time, which, between them, are changing the whole face of the industry and its role. These are technology push, market pull, and new ▶

government perceptions concerning the role of telecommunications and its strategic importance in the development of trade in goods and services.

Technology push

The last 20 years have seen the emergence for the first time of worldwide telecommunications facilities of high standard. These have fuelled, and been fuelled by, a continuing high rate of growth in demand for telecommunications services. This demand has been met by the development of both coaxial cable and satellite systems. Indeed, the last coaxial cable systems — Perth-Singapore, Singapore-Southern France, Singapore-Hong Kong-Taiwan — are all about to go into service.

Now we stand on the brink of a new era of technology change: the advent of optical fibre submarine cables, which will bring with them much greater capacities than earlier analogue systems. Perhaps more importantly, they will make possible for the first time the development of a worldwide scale of fully digital networks. By the mid-1990s Pacific-rim countries will be linked by such systems which will, at least to some extent, have displaced satellite systems on major trunk routes as the dominant technology.

As an example, OTC projects that its capital spending program over the next 10 years will exceed $A2 billion. The single most significant component of this capital expenditure will be the construction of a digital fibre optic submarine cable network, in which OTC expects to have a 50 per cent stake. The project will be constructed in three stages, commencing with a 2500 kilometre link between Australia and New Zealand. Extensions to the system are planned first to North America in 1993 and then to Asia by 1995. The quantity of submarine optical fibre cable required for the proposed South Pacific network is up to 25,000 kilometres, making it by far the most most extensive fibre optic communications network in the world. Other systems have been announced for the North Pacific and within the region.

Why is there this concentration by Australia on Pacific and Asian development? The answer is simply that of Australia's 12 biggest international telephone streams, eight are to countries on the Pacific-rim and they are the fastest growing. This is not to suggest that we are currently working without facilities. Again, for example, OTC is already a major owner and user of cable telecommunications capacity, and intends to remain so. With almost 20,000 kilometres of cable in service, Australia ranks as the world's third largest operator of cable systems. At the same time, satellite technology continues to advance, although at a more measured rate, for those applications for which it is ideal, such as point to multipoint distribution.

Market pull

It is a truism to point out that business (the dominant element in future technology demand) is well on the way to becoming global in its focus. This trend is essentially the emergence of the much discussed information society, and it's bringing with it fundamental changes in the way telecommunications is seen and used by the major corporations.

Communications has always been a strategic marketing tool. Now the success or failure of a business enterprise depends on how efficiently the task of communications is managed. Recently an Australian banker said communications are no longer an aid to his business, they are his business! More than one third of all his global transactions are performed electronically. What is true for an individual business is also true for a country and for the Pacific economic region as well. Success will depend on how effective regional communications are.

> *Now we stand on the brink of a new era of technology change: the advent of optical fibre submarine cables, which will bring with them much greater capacities than earlier analogue systems.*

Already responsible for nearly half the world's GNP, the Pacific region is widely described as the focal point for the world's economic growth in the coming decades. Forecasts suggest annual growth rates in the region's key economies of between five and 10 per cent a year into the 1990s. If these figures and the banker's remarks about the central importance of communications are accurate, then we can expect a proportionate boom in the telecommunications industry.

As chief executive of Australia's international communications carrier, OTC, I can vouch for the accuracy of these forecasts by reference to some of our own planning. This year OTC will just carry under 1000 gigacharacters of international information (a gigacharacter is a convenient measure enabling the aggregation of voice, telex, data and television information). Within five years we expect the volume of information to exceed 5000 gigacharacters and by 1996 more than 40,000, over 50 times growth in 10 years! Communications carriers have become used to the need for doubling capacities every four years or so. The projections I have just given show that merely duplicating facilities every four years would leave Australia short of international communications capacity by the end of the decade. The same position exists in other parts of the region. It will be the responsibility of the telecommunicators to ensure capacity is provided on a timely basis to meet these needs.

The globalization of business, therefore, has direct consequences for international communications. Firstly, the internal communications systems of global businesses expand proportionately. Thus, around the world, communications providers find an increasing demand for dedicated private line services by large corporate customers for their own communications needs. A subsidiary effect is the extent to which international service providers such as banks, insurance companies, airlines and governments are following large multinational corporations in establishing offshore operations to service their major industrial clients internationally. Effective national and international coordination would be impossible without highly advanced communications networks.

Secondly and of particular relevance to the development of new information networks in the Pacific region, is the expansion occurring in the market for financial services. In the United States, Japan and Australia the financial services sector is undergoing structural change which will inevitably lead to expansion and higher levels of international activity. Changing business needs include the desire to actively participate in foreign currency dealings, together with new patterns of fund-raising and the ability to switch available investment funds to maximize returns. The advent of 24-hour commodity, futures and currency trading in successive time zones around the world further demonstrates the changing requirements of business. Changes to the regulatory environment are exemplified by the decision in Australia to allow foreign banks into the market while in Japan, the US and elsewhere through the region, a general liberalization of financial regulations has occurred.

Technology in the finance sector is the third factor responsible for substantial expansion. The national and international spread of automatic teller machines, electronic transactions, development of debit card systems and tele-shopping promise to transform the delivery of financial services to consumers. And without doubt, major financial institutions in the region have linked communications directly to the bottom line — it's no longer a passive resource.

OTC is active in designing systems specifically tailored to individual customer needs, and has achieved considerable success in its efforts to establish Australia as a major hub for corporate communications networks in this important Asia-Pacific region. Just as effective communications management is a key to commercial success, the success of telecommunications carriers is increasingly dependent on their ability to recognize the different requirements of users and to provide innovative communications applications, as well as services. OTC, like many carriers around the world, has become more market driven, reflecting a host of pressures on the carriers plus a realization that customer demands and satisfying them, both socially and in business, are the only reason for being in this industry. And these demands are becoming more complex and more articulated.

A unique feature of international communications is that it can only exist through the cooperation of carriers in separate countries, notwithstanding political and cultural differences. This long standing network of cooperation between the service providers is a basic element in ensuring orderly and timely development of facilities. Now there is a need to add a new dimension. The major user seeks to deal with only one entity. He expects that the service providers will, within their own system, ensure that his needs are met in a timely fashion and cost effectively. This challenge for the telecommunications carriers is one which they are moving energetically to meet. One-stop shopping will be a feature, I strongly believe, of major user services in the future.

Government perception

Driven by both the technology push and the market pull, the regulators in many countries have seen a need to revisit the traditional arrangements whereby telecommunications services are provided. I suggest that the fundamental position of governments has not, in fact, changed, but the perception has deepened. They are as concerned now as they have always been by the need to ensure the security and reliability of their telecommunications links, and by the need to be satisfied that innovation (with its advantages in cost reduction and expanded range of services) is not being hindered by traditional ways of doing business. But they are increasingly influenced by the perception that communications is now a central and strategic aspect of trade policy, both in goods and services.

The consequences of these enhanced perceptions are being seen through changes, in many countries in the region, in the role and ownership of common carriers. In the US, Japan and other countries the concern of governments is to ensure that the challenge of the information age is met by the organizations which provide public telecommunications services. It is no coincidence that in Japan the role of NTT and KDD is taking place at the same time as Japan is emerging as the second biggest economy in the free world. It is not surprising that the decisions taken have been different in different countries. It is unlikely that a solution which is proper for Japan, with its high population and substantial business development, would be appropriate for Australia, with its large land mass, small population and heavy dependence on markets far away.

> “OTC is active in designing systems specifically tailored to individual customer needs, and has achieved considerable success in its efforts to establish Australia as a major hub for corporate communications networks in this important Asia-Pacific region.”

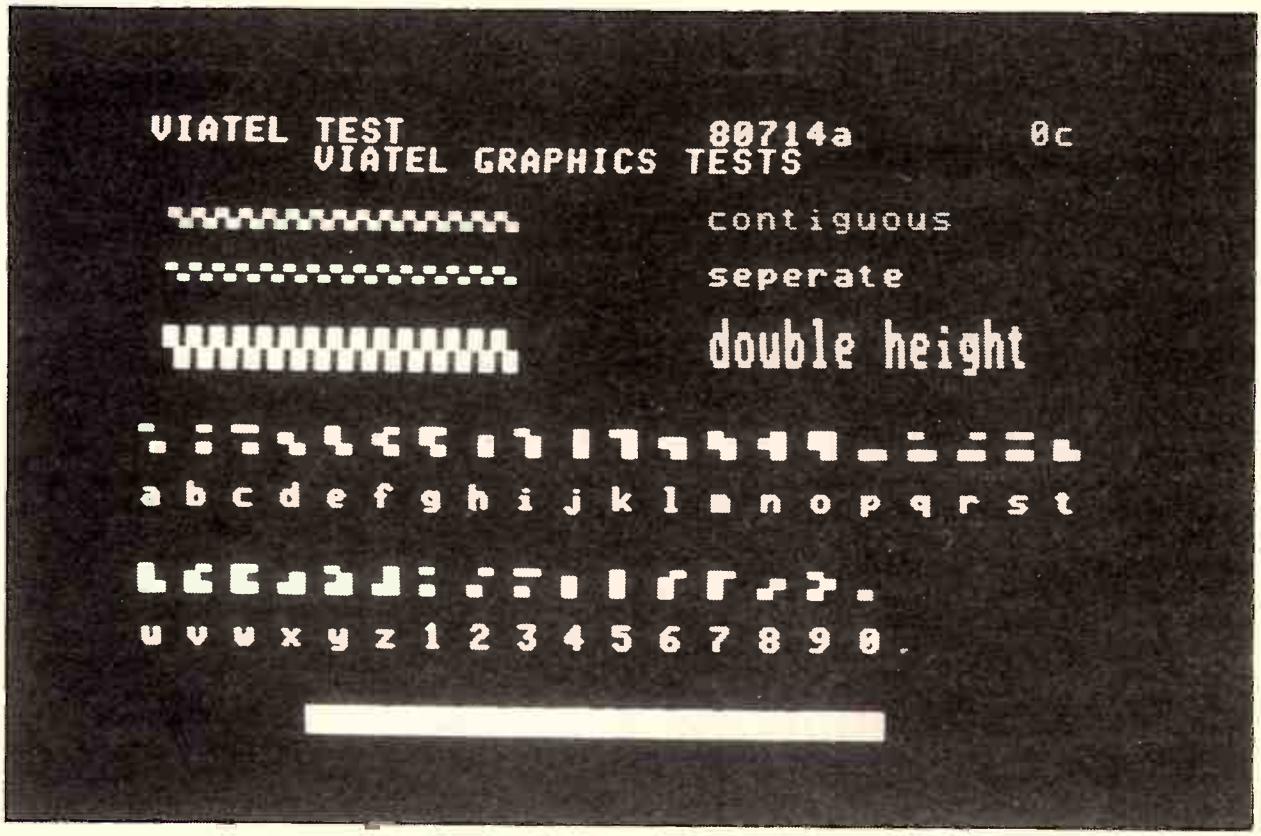
The key element is that the change process is there and is accelerating.

The 14 years to 2000 will see the region's ocean beds crossed and re-crossed with laser powered communication cables, while in space, new communications satellites will match the economics of submarine cables. Certainly in Australia OTC knows it has to manage this technology explosion and the changes in market needs and government perception it is bringing about, if it is to contribute to Australia's future growth and prosperity. ●

VIATEL UPDATE

Late in October 1986 Viatel signed on its 20,000th customer, and as a result Telecom is feeling bullish about its data communications flagship. All indications are that it's been a success in Australia.

Jon Fairall



Viatel continues to attract a growing number of Australians to its banking, shopping, financial and betting facilities. According to Telecom publicity, the number rocketed through 20,000 last October and is still growing.

The number of service providers seems to have taken off again, after plateauing in the middle of last year. Telecom recently signed an agreement with its 200th service provider.

It seems, in fact, that the age of 'new media' has arrived in Australia. The market penetration is reaching a point where Viatel is becoming an acceptable tool for doing business and pleasure. So what is it, where has it come from, how is it done and where is it going to?

Definition

Firstly, what is it? Viatel is a videotext service, a way of sending text and low resolution graphics down a telephone line. The fundamental structure of Viatel has users connected to a central computer. The connection is via the ordinary switched telephone service that Telecom provides to all subscribers. Cost is only a local call from anywhere in the country. The computer itself is located in a telephone exchange "somewhere in Melbourne".

The user connects with the computer from a terminal. This can be as simple as a small handheld console which uses a TV as a display, or as complex as a personal computer in terminal mode. The PC needs a modem which transmits at 75 baud (bits per second) and receives at 1200, plus some software to enable the PC to display Viatel graphics characters correctly.

At first sight this might seem an odd standard; 75 baud is not exactly setting the world alight. But in fact it makes very good sense for teletext services where the name of the game is to send lots of data one way, and very little the other. For the most part, communications from the terminal to the host computer consist of single keystrokes to select pages for viewing, answering yes or no, and so on. For this, a slow baud rate is quite adequate.

History

The first practical videotext system was Prestel, which was introduced by British Telecom in the late 70s. Although substantially the same as Viatel, its introduction was a resounding disaster. After an opening with fanfare and hyperbole, the Brits stayed away in droves.

The international community had watched the introduction with great interest and the British disaster provided an object lesson in how not to do it. The lesson seems to be that it all revolves around the marketing of the system. The British assumed, not without reason, that there were millions of people just hanging out for the introduction of Prestel. The expectation was that British Telecom would be flooded with business. As a result, prices were set at a reasonably high level when the service was introduced, and no special effort was made to attract the right sort of information providers.

> **66 *... the typical Viatel user is 35, earns more than $30,000, is well educated, likes new technology and is probably either in management or self employed.* 99**

The silence was deafening. Chastened British Telecom managers, indeed, managers of potential videotext services all over the world, were forced to conclude that people really *did* need a reason to use data communications. To get people in, services have to exist, and of course, services are hard to provide in the absence of consumers. It's a new version of the old chicken/egg conundrum.

Telecom Australia solved the problem quite neatly by providing the service to consumers at a ridiculously low level ($2.50 a month) and encouraging some critical service providers to come on-line. One of the first was the Commonwealth Bank which provided some limited computer banking services. Other early service providers were orientated towards business and domestic computer users.

COMMONWEALTH BANK

The Commonwealth Bank was one of the first information providers on Viatel. On day one it had a few frames up advertizing its services, and within a few months a full range of services.

Services offered include transferring funds between your account and other accounts on the system, paying bills, balances, statements and cheque book orders. It's possible to pay phone, gas, electricity, land and water rates, Bankcard and American Express bills on the system.

The service costs $4 a month, apart from the normal Telecom charges.

The world

The results have put Australia into the big league of videotext users in terms of per capita use of terminals. We overtook the British long ago, and the US doesn't really get a look in, primarily because of the difficulty in agreeing on a standard.

The exception is the French, who have the highest penetration of terminals in the world. The French experience has been very different from the Australian or British one, and is tied in to the history of their communications system in general.

In the 1970s the French woke up to find they had a communications infrastructure falling around their ears. After years of neglect, it was almost impossible to get a connection into the system, and when you did, almost impossible to dial out without getting a wrong number or crossed lines. It was expensive to run, and they had one of the highest maintenance bills in the world.

So they decided to rebuild from the ground up, using the very latest in technology. The French also decided that they would design and manufacture the system locally, only with locally owned companies. The result is that today France has a flourishing telecommunications industry.

They also have a flourishing computer industry, because one of the decisions taken early in the piece was to give subscribers terminals to use instead of a telephone directory. The result has been a healthy industry, and a data communications facility that goes far beyond finding telephone numbers. In fact, Minitel, as the service is known, has expanded dramatically in unexpected directions. For instance, one of the current favoured ways to meet someone of the opposite sex is via a lonely hearts bulletin board.

How Viatel works

The main players in the structure of Viatel are Telecom Australia, service providers, sub-providers, closed user groups (CUGs) and users.

Telecom provides the hardware, the lines, the exchanges and the central computer. It also provides a billing service (see table). It provides very limited editorial control, mainly towards ensuring that acceptable community standards are applied.

Telecom has little enthusiasm for its role as censor. To date, it has restricted itself to removing obscenities from various data- ▶

PRICES

	per month	frame rental per 50 frames	access	connect time M-F 8am-6pm	other
user	$12.50 bus $03.50 pvt	—	local call	0.09/min	discretion of SP
SPs	$260 for 50	100-1000 $22.50 1000-5000 $15.00 5000-10,000 $10.00	"	editing $0.12	5% of revenue
SSP	$40	—	"	"	"
CUG	$29	—	"	"	"
gateway	$360	—	"	—	—

bases. However, Viatel is a medium that thrives on anonymity, so its potential for generating controversy should not be underestimated.

Escort services, brothels, dating services of both heterosexual and homosexual persuasions, and other somewhat racy organizations may all be expected to come on-line soon. Doing it the French way seems to be the latest sport.

Telecom's legal obligations seem somewhat uncertain. It would appear to have no right to deny anyone access to the network. On the other hand it has a duty not to cause public affront. For publicity-shy Telecom managers, the situation has all the ingredients of a nightmare.

Service providers (SPs) hire 'frames' from Telecom. Each frame consists of a Viatel standard screen. The screen is equivalent to about 500 bits of information, consisting of 25 lines by 40 columns. Graphics are available as blocks of colour filling one text position, definitely low resolution, but extremely simple to transmit.

SPs can compose their own frames from special editing terminals. A special editing password gives access to the system editor, which allows the user to produce new frames and amend or delete existing ones. Editing may be done in the on-line mode from an ordinary terminal, or in the off-line mode using an intelligent editing terminal. This means that the frames are composed on the terminals before the connection is made to Viatel, and then bulk uploaded at 1200 baud to the Viatel computer. It's much faster where large amounts of data are to be used.

SPs hire an initial 50 frames and then more as they need them. If less frames are required, an organization can approach another service provider and sublet a small number of frames as a sub-provider. A number of organizations have sprung up solely to provide this sort of umbrella facility. Typically they offer not only space, but also technical assistance and advice. Naturally they charge for this, but it can still be an attractive propositon for people interested in testing the Viatel water before making a major commitment.

Another type of SP is one who already has a major commitment to a computer system. This SP might have a very large database containing company information, for instance. A connection can be established between the Viatel computer and the other computer via a 'gateway'. Usually the Viatel system then becomes completely transparent to the user, so that the way the system works is determined completely by the host computer. The advantage of the gateway system is that it makes long distance or public access to an existing database cheaper and easier.

The success or failure of the services offered by the SPs and sub-SPs is measured, by and large, by how many people try to access them. However, this is not always the case. There may be times when information is confidential as, for instance, in the case of a company with branch offices all over the country using the Viatel database for its inventory. In such cases it's possible to make access to particular frames available only to particular passwords. This then forms a closed user group, or CUG.

Many in Telecom see the CUG as a major growth area within Viatel. It will be interesting to see how growth in this area competes with the growth in private networks now being offered on Aussat. Currently, the Aussat option costs a lot more than a CUG on Viatel, but this situation will not last.

The user

The final player in the Viatel game is the user. Deliberately, their commitments to Viatel may be very low, yet it's their number, and the frequency with which they access the system that determines the success of the system. Who are they?

According to a survey by Paul Budde, the guru of videotext systems, the typical Viatel user is 35, earns more than $30,000, is well educated, likes new technology and is probably either in management or self employed.

Over 75 per cent of Viatel users access the system via PCs. Manufacturers, scenting profits in the Viatel hills, have jumped on the bandwaggon. Virtually all now provide dedicated software for their particular machines. In addition many have secured space on the database. There are also a large number of suppliers of related products, Nashua (disks) and Microeducational (peripherals) for instance.

There is, too, a fund of public domain software available from organizations like Microtext666, which has hundreds of programs, and smaller organizations like Tango and Tastel. It's interesting to speculate on whether the trend by PC users towards Viatel will spell the end of the 300 baud bulletin boards that now dot the country. Some bulletin boards have provided gateways into their systems from Viatel, others studiously ignore it.

Security

One of the most important elements of any public computer service is the security arrangements made to protect data. Service providers and Telecom claim their services are virtually tamper-proof. On the other hand, a string of articles has appeared in the popular press claiming that 15-year-old whiz kids are clambering all over the database writing grafitti on the walls.

The truth is a bit more prosaic. Actual manipulation of the database from outside

VIABET-WA TAB

Out of the enormous range of applications available on Viatel, one of the more intriguing is the Western Australian TAB. Punters can get the latest information on odds, horses and owners as well as place bets and see results. Best of all, the service is completely free except for Telecom charges. There's a cheque withdrawal system to get your winnings out and an account system to allow you to pay when required.

the system seems to be almost impossible. After 20 or so years of writing software for public databases, programmers have managed to trap most of the errors which once allowed access.

However, there is another type of crime that is gaining a lot more popularity than anyone, especially Telecom, would care to admit, and that is the type that involves perfectly straightforward manipulations of the database, but using stolen or fraudulently obtained passwords.

In Viatel, there are three codes that the system must receive, a customer identity number, a personal password and a Viatel number. The Viatel number is a low security number, used by any member of the public to address the user directly. This function is necessary for the messaging service. The personal password is a four digit combination originated by Telecom when the user first joins the system. However, you can change it any time by using Frame 920. The customer identity number is a 10-digit number used mainly for billing purposes. It is confidential of course, but can't be changed without talking to Telecom.

When the user logs on to Viatel, it's necessary to enter both the customer identity and the personal password. The system compares them, and if they don't match will disconnect you after three tries. It should be a very secure arrangement, especially if, as Telecom suggests, you change your password often.

One method of defeating the password system, popular in the early days, was to use the computer to generate all possible combinations of the password and to try them in sequence. This has been effectively foiled by the disconnect facility. Of course, there is nothing to stop you using an auto dial modem to redial automatically, except the cost of calls and the length of time it would take.

In fact, on the assumption that it was necessary to search half the possible combinations before hitting the right one, and that it took 30 seconds to make a call and cycle through three options, and assuming that Telecom charges 15 cents for a call, some simple calculations show that it would take about 26 days and cost $11,000 to achieve. And all that assumes that no one would notice your auto dialler in action consistently for 26 days.

According to Telecom, even if you did get in, there wouldn't be a great deal you could do to damage things. This is illustrated by the 'Robin Hood' case. Apparently, a person using the pseudonym Robin Hood acquired access to Viatel by stealing a password number. He managed to cause a great deal of unpleasantness by sending Telecom money to an Adelaide service provider.

This did no one any good at all, since the transaction was instantly recognized, traced and reversed. However, it did underline the vulnerability of the database from stolen passwords. Telecom had been sufficiently relaxed in its attitude to security to allow prospective users of the system to operate terminals from Telecom business offices. Robin Hood apparently watched an operator key in a password, and was then allowed unsupervised operation of the terminal. He apparently accessed the frame where the 10-digit customer identity is stored, after which he had free access to the system.

Needless to say, Telecom has since changed its procedures. However, it would be silly to suppose that this will be the last incident of its type. The ultimate defence, however, is already available. Change the password often.

The future

The future for Viatel seems secure. Leo Chessell of Syscorp, a major Viatel system vendor, says that progress in Viatel "has an inevitable quality about it," even if it seems to progress in fits and starts. In the short term the future for Viatel will undoubtedly consist of getting more and more people onto the system. As market penetration becomes greater the number of services will increase dramatically.

At the same time the growth of data transfer capacity over the next decade will improve the quality of the system. Progress on ISDN is well advanced, both in terms of exchange equipment and trunk capacity between exchanges. With ISDN in place will come the ability to do photo videotext.

An experimental British version of 'phototext', for example, utilizes 64 Kbps to send its images around, and a rather small frame store to take in the received information. The definition is achieved by sophisticated compression techniques and digital-to-analogue conversion which removes the aliasing from the image. Even if Telecom doesn't go for this system, it is likely this is the level of definition we will be looking at in the year 2000. ●

NON-TELECOM SERVICES

A side effect of the creation of the Viatel system has been the growth of complementary services. These use exactly the same protocols and structure as Viatel, but are operated independently by large firms. In fact, the first public access data base in Australia was of this type, run by Elders-IXL.

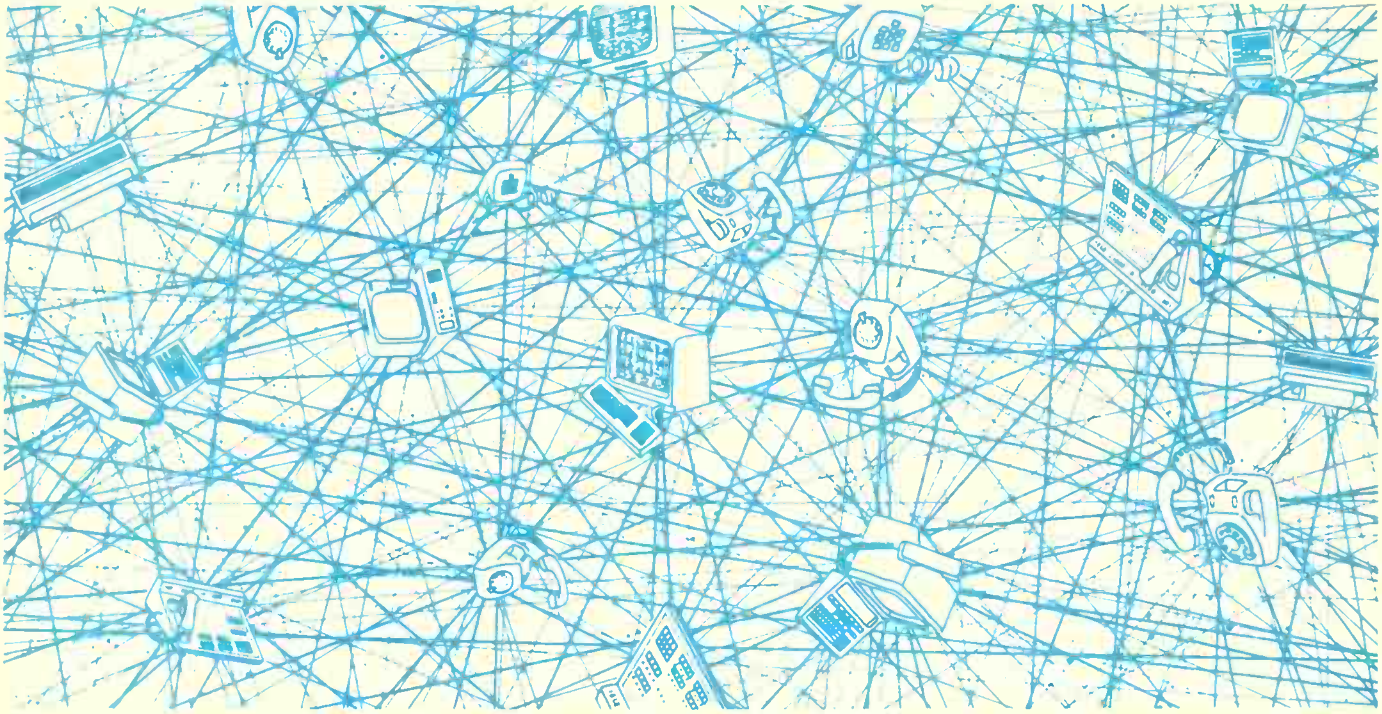
Frequently the motivation for creating a separate system has been security. In the case of the banks this is especially so. Not unnaturally, they take the view that they must be responsible for their own security. Whether Telecom's arrangements are satisfactory is beside the point. A recent trend has been the creation of gateways between the various systems. In the case of Westpac, for instance, it's possible to access the system either from Viatel or by ringing a separate number.

SOME USEFUL NUMBERS

Elders Agriservice: runs Elderlink and Sharelink. A very large database, one of the first in the country. Access is via Austpac 01921 then *211113999# or *21108999# or direct on (02) 221-6077 or (03) 602-1544 or (08) 212-5288.

DTX Australia: specializes in providing services for CUGs, but has some public areas. Messaging at $6 an hour is claimed to be the cheapest in town. Call on (02) 957-4203 or (09) 225-0444 or (03) 614-5066.

Westpac: Westpac will be offering a home banking service later in the year. Currently, just some information frames tell you all about it. It will offer a gateway from Viatel, or a separate access number (02) 266-0240. Currently, use 1# as ID and ## as password, and you can look around.



THE LOCAL AREA NETWORK

The local area network is becoming a more attractive means of linking your office micro to peripherals. Its real advantage lies in the fact that it does away with changing plugs and connections to provide a permanent connection.

Stewart Fist

For a number of years it has been just as easy to have two computers communicating across the continent as it was to link two in adjacent offices. Unless they were physically only a short cable-length away, the easiest way to transfer information was to plug both into modems and use the inter-office telephone connection.

The problem with this arrangement is that often you need to transfer large quantities of information and to share resources such as hard disks, printers, plotters and transient items like addresses, stock records, electronic mail, electronic filing systems and applications programs.

Even at a speed of 4800 bits per second (bps) on a standard telephone network, it still takes over five hours to transfer the contents of a 10 mega-byte hard disk. This is obviously not the type of zappy information interchange that comes under the heading of 'resource sharing'.

Here is where local area networks enter the picture. By linking microcomputers and peripheral equipment like printers, mass storage devices and, particularly, hard disks, into a local area network, information can be exchanged and resources shared.

What sets LANs apart from single direct connection or PABX-linking, is that all devices have a permanent electronic connection to the system at all times; there is no real (cable) switching involved. Every 'node' on a LAN can communicate with every other as long as both speak the same language, ie, use the same protocols.

Three different architecture, or traffic patterns, are now being advocated by different system proponents:

Bus

This is the simplest and cheapest overall topography. A bus structure usually uses a main-trunk twisted-pair or multi-wired cable into which the peripherals and PCs are connected just as branch roads run off a main highway. Every connection into the circuit (road junction) is known as a 'node' (by extension, the term is usually applied to the terminal workstation as well).

One of the advantages of bus topography is that a wide range of equipment can be hung on the LAN without problems. Dissimilar items of equipment may not be able to talk to each other, but they can share the use of the cable and the use of various peripherals.

In terms of data rates the bus form of LAN is the slowest but also the cheapest of the alternatives. It has the added advantage that if one element in the system fails, the others continue to operate as before.

Star

The star is a carry-over from the old days when central mainframe computers were linked by dedicated radiating cables to a series of terminals. The idea might be ancient but it still has merit. Star design needs a network-server (usually a dedicated computer which controls the network) at the centre. All other computers and peripherals are on the end of lines which radiate out from this computer and all information is routed through it.

This central network-server needs to be dedicated to its job of looking after the system; if it crashes, the whole network goes with it. By the same token, if a peripheral fails the system continues uninterrupted. The network-server polices the operation of the network and the peripherals and ensures that the files (groups of data) on the hard disk unit aren't corrupted by uncontrolled access.

Over short distances, star networks are usually connected by twisted-pair cables (as are telephones) and transfer speeds to about 1 Mbps are possible. They are only handling traffic between the centre and one node, so this is usually adequate.

Twisted pair cabling also has the advantage that it is often already installed for the PABX network in a building but for the LAN to work well, nodes must not be more than 600 metres from the hub. For longer distances, coaxial cable or optical fibre can be used.

The new digital PABX systems which handle data and voice are, of course, a specialized form of star network and they share many of the star-LAN features.

Ring

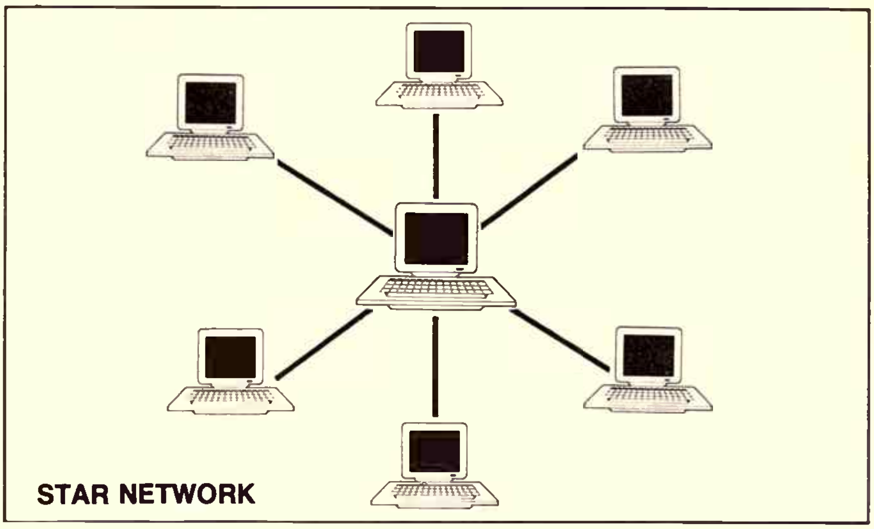
The third type is the ring, or *daisy chain*, which is a large electronic traffic circle. All PCs and peripherals are connected together in a circle and all information passes through each node in the system all the time.

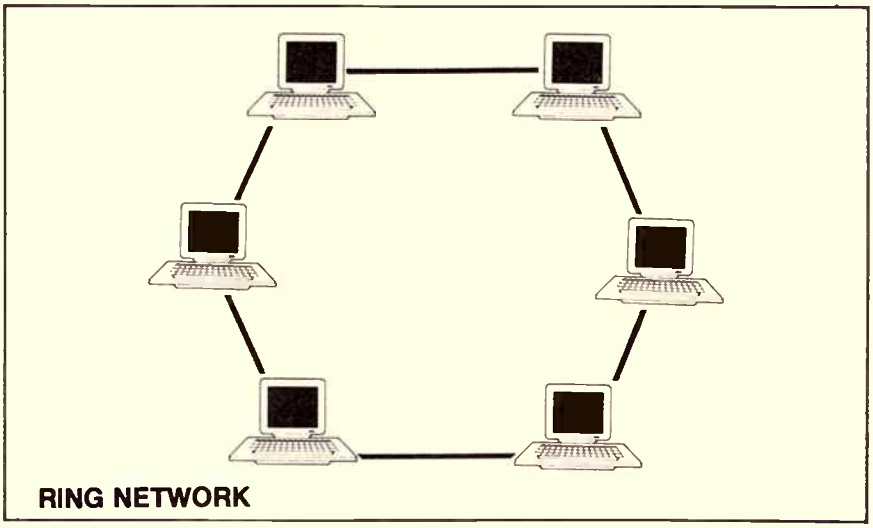
In the early days of ring topography, if one PC crashed the whole ring would grind to a halt. Nowadays, a parallel path around each node provides a detour when problems are experienced. But this means costly electronics to handle the detour defaults.

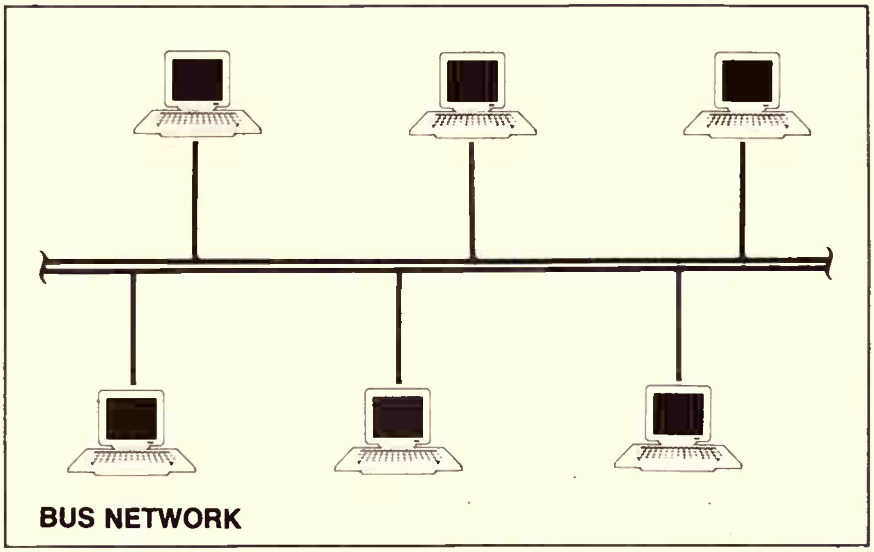
Like a PC star network, the nodes can be connected to either twisted-pairs, coaxial or optical fibre — with the same limitations and advantages.

Transmission

Apart from the network architecture/topography, LANs differ in their approach to signal transmission. ▶







Baseband

Some local area networks like Ethernet and Cambridge Ring use a form of transmission known as baseband where the digital data is transmitted in the same form as it was generated, through a single channel.

Xerox's Ethernet, which is the most popular example of a baseband LAN, uses a coaxial cable to allow nodes to be separated by distances of up to two kilometres. The system also has the advantage of extremely high speeds, although the capacity is much less than the rival broadband techniques.

With baseband LANs, only one user at a time can access the system — that's what the word 'baseband' implies. There is only one *base* channel *band* available, so special measures need to be taken to control potential 'collisions' between data originating from different terminals trying to use the channel at the same time.

This single-user capability sounds more of a limitation than it usually is in practice since LANs can move data around at very high speeds. A thousand word file (a four-page letter) could be transmitted along a LAN to the hard disk in 0.008 of a second at the Ethernet speed of 10 Mbps. Unless a system is grossly overloaded, most users won't notice any delays.

Broadband

Broadband, the second form of network transmission, also needs coaxial or optical fibre links. If you've got many users and multiple-sourced, different-type transmission problems, then broadband is probably the only way to go. Naturally, it is also the most expensive.

This transmission approach avoids data collision problems by modulating the signals into different frequencies using band-pass filters for channel separation. It's much the same idea as radio and television broadcasting: the signals from different stations don't collide because they are modulated by different carrier frequencies. We tune our receiver into the one we need.

In the more elaborate broadband systems, the bandwidth may be carved up into dozens or even hundreds of different dedicated channels. You might have a large number of channels dedicated to the transmission of 1200 bps data, others which are Ethernet channels superimposed onto the broadband for those using the baseband LANs, and yet another carrying the video signals to the boardroom, and so on. You are not restricted to one form of data.

The third major factor to be considered is access protocols. If anything, this is the most confused area of all. Network protocols allow all terminals and PCs to get fair access to the system while preventing them from corrupting the data of others.

Token-passing

Token-passing systems have a way of passing around control of the LAN from one machine to another — it's like the kids' 'pass the parcel' birthday party game.

> **_The development of LANs and the introduction of digital technology to PABXs is still in the early stages, but it is becoming increasingly apparent that the LANs v PABX argument is no longer an issue; it is a matter of 'horses for courses'. Both can be used separately or together._**

Whichever machine has the *token*, controls the system, while the others are blocked from access. The tokens are just a digital code which is recognized by all the nodes in the network.

Token-passing is particularly suited to ring topography. Each station passes on the permission to transmit to its nearest neighbour until one is found with a message to send. The peripheral with the message modifies the token to show that the system is in use and then attaches its message to the token before passing it off around the ring.

Each node in the chain reads the token, and if it is not addressed to it, passes it off to its neighbour. The receiving station detaches the message, restores the token, and off it goes around the ring again.

CSMA/CD and CSMA/CA

Carrier sense multiple access with collision detection (CSMA/CD) or collision avoidance (CA) systems allow each node to listen to the network, and if they find a gap (milliseconds long) they butt in and use the system. There is no control, as such. If two machines try to use the system at the same time, the collision of data is detected by both and both close down for a random period then try again.

This form of protocol is the cheapest to implement, and is particularly suitable for bus systems, so you'll often find bus-CSMA/CD systems at the low end of the market where only a few local computers need to be linked to share peripherals. It is obviously not a protocol that can be used effectively in large capacity high-speed systems.

Distant connections

Once a network extends out beyond a large office block (or perhaps university campus) the LAN will probably need to be connected to a packet-switching network or dedicated data lines. Protocol translation may then become a problem. One solution is to use a common carrier which has been specially designed to handle many forms of input. This is the advantage of Austpac, Australia's packet-switching network.

When Austpac links together your headquarters and branch offices, you no longer have to worry about equipment compatibility. You can choose the best machine for the job, rather than one that fits a standard perhaps decided many years before.

In time perhaps, we will have wideband cables and longer range LANs available to connect homes and offices. Working at home will then become a distinct possibility for the many information workers now tied to the office by the need to constantly access the office systems. But at the same time, packet-switching costs could drop to the point where these developments are unnecessary.

The range of possibilities for data communications on LANs is steadily increasing. Already there are LANs which carry digitized voice as well as data and, as far back as 1981, successful experiments were carried out in the US to link cable television systems into local networks designed for data distribution. Tymnet, the major packet-switching system provider in the US, successfully linked the Viacom cable TV network in San Francisco to the Manhattan cable station in New York. The cable TV circuits were simply used as large-scale local area networks.

Within most offices however, we already have our gateway to the outside world through the PABX. The electronics industry has had much more experience over the years with PABX systems than with LANs; automatic telephone exchanges are reliable, easy to operate and easy to expand.

The development of LANs and the introduction of digital technology to PABXs is still in the early stages, but it is becoming increasingly apparent that the LANs v PABX argument is no longer an issue; it is a matter of 'horses for courses'. Both can be used separately or together. Switched and dedicated lines have advantages in some situations and some office environmnents, while LANs and their close relatives, the packet-switching networks have more value in others.

In our office of the future, all forms of data communications will probably exist ▶

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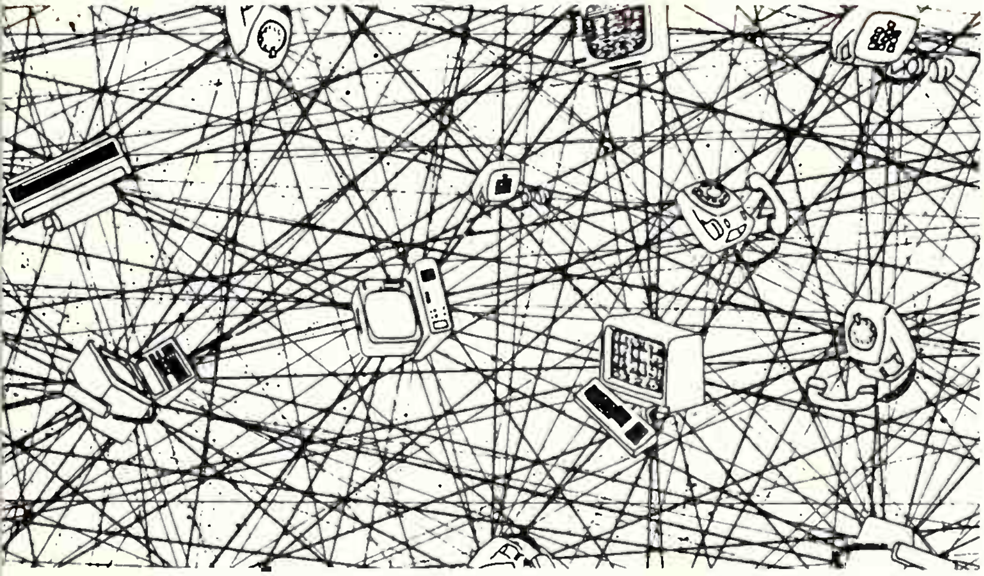


side by side, or perhaps the systems will become so integrated that it will no longer make sense to talk about them as separate entities.

Where the action is

Many business users seem to be waiting for IBM to consolidate its move into local area networking before making a decision. IBM has chosen to run with the Sytek system at present, but its own star-ring system is only one or two years away.

In a recent survey of large US businesses only nine per cent had a LAN installed, although another 12 per cent said that they had plans to put one in before the end of 1986. Sixty per cent of these respondents were leaning towards the futuristic IBM system — as always, IBM is a safe buy for the faint-of-heart.

The survey was taken before AT&T released its plans, however. This telecommunications giant is fast imposing its presence on the US computer industry although it seems to be choosing to run with IBM rather than in competition to it. AT&T has thrown its hat into the ring to support a star-type network called ISN which is essentially a small digital PABX system — an appropriate decision for the company that pioneered the telephone.

At the same time AT&T has continued to back its own 3B-Net which is based on Ethernet and says it will support Corvus's Omninet for the low-end PC user. Industry gurus agree that smaller local work-group LANs (like the Macintosh Apple Talk) will survive as long as they connect easily into the larger (read *IBM*) systems.

The surveys also reveal that large LAN systems are now growing strongly against digital PABXs which are their only rival as company-wide data communications devices. This could be because LANs have been getting the headlines in computer magazines for the past few years. There aren't too many 'telephone' magazines around to boost the popularity of PABXs, but digitial PABXs are still a valid alternative with advantages to many companies.

The prospective business-user survey revealed some bad news for Xerox whose version of Ethenet (used by four per cent of the respondents) now seems not to fit into the long-term plans of many large corporations since IBM belatedly made a showing on the scene. But IBM's real impact is still to come, and Ethernet is now too large for even IBM to ignore anyway.

Of the 42 per cent of respondents *not* intending to use IBM, the choices were: 9 per cent Sytek, 5 per cent WangNet, 4 per cent AT&T's 3B-Net, 3 per cent 3Com, 2 per cent Corvus/Omninet and 19 per cent others. The response shows AT&T's problem: it just isn't seen by American businessmen as a power in the computer industry, but it is, of course.

When the computer industry itself is surveyed, the projected picture is quite different. IBM is not seen by these people as such a technical innovator in the micro area despite its undoubted skills with main-

WHAT CAN LANs DO?

Networking is still not well understood, and there are too few working examples of succesul LAN implementations for the success of the technology to be taken for granted. If you are planning to buy a LAN system, this is the minimum you should expect it to do.

Sharing. It should permit a number of users to share files on a hard-disk without risk of corruption, and all PCs should be able to use the same printer.

Interaction. Letters, memos and files should be transferable between nodes. Computer conferencing is also a valuable management tool to have in many businesses; it should be possible with the right software.

External access. With only a small number of modems the users should be able to link up to the telephone system and to the national and international packet-switching networks and through them to other branches, other PC networks or mainframe computers and online data bases.

Security. The security requirements of each business are different so no one system will suit all. There are two aspects of security that should be taken into account: security from system crashes and data collisions, and security to prevent unauthorized access to files on the system.

That's the minimum you should expect from a LAN. Other points that should be considered are:

Noise. Because of the high data rates over relatively long distances, LANs are particularly subject to electrical interference. Optical fibre is in front as far as interference is concerned, with coaxial, then twisted pairs a long way behind.

You can't run LAN copper twisted pairs through power ducts for this reason. If you believe that you are likely to suffer problems from electrical noise or just sheer cable distance, you should keep the bps rate of the system down.

Lan within LANs. There is the temptation to try to link up all computerized equipment into one gigantic LAN, but this is often costly and unnecessary. The ideal network size depends on the work group size. It might be as small as four or as large as 30, or more.

Below four, a multitasking computer would probably be a better solution, and for large numbers it is preferable to break the LAN into smaller sub-units and then link these work-group LANs into the major network. A lot of the LAN systems listed here already have this sub-group breakdown.

If you are in doubt about the direction to take with LANs in large organizations, a primary work-group network could be established first, and the larger LANs only implemented after experience with the smaller units. If you stay with the more popular system you should have no problem in the future with expansion and interconnection.

Always leave plenty of extra capacity when figuring LAN requirements but don't be trapped into thinking that 'bigger and faster' is necessarily better. You should certainly check that the preferred system is readily expandable.

frames; and the industry also recognizes the potential power of AT&T. Both companies have now announced LAN development systems which use virtually the same wiring architecture, and yet industry forecasters only give the combined forces of IBM and AT&T 25 per cent of the large-system LAN market by 1987. The next five (Ungermannbass, Sytek, 3Com, Corvus and Interlan) share 69 per cent of the remaining market.

AT&T's Network Star is not yet fully developed, and IBM's token-passing ring is still only a cabling system at the time of writing, but unless a work-group LAN system has a gateway to IBM's token-passing ring it will probably not find market acceptance. IBM will call the shots, but anyone can play as long as they abide by the rules.

The Lexicon of LANs

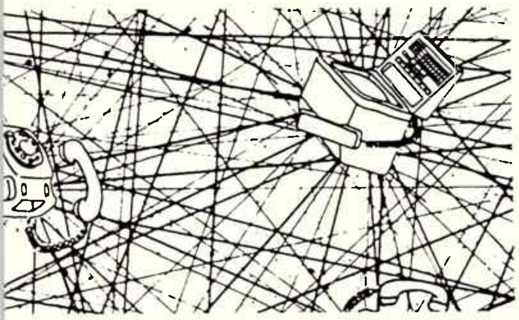
Confusion reigns in the lexicon of LANs. Let's try and straighten some of it out.

Disk servers. Disk servers are used in the simplest form of network structure. They are little more than a hard disk that can be accessed by more than one computer. From the point of view of the user, the hard disk appears to be just another mass storage device added to his or her PC.

The disk serving approach is used when a hard disk is partitioned to provide a virtual space for users on the system. Normally the work-station operating system keeps a copy of the file-allocation tables (which tell it which part of the disk it can use) in its own memory. This is used to avoid over-writing data on the host disk, but it may not work since data can be added without the peripheral PCs knowing.

File servers. If one LANs user tries to access a file while another user has it open, weird and wonderful things can occur. File 'clobbering' has been the bane of multi-user systems for a couple of decades; many interesting technologies and techniques have been developed to overcome it.

Disk sharing is an obvious technique but it has its limitations. If users are sharing a 10 Mbyte hard disk, then it is easy to partition the disk and so create 10 'virtual' spaces. Each user can access only his particular space, and no one risks information owned by the other. The problem with this approach is that users may want to share information; there is little point in having 10 company mailing lists, when all could access the same one.



To overcome this problem the system needs to differentiate between private and public *volumes* (virtual spaces). Public volumes can be made read-only to most users, but someone will need to update them so you have to create a system of access rights. Usually these rights are controlled by the use of passwords during the sign-on procedures, or through different PCs having unique reference numbers recorded by the system.

> *What sets LANs apart from simple direct connection or PABX-linking, is that all devices have a permanent electronic connection to the system at all times.*

Dedicated or non-dedicated servers. A dedicated server does nothing but perform network functions. It may be a computer in its own right but it is not used as a workstation for general data processing. Some systems, however, allow the server to be partly withdrawn from its central function and used as a workstation when traffic is light. Obviously this is more economical in some systems, but the server must divide its time between its workstation function and the network control, and this can create problems.

File locking. System software must have a way of preventing others from using a file that is already being used by someone else. Unfortunately almost everyone makes alterations to files by transferring the data to their own machine, updating it, then copying it back. Sometimes the file can be away from the hard disk for a long time and anything could happen to the disk-based version in the meanwhile.

Controlling this problem is one of the jobs of the file server which sits between the hard disk and the network. Its job is to keep track of where files are in the system, and differentiate between those users who have access on a read-only basis and those who have it for modification. The server must grant or deny access to users dependent on their status, and it must distinguish between ACQUIRE and ACCESS functions. File servers often have ancillary functions, as well. For instance, a certain group in the company might have priority of access to certain files.

Record locking. With some companies the main function of a LAN is to link a number of terminals to one large file stored on hard-disk so that this master file can be constantly updated to all operators. In these circumstances it makes litle sense to lock files while records are being updated since all other users will be just sitting around waiting.

The solution is more risky than file-locking, but necessary. Files must be left open, but individual records must be lockable to prevent duplicated access during the updating process. The type of processing involved here in record locking is largely dependent upon the operating system of the peripheral PCs and it is for this reason that the advent of DOS 3.1 is so important. ●

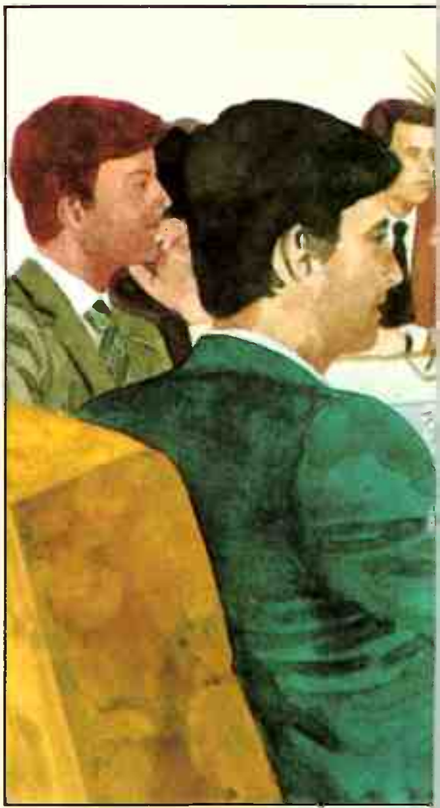
IBM GOES HALF-WAY

At the time of writing IBM is marketing cables and network connectors for its own long-awaited LAN, but without software the system is little more than a new design in cable connections. At this stage we only know that IBM is committed to using a token-passing technique although it also says that its network will link with those smaller systems using CSMA/CD and /CA schemes.

Big Blue has managed to complicate the topography somewhat by twisting the simple ring network into something much more complex. IBM wanted short cables and easy trouble-shooting; the first requirement needed a ring structure while a star suited the second. IBM, not fazed by this apparently incompatible duality, devised a star-ring structure. Each node is attached to a double cable coming from a *wiring concentrator*. The double cable runs are linked to form a large ring, while the wiring of the concentrators is connected to form a kind of inner ring.

This ring-within-a-ring idea has many advantages, and numerous other companies have already jumped on the bandwagon to produce compatible equipment. The main advantage of the ring-star structure seems to be that if one part of the cable system is broken it is easy to jump across the problem at a concentrator. The re-linking can be automated.

TELECONFERENCING BY VIDEO OR COMPUTER



Teleconferencing is widely regarded as something which lies just around the corner. It's the dream of almost every manager to be able to set up national and international conferences without his executives leaving the office. And now it's possible using video or computer technologies.

Stewart Fist

It's not just the status of having the latest whiz-bang technology: executives away from their home offices cost money and waste time. Letters and telex communications just won't do for many important meetings. You need face to face confrontation and discussion.

Video conferencing

Video conferencing is a technology with obvious appeal to the executive. It appears to be the closest we can get to the interaction of physical meetings. But video conferencing has been tried all over the world, and has rarely been successful.

Part of the problem is cost. To use a full televison transponder on a Pacific satellite for an hour or two costs thousands of dollars; and if you are going to simulate a real meeting with two -way interaction, you need at least two transponders plus, of course, the studios, cameras and microphones, the landlines, standards conversion equipment and ground stations.

Even when a company can afford the cost, there is still the question of reliability. Unless the linkages are set up on a daily basis there is always something new and untried in the communications chain. Systems failures are almost a matter of course.

If you live in either Sydney or Melbourne and want to communicate with the other, one way to get reliability is to use Telecom's service, Confravision. It has a small studio in each capital ready to go, which will give you colour video and stereo sound.

Another way, especially for larger meetings or important group announcements, is to hire television studios in the locations that you need. Usually a channel will have some down-time that they are willing to sell. Since TV stations exchange programs over the broadcasting cables on a day-by-day basis, everything is in place, and everyone knows what to do to make the show a success.

Even more important than the electronic problems are the psychological ones. Video conferencing is a form of television, and appearing on television does funny things to many people. Whereas a relaxed atmosphere can often be generated at an all-day, person-to-person meeting and you can expect to have a reasonable amount of friendly discussion, video conferencing, by its very nature, invites grandstanding, role playing and hurried decisions.

> **"Video conferencing, by its very nature, invites grandstanding, role playing and hurried decisions."**

While satellite connections cost thousands of dollars an hour, there will always be the tendency to rush through important points, miss valuable contributions and decide in haste. There is always something fake about television — even the most experienced politician with years of experience and on-camera training will often still come across as posing, pretentious and pseudo-real.

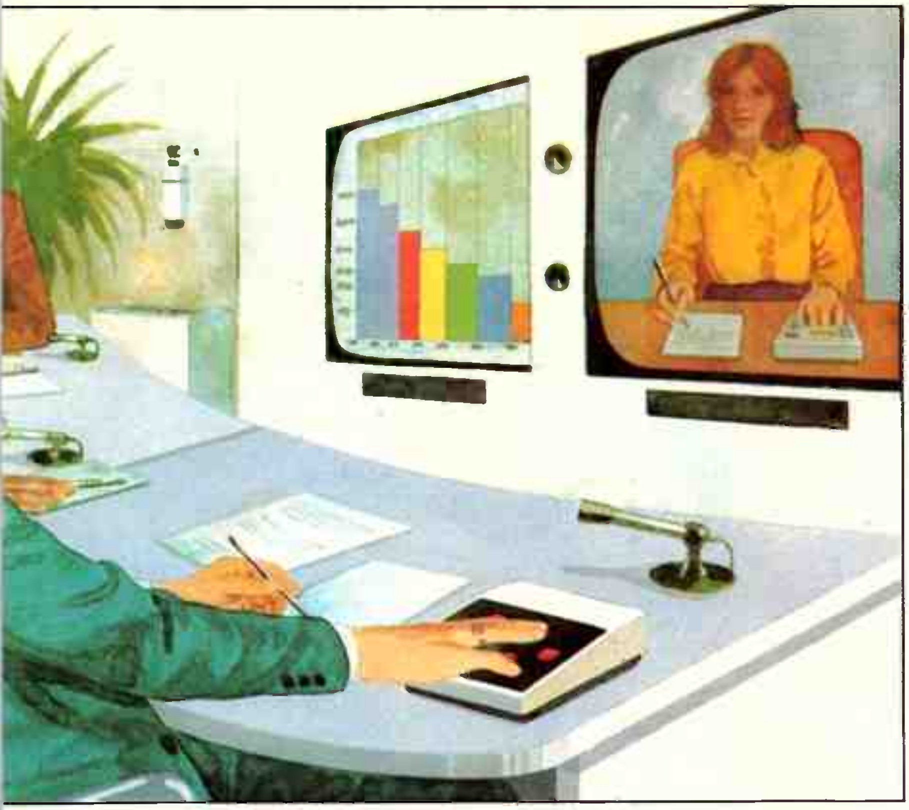
With inexperienced executives, all worrying about their image and preening and posturing in front of their bosses, peers and the cameras, the results can be ludicrous. However, many companies still persist. There is undoubtedly big money in store for the company that first manages to produce a cheap and workable in-house video conferencing system, preferably one that can broadcast over the normal phone lines.

The key to this possibility is the use of the codec, the electronic mirror-image of the modem. Codecs are used to convert video's analogue signals to digital. There's a bit more to it than this. To preserve quality, the codec must sample the analogue signal at a very high rate, and it must still be economical in its production of digits if a standard line is to carry the data stream.

There are a number of *bandwidth compression* technologies over the horizon which may cut the cost of video conferencing greatly in the next few years. Most of these depend on *redundancy checking*, which is only possible once the image has been digitized.

The ideal situation is for the transmitting codec only to send those parts of the image that have changed in the 1/50th of a second since the last picture was sent. To do this, one picture must be held in memory and the second compared with it. Special codes are provided to convey the redundancy information in a meaningful way to the codec at the other end of the line, and from here on to the video circuits.

The technical problems of codecs will soon be solved for slow-scan video systems,



anyway. For simple conferencing you don't need images to change at a rate of 50 fields (25 frames) a second as does our normal PAL TV. The problem is usually with people falling asleep visually, rather than being highly active.

At the one or two pictures-a-second rates the image is like a rather badly drawn animated cartoon where the mouth movements don't match the words being said — yet this is the practical level for telephone circuits at the present moment. Faster transmission speeds are possible using circuits with a greater bandwidth.

These systems still allow a single satellite transponder to carry many conferences at the same time, and cut the costs accordingly, but the problems of role playing and grandstanding remain. And there is no way to overcome the time differential problem. When it is late evening in New York, it is pre-dawn in Sydney, so at least one party to the trans-Pacific conference must be working at a time less than ideal for rational discussion.

Despite the problems with video conferencing, many of the alternatives aren't much better. The physical-meeting business conference itself has been much maligned, and rightly so. It consumes an enormous amount of staff and executive time, rarely keeps to the subject at hand, and often results in decisions that are based on poor facts or poor logic. The participants may be skilled and knowledgeable, but they aren't given the time or the threat-free environment in which they can actively participate.

We keep having business conferences because we have had no option until now.

“The greatest problem with the system is the lack of typing skills among senior executives . . . and anyway, it's pretty hard to beat a company-paid trip to New York.”

Computer conferencing

The best form of teleconferencing to be developed in the last few years takes an approach almost opposite to that of video conferencing. This is computer conferencing where the parties communicate only by written word using a computer keyboard.

Computer conferences aren't usually limited by time, they often go on for days, weeks or months. There are no time differential problems, and few reasons to grandstand, role play, or rush. But there is always a fly in the ointment. In this case, it is the need for keyboard literacy. Executives won't become involved in computer conferences if they have to ask their secretary to type in their priceless words of wisdom: it destroys the impression of being personally involved in a long-term discussion.

The ideal set-up for computer conferencing is to equip every participant with a computer terminal and keyboard in their own office. These terminals are linked to a central computer which stores, sorts and delivers the electronic messages.

A manager arriving at his office in the morning simply switches on his terminal, keys in a password or two to gain access via the Pacific satellite to the central computer. Comments added to the discussion overnight by associates in New York immediately begin to scroll across the screen.

The manager can stop, re-read, add comments, give information, check back what was said weeks before, and above all, think before replying.

This last point shouldn't be skipped across without emphasis. This is virtually the only form of conference where the participants have time to listen to (read) what the others are saying, think about it, and formulate intelligent responses, remarks or questions.

When participants have to write, you seem to lose those off-the-cuff, impress-the-boss-how-articulate-I-am, or let's-put-down-that-upstart-from-accounting remarks. The written witty reply or snide comment doesn't carry the weight of a carefully considered analysis.

A participant can send messages to the group as a whole, or direct them only to the attention of one party. In some systems he can even make remarks, which tends to remove barriers of hierarchy. The boss has to be on his toes, too. This is not a system for those who like yes-people around them.

Most surveys show that role playing in computer conferencing is kept to a minimum. Participants tend to pride themselves on brevity and relevance, rather than holding the floor and sounding impressive.

The system lacks the warmth of human contact, but so does video conferencing. And, unlike the video system, it replaces that contact with time for thought and investigation. In one division of the Bell Telephone company, computer conferencing became the most popular way to hold a meeting, even when the participants were in the same building. They found that conferencing this way disrupted their daily schedules less than direct meetings, and participants at all levels felt that they were able to contribute more.

The greatest problem with the system is the lack of typing skills among senior executives. Typing is still seen by executives in many companies as a skill for secretaries, not the man at the top. Until you regularly use a personal computer, the idea of communicating via a keyboard doesn't greatly appeal . . . and anyway, it's pretty hard to beat a company-paid trip to New York. ●

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Gaussian Transformations
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Electromagnetics
Thermodynamics
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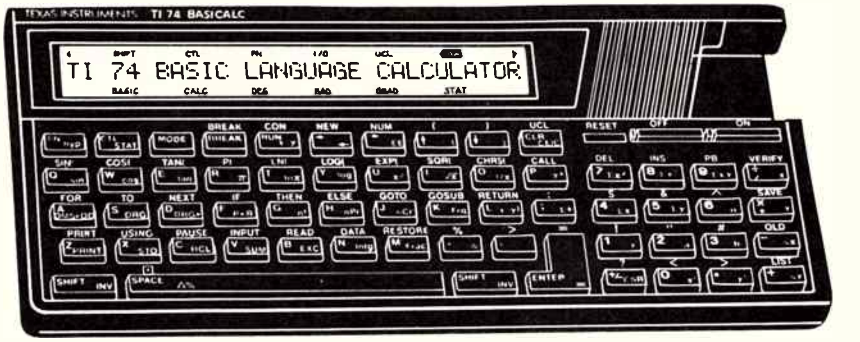
Your BASIC solution:



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TEXAS INSTRUMENTS

ADVERTISING INFO No. 20

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Easy expansion and network flexibility.

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SKYSWITCH offers cost savings of over 30 percent compared to public charges for interstate calls. Plus, typical SKYSWITCH payback occurs within 24 months, or if you prefer McConnell Dowell-Nichols will rent you the system and you can enjoy the savings immediately. Your company accountant will like that!

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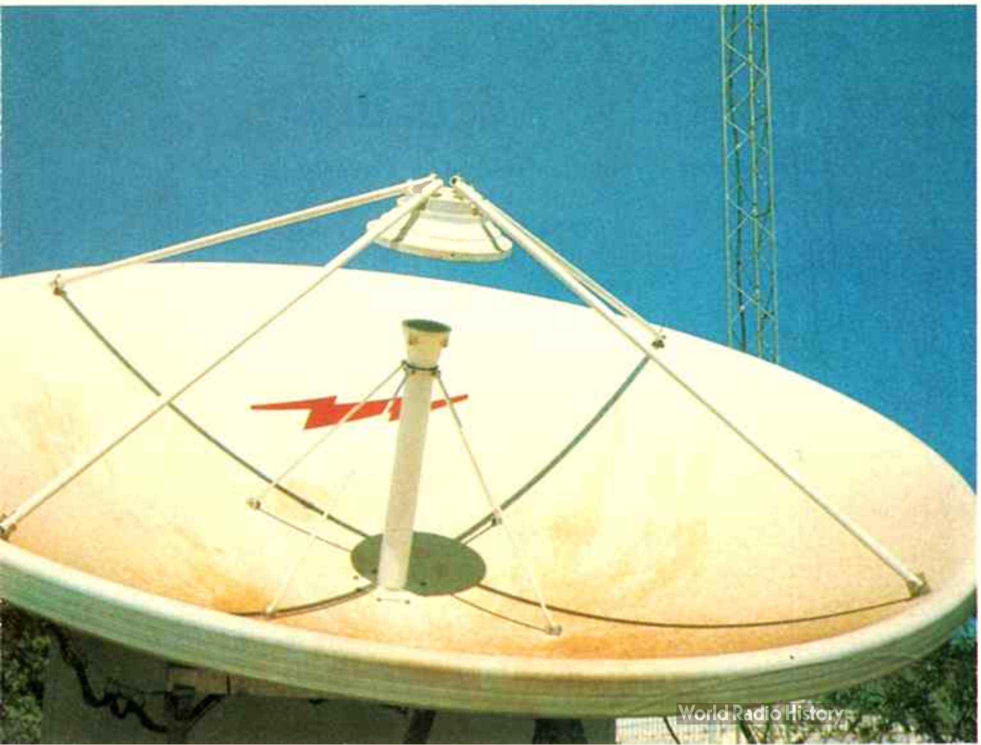

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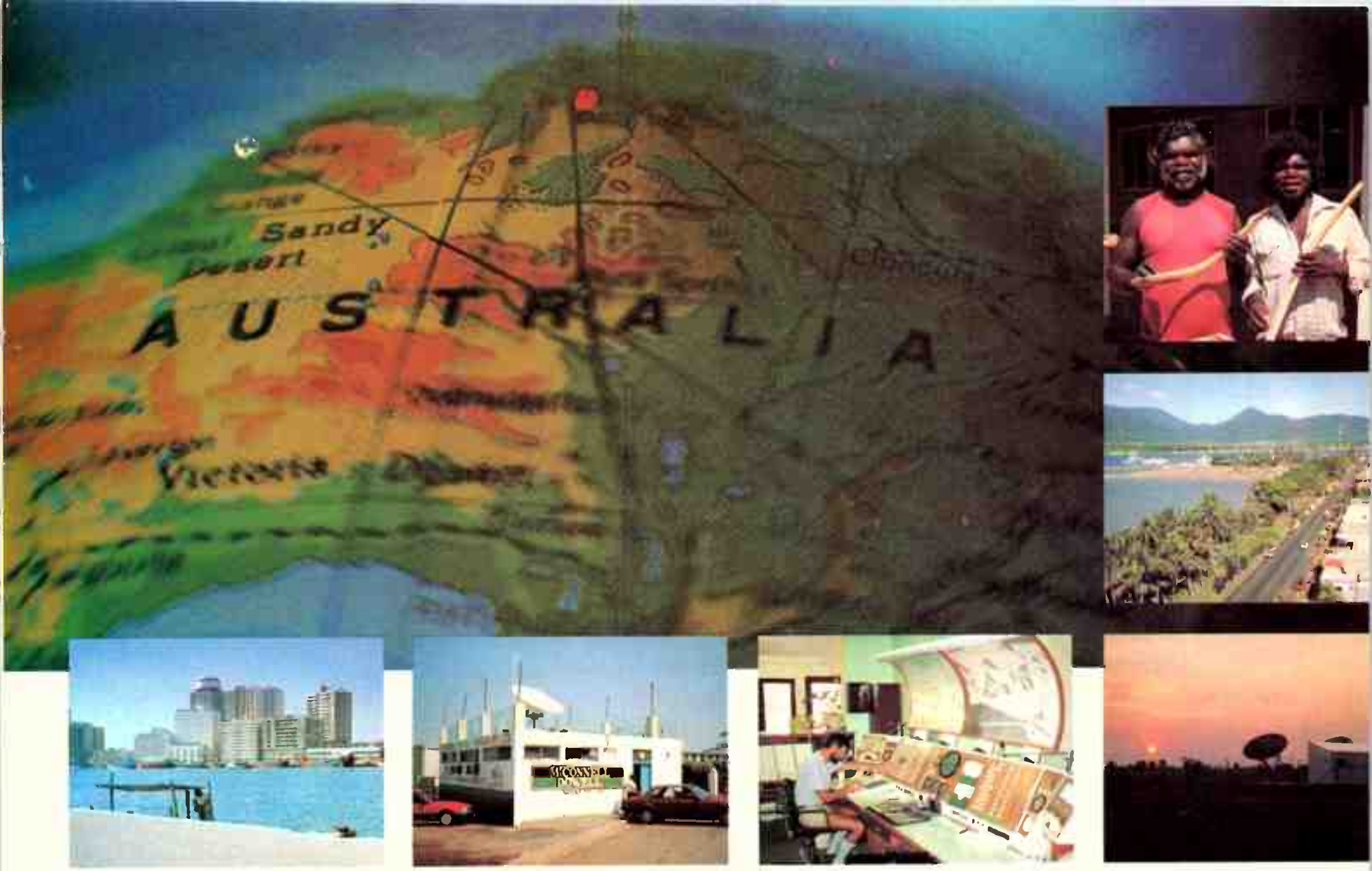
Sky Switch™



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Talking to your world shouldn't cost the earth.

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Skyswitch is compatible with standard PABX telephone systems. It just plugs into your existing phone network and works. Over land, water or ice; to branch offices, subsidiaries or distant exploration sites, Skyswitch has a reach that no landline can match.

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ADVERTISING INFO No. 21

McCONNELL DOWELL
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Sky Switch™

SECOND GENERATION AUSSAT

With two satellites now in orbit and a third scheduled for launch in March this year, Aussat has embarked on extensive planning which, by the middle of the year, will lead to a call for tenders for the next generation of spacecraft. These 'follow-on' satellites will be phased into service in the early 1990s as the current ones run out of fuel. They will incorporate a range of new technical features and service capabilities tailored to Australia's market needs of the 1990s.

Based on a paper by Dr Wayne Nowland of Aussat Pty Ltd.

During the 1990s Aussat's second generation system will provide the Australian marketplace with a range of new, improved and more economical communications services. It will continue the pioneering work in communications commenced by the first two Aussats now in orbit.

Aussat's next generation of satellites will operate beyond the turn of the century, ideally, catering for market needs throughout the 1990s and providing opportunities to capitalize on any of the emerging technologies of the next decade.

The current generation satellites are scheduled to be retired from service in March 1993 (A1), January 1994 (A2) and March 1997 (A3). The replacement satellites, however, will be launched around mid 1991 (B1) and early 1992 (B2), two years before the first generation is retired. Such an overlap in time is required to cover the possibility of first generation transponder failures given that they will be near their 'end of life', as well as second generation launch failures.

With a nominal lead time of three years for satellite construction and launch, and allowing one year for tendering and contract negotiation, Aussat is now in the first stages of planning and design.

The third replacement satellite isn't scheduled until early 1995. This provides an opportunity to tailor it to actual market needs, but Aussat faces a problem with the first two second generation satellites. It must define satellite capacity need for predicted markets some 15 years hence on less than one year's operational experience with the current system.

Notwithstanding, some broad identification of future growth areas can be made, based on market analyses, current trends in emerging technologies and the experience of other satellite operators. These are sufficient at least to permit defining the major requirements that will drive the design of a flexible 'follow-on' system.

The current market

As it stands, Aussat's current market base can be segmented into four broad areas: television and radio; government; corporate; and offshore.

The 'television and radio' market currently represents by far the largest use of satellite capacity on the Aussat system and by the end of 1988, this market is expected to utilize some 50 to 60 per cent of the available transponder capacity (approximately 24 transponders).

Its main applications will encompass television broadcasting (HACBSS, RCTS); television program interchange and distribution (ABC, SBS, major commercial broadcasters); VAEIS, or video and audio entertainment and information services, (Club Superstation, Sky Channel, etc); itinerant television and videoconferencing (news gathering, special events, etc); and radio interchange and distribution (ABC, commercial radio).

SYSTEM CAPACITY

The transponder capacity prospectively available to Aussat customers during the initial phase of the 'follow-on' system (ie, prior to 1997) is summarized below:

Australia (Ku Band) **30x54 MHz high power transponders (B1,B2); 11x45 MHz lower power transponders (A3); 4x45 MHz high power transponders (A3) (ie, 45 transponders in total).**

New Zealand (Ku Band) **8x54 MHz high power dedicated transponders for New Zealand domestic service.**

Defence (X Band) **2x20 watt dedicated X Band transponders for Australian and Earth coverage service.**

Mobile (L Band or UHF) **2x160 watt dedicated L Band mobile transponders for domestic land, sea and aeronautical mobile service.**

The 'government' market is expected to be the second largest user of satellite services, with around 20 to 25 per cent of the available capacity (approximately nine transponders) in service by the end of 1988. These will be used in the areas mainly of aeronautical communications (DOA); public-switched telephone services (Telecom); defence administrative services (DOD); State government networks (QNET, etc); and minor government services (police, railways, etc).

The 'corporate' market, while presently in its infancy, represents a significant medium term growth area for Aussat. It is expected to utilize 10 to 15 per cent of the available transponder capacity on the current system (approximately six transponders). The ongoing development of this market depends to a large extent on the continuing evolution of miniaturized low-cost VSATs. These very small aperture terminals can be installed directly on customer premises and networked via satellite to thousands of other similar ground terminals throughout the country.

The major Aussat applications for the corporate market will include customer-owned corporate networks (AAP, banks, retailers, etc), and Aussat private network end-to-end services (STARNET, MESH networks, Capital City Network Services).

The 'offshore' market will be served by a regional South West Pacific beam on the third satellite of the first generation still to go up. New Zealand will make use of two transponders on this satellite for its domestic telecommunications and broadcasting. There is the possibility that this use may be extended in a limited fashion for trans-

"*Apart from expansion in these markets, Aussat is looking to mobile services, satellite position fixing, and remote low speed data collection to constitute a service base for the second generation.*"

Tasman private network traffic with the second generation Aussat.

Apart from expansion in these markets, Aussat is looking to mobile services, satellite position fixing, and remote low speed data collection for telemetry applications to constitute a service base for the second generation. The market segments (both commercial and government) with potential applications for domestic mobile services include Telecom (cellular mobile radio overlay), the airlines, surface transport (rail, road, sea), minerals and petroleum exploration, police and emergency services, education, forestry and agriculture, electricity and water resources, etc.

Assumptions

The service base for Aussat's second generation system will, of course, be conditioned by the communications environment that will prevail in Australia in the 1990s. In this regard, a number of assumptions must be made.

Firstly, it is assumed that Telecom and Aussat will continue to jointly provide Australia's national communications system, with Telecom retaining its monopoly in the provision of public-switched services and Aussat continuing to offer satellite delivery systems for private network applications.

Secondly, it is assumed that all capital cities will be linked by high-capacity optical fibre systems by the mid 1990s. This may lead to more cost-effective terrestrial solutions for many point-to-point communication services.

Thirdly, while not fundamental to the design of the next generation system, Aussat recognizes that the implementation ▶

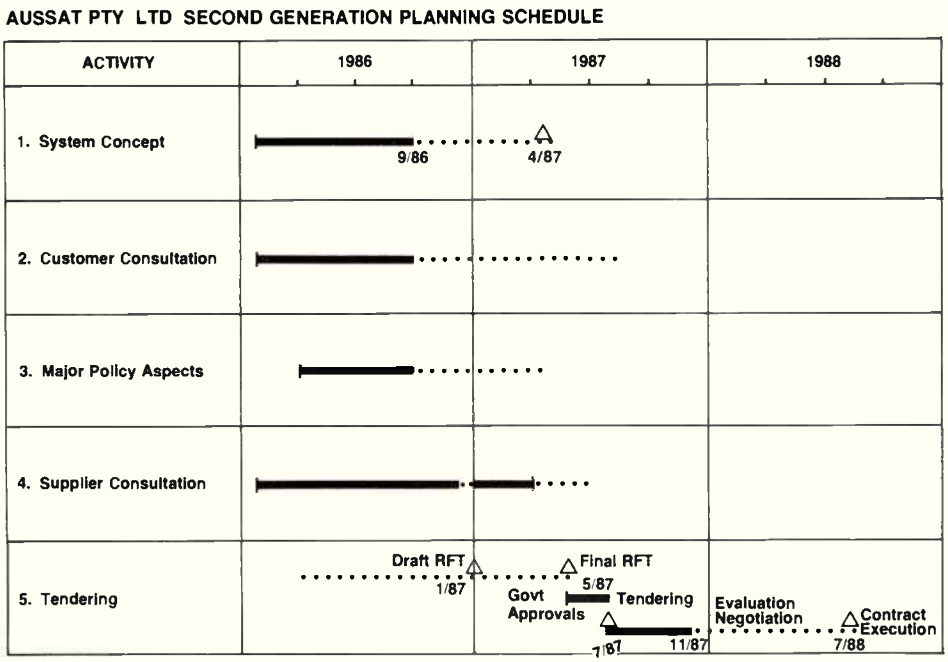


Figure 1. Second generation planning schedule.

of privately owned international satellite systems over the next 10 to 15 years could seriously erode the Intelsat monopoly for international services. Under such circumstances the Australian government will need to consider whether it's in the national interest for international services to be carried by the Aussat system.

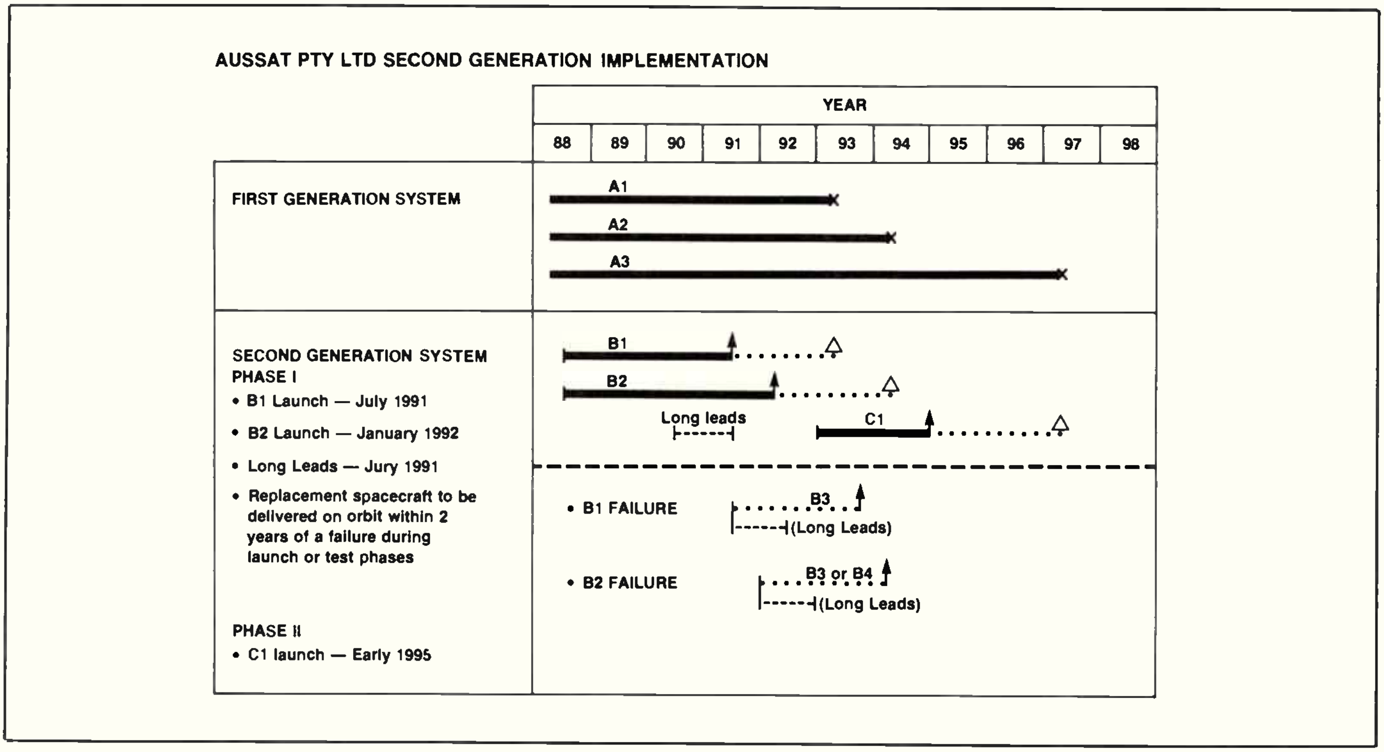
Against this background, Aussat considers that the next generation system must build upon existing satellite markets and expand into those areas best suited to satellite delivery, ie, multi-point networking, broadcasting, remote area services, mobile communications and offshore applications. In this way, the Aussat system will evolve largely in complementary fashion to the terrestrial network, and vice versa, with the marketplace benefiting from the emerging technologies and service opportunities offered by both systems.

"Aussat predicts the value of work which might be expected to flow into Australia in these areas over the next decade as a direct result of the Aussat program could well exceed $A150 million."

The planning activity

Extensive planning activity has been underway over the past year to develop a design concept for the follow-on system. Major elements of this planning activity and the associated schedules are highlighted in Figure 1. The planning activities will culminate in the issue of a request for tender for the system in July, and placement of the space segment contract one year later (July 1988).

As well as assessment of market needs, the development of a system has required detailed analysis of the available technologies and consideration of relevant communications policy aspects. Extensive analysis of numerous alternative system models has been carried out under varying ▶



IMPLEMENTING THE CONCEPT

The concept proposed for the follow-on system involves two distinct phases. Phase I will comprise the purchase of two satellites (termed B1 and B2) to replace the two satellites currently in orbit. Phase II will comprise the purchase, prospectively, of a third satellite (termed C1) which may be identical to or different from the first two, to replace the third satellite in the current system.

The proposed system implementation strategy is illustrated above. This diagram also shows the strategy for recovering from launch failures while maintaining service continuity. This will be accomplished through the provision of 'long lead' items which permit the turnaround time for a replacement satellite to be reduced substantially in the event of a failure.

An important feature of the proposed implementation is the flexibility available in the choice of start-up dates for the follow-on satellites. This flexibility is provided through the selection of an appropriate storage orbit for each satellite. Either satellite may be brought directly into service following launch, depending on operational needs at the time. Otherwise, a low fuel usage storage orbit (up to two years duration) may be used to defer the in-service date.

assumptions of market projections, spacecraft technology, system capacity and overall costs.

One other consideration for the second generation Aussats is the amount of Australian industry involvement. After last February's advertizing for registrations of interest from satellite manufacturers and equipment suppliers, Aussat received 60 responses, over half of which came from Australian companies or overseas companies which have substantial Australian operations.

Unfortunately, it is unlikely that a locally based company could tender successfully as prime contractor for the second generation space segment. However, there are parts of the space segment manufacture and possibly even the design which could be performed in Australia on a subcontract basis.

The areas identified by Aussat for Australian industry participation include spacecraft hardware manufacture; spacecraft subsystem integration and test, antenna system design and fabrication; beacon transmitter hardware design, development and manufacture; spacecraft software simulator development and export. More down to Earth areas include mission planning and launch support services, launch insurance, mobile satellite terminal R&D and manufacture.

Aussat predicts the value of work which might be expected to flow into Australia in these areas over the next decade as a direct result of the Aussat program could well exceed $A150 million.

Current system concept

Against this background, Aussat's current view of the system concept for the follow-on satellites is twofold.

Firstly, the initial phase of the second generation system will comprise two spacecraft, B1 and B2, with target launch dates of July 1991 and January 1992. These satellites will replace A1 and A2 now in orbit. A third satellite, C1, would prospectively be implemented at a later date to replace A3 which is scheduled for retirement in early 1997, assuming a launch in the first quarter of this year.

Secondly, the 'B' series will have a 10-year operational life, plus up to two years of in-orbit storage prior to service commencement.

Australian capacity

Each satellite will carry 15 x 54 MHz high power Ku Band transponders for Australian use. The actual rf power of each transponder will depend on how the spacecraft contractor ultimately implements the signal strength requirements but it is likely to be greater than or equal to 30 watts. All transponders will have limiters and linearizers for improved and more robust performance, and 8 x 2.5 dB commandable gain steps for greater operational flexibility.

Transmit and receive national coverage is planned to include 3 dB weighting in capital cities and the more populous coastal regions. The transmit performance will be 42 dBW minimum over all Australia and at least 45 dBW in the weighted regions. The receive performance will be −2 dB/kelvin minimum over all Australia and at least +1 dB/kelvin in the weighted regions.

Four transmit spot beams similar to the first generation SE, NE, CA and WA beams will be provided. Additionally, the SE beam will provide secondary coverage of all capital cities including Darwin, plus Lord Howe and Norfolk Islands, and the target performance will be 49 dBW or better over primary service areas, ie, up to 2 dB better than the performance provided by the current satellites.

New Zealand capacity

Specialized facilities will be provided for New Zealand domestic telecommunications and DBS services, most likely comprising 4 x 54 MHz high power Ku Band transponders on each satellite. These transponders will use the same size TWTA as for Australian services and will be designed to provide at least 50 dBW performance over the whole of the New Zealand coverage area, and better than 55 dBW over defined segments of the coverage when used for DBS service. The latter requirements will be achieved if necessary by paralleling the TWTAs in each pair of transponders.

Options

Several options are being examined for the B1 and B2 satellites, including:

- an L Band mobile communications transponder for Australian use;
- an X Band defence communications transponder providing switchable Australian and Earth coverage;
- beacon transmitters at VHF, UHF, L, Ku and Ka Bands for propagation research; and
- a 'passive' retroflector for precision laser ranging measurements and accurate time transfer experiments.

There is a reasonable prospect that each of these options will proceed.

Other options have been discarded from earlier versions of the system concept following extensive analysis of market requirements and technical/cost implications. They included high power Australian DBS, major city spot beams, transponder AGC, and a meteorological imaging/sounding package. The third satellite of the follow-on series, nevertheless, offers the possibility of incorporating additional facilities such as these if market or policy requirements emerge at the time that design decisions are made for this satellite (ie, the 1991/92 timeframe).

Procurement strategy

To implement the system concept outlined above, Aussat is planning to call worldwide competitive tenders in mid-1987, leading prospectively to contract placement for the space segment in mid-1988.

The tender documentation to be issued in July will carry specific requirements for substantial technology-related Australian industry involvement. Through the second generation space segment procurement, Aussat will be seeking, in effect, to develop a means to encourage the highest possible levels of Australian industry involvement in the contract while ensuring acceptable overall costs, schedule risk, and technical risk.

Additionally, Aussat will be seeking to ensure that significant flow-on work in space and space communications areas results from the procurement in a manner consistent with development of a viable long-term space industry base in this country. Discussions on the mechanisms by which these goals can be achieved are ongoing with the Department of Industry, Technology and Commerce which has overall responsibility for the Government's Offsets policy and is the servicing organization for Australia's newly appointed Space Board. ●

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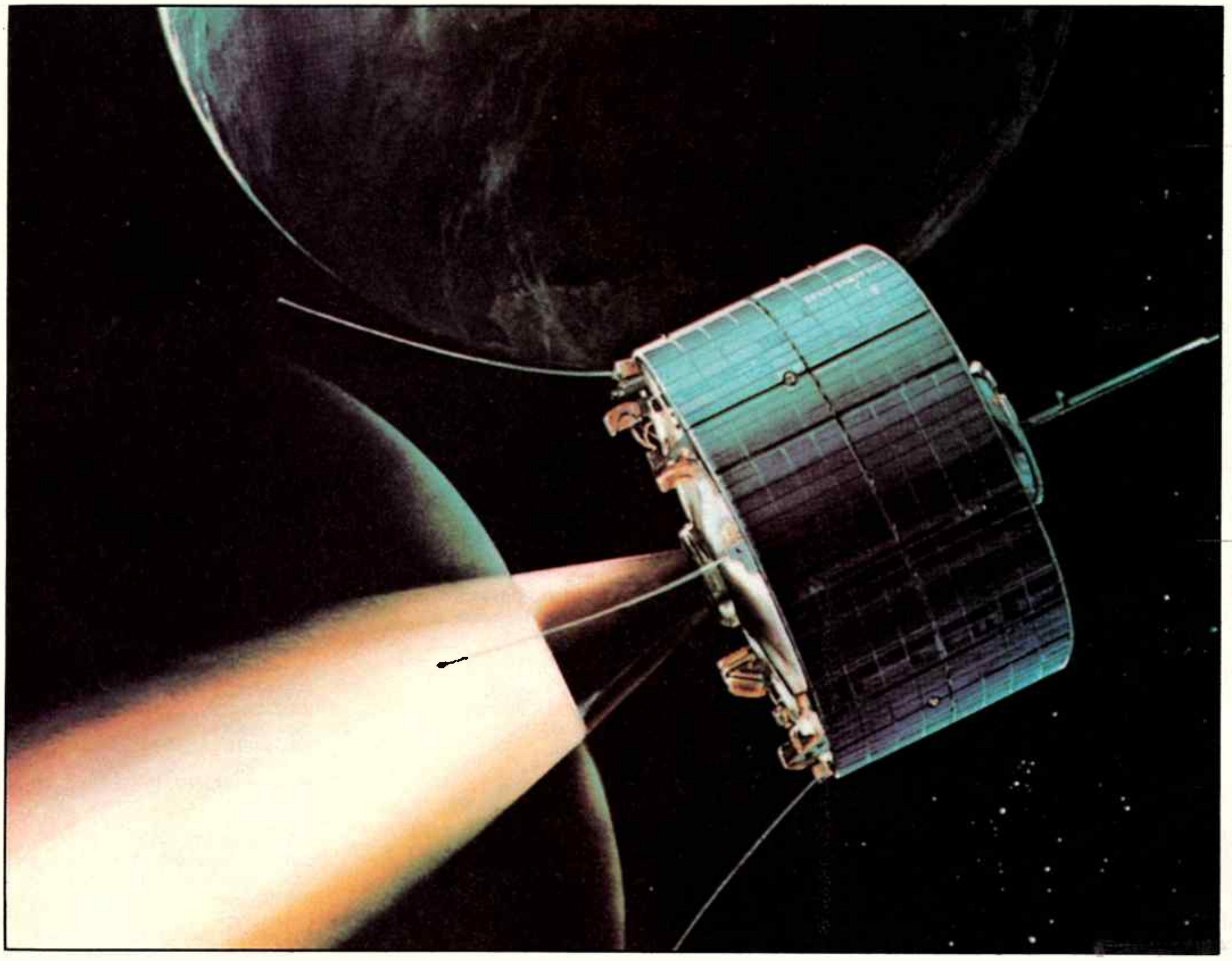
Wally Shand

This list is representative only. Omission implies only that our records were incomplete at printing.

SATELLITE LIGHTWAVE COMMUNICATIONS

Bernie Seth

Bernie Seth is research and development officer with OTC.



The use of lasers for intersatellite and satellite-Earth links is a promising technology for future satellite systems. However, before these lightwave links can be implemented commercially, substantial engineering effort will be required.

Satellite communications is facing increased competition in terms of cost, capacity and performance. This situation has come about due to significant developments in single mode optical fibre cable technology, which is becoming extremely attractive to both users and administrators.

Communications satellites progressively may become relegated to broadcast, mobile and thin route type applications, with point-to-point trunk capacity being provided predominantly via terrestrial or submarine optical cable networks.

Capacities via spacecraft have traditionally been increased by the use of more power, higher frequency bands and larger bandwidths, by employing frequency reuse techniques such as orthogonal polarizations and spatial beam separations, or by utilizing more efficient modulation, coding and multiple access techniques. These methods have been effective in maintaining a large share of the telecommunications market for satellites.

But if satellite communications is to successfully meet the challenges posed by rapid advances in low loss, low dispersion optical fibre cables operating in the 1550 nm region, a new satellite transmission technology will be required. The opportunity for such a new technology lies in the use of lightwaves for both intersatellite space links and for satellite-Earth links.

Satellite lightwave communications operating in the frequency range of approximately 10^{13}-10^{15} Hz has the potential to provide extremely high capacities. For example, an optical carrier with a frequency of 5 x 10^{14} GHz at one per cent fractional bandwidth provides a channel with a theoretical bandwidth of 5000 GHz, a factor of 10^5 greater than a microwave system operating at 5 GHz. Furthermore, satellite communications via lightwave will permit closer satellite spacings on the geostationary orbit, lower system interference, network privacy, very small earth station size and potentially low user costs. In addition, optical intersatellite links (OISLs) will permit high capacity satellite networking and interconnectivity, and they will reduce or obviate the necessity for low elevation angle links and satellite double hops.

However, before satellite lightwave communications can be used, component problems will need to be resolved. Propagation effects through the Earth's atmosphere can limit system availability. Suitable laser transmitters, and receivers for the spacecraft and earth stations, will need to be developed. High precision beam tracking systems will have to be designed, and appropriate modulation schemes will need to be employed. These and other factors will play a major role in determining when and in what form lightwave links will be introduced in commercial satellite systems.

The potential for application of this innovative technology in the space and Earth segments was recognized early by Intelsat, the international satellite cooperative whose satellites OTC accesses to provide the majority of Australia's overseas telecommunications. Intelsat's ongoing R&D program in satellite optical links has indicated the overall feasibility of the technology and identified several areas which will require further development in the future.

> **"Furthermore, satellite communications via lightwave will permit closer satellite spacings on the geostationary orbit, lower system interference, network privacy, very small earth station size and potentially lower user costs."**

System description

The intersatellite and Earth-space lightwave links will involve three spacecraft travelling in synchronous orbits. Lightwave communications systems for these links may be classified as either non-coherent or coherent. Coherence is a measure of the phase relationship of an optical wave as it passes a reference point in space, and the phase relationship between two points on the wavefront at a given time.

Non-coherent (or direct detection) lightwave systems are those in which the output of the photodetector is proportional to the power of the incident optical field and in which no use is made of the carrier's coherence in the detection process. These systems are insensitive to the frequency or phase of the carrier and are useful for intensity or AM modulation.

Coherent lightwave systems utilize both the spatial and temporal properties of the carrier for photomixing, as in heterodyne and homodyne detection schemes. The heterodyne detector's output is dependent on frequency, phase and amplitude, whereas the homodyne detector is sensitive to amplitude and phase. Thus with coherent systems, conveniently ASK, FSK and PSK modulation techniques are possible.

Coherent heterodyne detection offers a theoretical advantage in receiver sensitivity over direct detection, but it suffers from the requirements of increased system complexity, and propagation effects which disturb wave form coherency.

Optical transmitter

The optical transmitter is composed of an optical source, a modulator and an optical antenna.

Lasers are used for the source in view of their large brightness and their directionality, coherence, focusing and tunability properties. Three laser types which have been developed thus far include the solid state doped insulator Nd: YAG laser operating at 532 nm; the molecular CO_2 laser working at 10.6 μm; and the semiconductor GaAs laser with a 0.85 μm wavelength.

Modulation of information into the laser beam can be achieved by the use of modulators external to the laser cavity ultilizing the electro-optic, magneto-optic or acousto-optic effects, or it can be accomplished by the direct modulation of the laser.

For the lightwave carriers, cost and weight considerations deem the use of reflective optics for the antenna sub-system (Cassegrainian and folded Gregorian antenna configurations).

The beamwidth of the optical antenna working at the diffraction limit is given approximately by BW $\sim$ λ/d, where d is diameter of the antenna aperture. At 10.6 μm an antenna of 18.5 cm diameter gives a bandwidth of approximately 57 μr. At 532 nm, a 15 cm diameter antenna gives a beamwidth of approximately 4 μr.

Optical channel

The performance of the lightwave system will be affected by background radiation and by impairments due to free space and atmospheric propagation.

Background radiation arising from celestial bodies and the sky impairs laser signal detection because of increased detector shot noise level. The propagation of a laser beam in free space in an intersatellite link is distortion-free, the objective of the system design being to overcome path attenuation and to provide a sufficient carrier to noise level.

However, propagation through the atmosphere can result in such severe attenuation and distortion of the signal as to render communications impossible. Impairments due to atmospheric propagation result from the mechanisms of absorption, scattering and atmospheric turbulence.

Absorption of the optical field is caused by molecular constituents such as ozone, water vapour and carbon dioxide. Strong absorption occurs at the wavelengths of 1.13 μm, 2 μm, 4.3 μm and 6 μm.

Scattering, when caused by molecular-sized particles, is called Rayleigh Scattering, and is predominant at shorter wavelengths. Scattering caused by larger particles such as hydrometeors, dust and smoke is more severe and is called Mie Scattering. Both absorption and scattering result in increased attentuation.

Atmospheric turbulence characterized by fluctuations in air temperature causes refractive index variations which lead to random changes in amplitude and phase of the optical carrier. The resulting impairments include scintillations (variations in signal power), deviation (movement of the beam from the boresight), spreading (increase in beam divergence), image wander (variations in beam angle of arrival), coherence degradation (loss in spatial coherence), dispersion (delay spreading over the modulation bandwidth), and polarization fluctuations (changes in polarization state and isolation).

The impairments due to atmospheric propagation will be more significant on the uplink where the effects occur closer to the laser source. The result of these impairments will be a decrease in system availabilities at higher bit rates, or alternatively, they will limit the maximum bit rate achievable.

> *A major difficulty with photodetectors operating at wavelengths greater than about 3 µm is that the thermal energy of atoms becomes comparable with photon energies resulting in thermally excited quantum events and noise.*

Some authors have suggested the use of active optics to reduce the adverse effects of atmospheric propagation. For most systems, atmospheric propagation will require the use of earth station diversity in order to provide sufficient system availability.

Optical receiver

The optical receiver consists of the optical antenna, a photodetector and an appropriate demodulator. Suitable photodetectors include photodiodes, photoconductive detectors and photoemissive devices. Candidate photodetectors include APDs of III-V compounds, HgCdTe photodiodes, extrinsic doped Ge photoconductors, intrinsic $Hg_{1-x}Cd_xTe$ photoconductors and GaAsP photoemissive detectors.

A major difficulty with photodetectors operating at wavelengths greater than about 3 μm is that the thermal energy of atoms becomes comparable with photon energies resulting in thermally excited quantum events and noise. This noise can be reduced by cryogenic cooling of the photodetector to within 70-100 K.

The performance of the photodetectors can be assessed by means of various parameters including quantum efficiency, responsivity, spectral and frequency response and noise equivalent power.

The performance of the receiver as a whole can be determined by the required signal of noise level for a given BER.

Optical pointing acquisition and tracking

Pointing, acquisition and tracking equipment will be required to ensure that the transmitted optical field reaches the receiver.

Optical pointing is the process of aiming the transmitter towards the receiver. Acquisition is the procedure the receiver uses to determine the direction of arrival of the incoming laser beam; and tracking is the process of automatically maintaining the transmitted beam on the detector area.

In view of the very narrow beamwidths of optical antennas, atmospheric propagation impairments, relative motions between the transmitter and receiver, and errors due to mechanical tolerances, the processes of pointing, acquisition and tracking present a major hurdle to be overcome in satellite lightwave engineering. An expected direction of research and development will be in the modelling and characterization of the probability distributions of the pointing errors. At present, high speed closed loop optical beacon tracking systems are envisaged.

TABLE 1: OPTICAL LINK BUDGETS FOR INTERSATELLITE AND EARTH SPACE LINKS.

Link Components	Inter-satellite Link	Earth-space Link
Laser Output Power (dBW)	0	0
Feeder Losses (dB)	−2	−2
Transmit Antenna Gain (dBi)	97	97
Tracking Loss (dB)	−3	−4
Path Loss (dB)	−280	−274
Atmospheric Propagation Loss (dB)		−10
Receive Antenna Gain (dBi)	97	97
Receive Feeder Losses (dB)	−2	−2
Received Power (dBW)	−93	−98
Required Power (dBW)	−100	−100
Margin (dB)	7	2

Optical link budgets

An optical link budget is an estimate of the signal and noise contributions arising from the various components of the optical link, and the impairments introduced by the propagation path. The important elements of a link budget are the signal-to-noise level required to sustain a given message rate at the desired BER and jitter performance, and the margin available above this level.

Typical link budgets for 10.6 μm, 280 Mbs^{-1}, BER = 1×10^{-6}, direct detection intersatellite and Earth-space links are given in Table 1. The path loss is calculated for the maximum range involved in each link.

Recent progress

Laser communications for satellite links has been the subject of considerable interest since 1960 when the US Air Force initiated R&D studies in this area. In 1973 the McDonnell Douglas Astronautics Company was contracted to build an engineering feasibility model for the Air Force Lasercom system. These studies indicated that Nd: YAG laser links could support 1 gigabit/s data rates with a potential capability of up to 16 gigabit/s at BER = 1×10^{-6}. Recent tests have lent support to these claims.

Satellite lightwave communications presents a field of opportunities for the Australian space industry to undertake R&D activities, component technology development and systems engineering. Intelsat's on-going program of studies in optical links will be part of that. ●

MICROBEE

Graphics dump

As soon as you boot up BASIC, switch on your printer and run this program. Type *new* and continue with your program. At any time press control P and the screen contents will be sent to the printer. Graphics can also be printed.

K.J. Lingohr
Carrum Downs, Vic

```
100 REM **   Basic listing for Graphic Screen Dump   **
110 REM **    By Kurt J. Lingohr for the microbee.   **
120 OUTL#1
130 FOR X=32000 TO 32168 : READ B : POKE X,B :NEXT X
140 A=USR(32000)
150 REM ** DATA FOR CTRL.P FUNCTION **
160 DATA 33,15,125,34,194,0,33,254,124,34,160,0
170 DATA 195,33,128,205,233,163,192,254,16,40,2
180 DATA 191,201
190 REM ** DATA FOR GRAPHIC SCREEN DUMP **
200 DATA 197,213,229,33,0,240,14,32,6,64,205,158,125
210 DATA 205,137,125,126,229,111,38,0,41,41,41,41,17,0,240
220 DATA 203,65,40,3,17,8,240,25,205,97,125,225
230 DATA 35,16,229,62,13,205,69,128,62,10,205,69,128
240 DATA 203,65,32,4,17,192,255,25,6,64,13,40,2,24,201
250 DATA 225,209,193,201,62,1,211,11,197,22,128,6,8
260 DATA 197,6,8,229,203,33,126,162,40,2,203,193
270 DATA 35,16,245,121,205,69,128,225,193,203,58,16,231
280 DATA 193,62,0,211,11,201,62,27,205,69,128,62,75
290 DATA 205,69,128,62,0,205,69,128,62,2,205,69,128
300 DATA 201,62,27,205,69,128,62,49,205,69,128,201
```

COMMODORE

Lotto checker

This program for the Commodore 64 checks your lotto form and returns a list of results on the screen. It is useful when you enter lotto on a multi-week basis. It is based on a 10-game entry form and will handle a large number of forms, if required. Each data line represents one game and all you need to do is insert your own selection of numbers. Copy the program as listed, replacing anything inside the square brackets as indicated.

I.P. Stone
Leigh Creek, SA

```
10 PRINT"[SHIFT/CLR HOME]"
20 INPUT"[CRSR DOWN]FIRST NUMBER";A
30 INPUT"[CRSR DOWN]SECOND NUMBER";B
40 INPUT"[CRSR DOWN]THIRD NUMBER";C
50 INPUT"[CRSR DOWN]FORTH NUMBER";D
60 INPUT"[CRSR DOWN]FIFTH NUMBER";E
70 INPUT"[CRSR DOWN]SIXTH NUMBER";F
80 INPUT"[CRSR DOWN]FIRST SUP";G
90 INPUT"[CRSR DOWN]SECOND SUP";H
100 PRINT"[SHIFT/CLR HOME]":FORI=1TO10:FORJ=1TO6:READZ
110 IFZ=ATHENY=Y+1
120 IFZ=BTHENY=Y+1
130 IFZ=CTHENY=Y+1
140 IFZ=DTHENY=Y+1
150 IFZ=ETHENY=Y+1
160 IFZ=FTHENY=Y+1
170 IFZ=GTHENX=X+1
180 IFZ=HTHENX=X+1
190 IFZ=-1THENPRINT"[CRSR DOWN]"SPC(10)"NO MORE FORMS TO CHECK":END
200 NEXTJ:GOSUB300:X=0:Y=0:NEXTI
210 PRINTA;B;C;D;E;F;"SUPS"G;H
220 PRINT"[CRSR DOWN]HIT ANY KEY TO CHECK NEXT FORM"
230 GETK$:IFK$=""THEN230
240 GOTO100
300 PRINT"GAME"I"HAS"Y"NUMBERS CORRECT &"X"SUPS":PRINT
310 RETURN
999 REM : NUMBERS SELECTED ON ENTRY FORM ONE FOLLOW,EXAMPLE:-
1000 DATA10,11,21,27,37,44
1010 DATA17,18,30,34,35,38
1020 DATA18,22,38,42,43,45
1030 DATA19,25,27,29,44,45
1040 DATA2,3,7,14,19,30
1050 DATA8,21,26,31,32,34
1060 DATA5,19,21,24,32,33
1070 DATA15,19,33,39,40,41
1080 DATA1,9,12,15,16,31
1090 DATA13,19,24,26,35,38
1099 REM : NUMBERS SELECTED ON ENTRY FORM TWO FOLLOW IF REQIURED
9999 DATA-1:REM END OF DATA FLAG

READY.
```

MICROBEE

```
ØØØØ1 REM12345678901234567890123456789012345
ØØ1ØØ FORA=23Ø9TO2338
ØØ11Ø READB:POKEA,B:NEXTA
ØØ12Ø DATA 33,Ø,24Ø,1,Ø,4,126,254,32,4Ø,12,254,123,48,5,198
ØØ13Ø DATA 128,119,24,3,214,123,119,35,11,12Ø,177,32,233,2Ø1
ØØ14Ø CLS
ØØ15Ø FORA=ØTO12
ØØ16Ø PRINT"Imagine alternate ";:INVERSE:PRINT"INVERSING";:NORMAL:PRINT"
and normal characters"
ØØ17Ø S=USR(23Ø9):REM........ CALLS  ROUTINE - AND 2ØØ ........
ØØ18Ø NEXTA
ØØ19Ø PRINT"Pretty good eh!!"
ØØ2ØØ S=USR(23Ø9):PLAYØ:GOTO2ØØ
```

Character inverse

This machine code routine changes all normal characters on the screen to PCG characters, and vice versa. The routine could be used in headings, instruction pages or anything else you can think of. The example program here prints some text up on the screen and flashes it continuously.

The routine is POKEd into the REM statement in line 1 so make sure you type this line exactly as it appears in the listing.

G. Heathcote
Ingleburn, NSW

Long multiplication

Home computers will usually display scientific notation if an arithmetic calculation runs higher than about nine figures leaving you wondering what the tenth figure is.

This program, written for Amstrad 6128 will accept a long multiplication sum from 1x1 to 60 digits by 20 digits and display the 'working out' just like we were taught at school.

In fact the program uses exactly the same method of multiplying and then adding up the columns.

The display is in mode 1 (40 column screen) unless the sum is too large when it changes to mode 2 (80 columns).

If a printer is connected, a hard copy may be selected as shown in the sample attached.

The listing is submitted in 40 column mode which is easiest to read in colour and also 80 column in case you like it that way.

A. B. Pounsett,
Norlane, Vic

AMSTRAD

```
                 EXAMPLE OF 60 DIGITS TIMES 20 DIGITS

                    999999999999999999999999999999999999999999999999999999999999
                                                           x99999999999999999999
                    ------------------------------------------------------------
                   89999999999999999999999999999999999999999999999999999999999991
                  89999999999999999999999999999999999999999999999999999999999991
                 89999999999999999999999999999999999999999999999999999999999991
                89999999999999999999999999999999999999999999999999999999999991
               89999999999999999999999999999999999999999999999999999999999991
              89999999999999999999999999999999999999999999999999999999999991
             89999999999999999999999999999999999999999999999999999999999991
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    89999999999999999999999999999999999999999999999999999999999991
   89999999999999999999999999999999999999999999999999999999999991
  89999999999999999999999999999999999999999999999999999999999991
 89999999999999999999999999999999999999999999999999999999999991
89999999999999999999999999999999999999999999999999999999999991
--------------------------------------------------------------------------------
99999999999999999998999999999999999999999999999999999999999900000000000000000001


                 EXAMPLE OF 78 DIGITS TIMES 2 DIGITS

  999999999999999999999999999999999999999999999999999999999999999999999999999999
                                                                             x99
--------------------------------------------------------------------------------
 8999999999999999999999999999999999999999999999999999999999999999999999999999991
8999999999999999999999999999999999999999999999999999999999999999999999999999991
--------------------------------------------------------------------------------
98999999999999999999999999999999999999999999999999999999999999999999999999999901
```

MICROBEE

```
00100 CLS
00110 A1$="CHR$"
00120 FOR I=33 TO 256 STEP 4
00130 PRINT TAB(3);A1$;I;
00140 PRINT TAB(20);A1$;I+1;
00150 PRINT TAB(37);A1$;I+2;
00160 PRINT TAB(54);A1$;I+3
00170 FOR L=0 TO 3
00180 FOR J=1 TO 10
00190 PRINT CHR$(I+L);
00200 NEXT J
00210 PRINT SPC(7)
00220 NEXT L
00230 PRINT:PRINT:PRINT
00240 NEXT I
```

ASCII characters checker

This small program works on any Microbee 16, 32 or 64K. If you are frustrated and angry because you do not know how to use the ASCII characters, then this program is for you. All you have to do is PRINT CHR$ (a number between 33 and 256) and press RETURN. The program will tell you the character that would be printed on the screen corresponding to the number which is used in the brackets.

C. Ayfandis
Belmore, NSW

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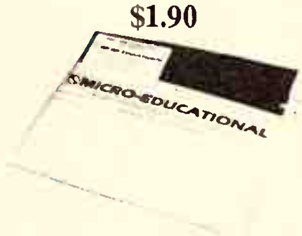

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COMPUTER:______________ SIGNED:______________

Master mind

This program re-creates the 'Master Mind' game.

The computer randomly chooses seven letters, and then asks the operator to guess them.

If a letter chosen is one of the letters the computer randomly selects, a 0 is displayed in the column beside it. If the letter is also in the right place, a 1 is displayed.

Once the operator chooses the correct letters in the correct order, the computer then uncovers the letters under the top stars. It then asks if you want to repeat the game.

C. Hacker
Rockhampton, Qld

APPLE

```
1   REM                 MASTER MIND
2   REM              BY CHARLES HACKER
5   DIM A(7),B(7)
10  TEXT : HOME
25  HTAB 13: PRINT "* * * * * * *"
30  FOR T = 1 TO 7
40 A(T) =  INT ( RND (1) * 25 + 66)
50  NEXT T
60  FOR T = 23 TO 2 STEP  - 1
70  FOR I = 1 TO 7
80  VTAB T: HTAB 11 + (2 * I): GET A$
81  IF  ASC (A$) < 65 THEN 80
85 B(I) =  ASC (A$)
90  VTAB T: HTAB 11 + (2 * I): PRINT A$
100  NEXT I
105  VTAB T: HTAB 29: PRINT ":::::::": VTAB T
110  FOR I = 1 TO 7
120  FOR X = 1 TO 7
121  VTAB T
130  IF A(I) = B(X) THEN  HTAB 28 + X: PRINT "0"
140  NEXT X,I
141 AM = 0
150  FOR I = 1 TO 7
155  VTAB T
160  IF A(I) = B(I) THEN  HTAB 28 + I: PRINT "1":AM = AM + 1
170  NEXT I
171  IF AM > 6 THEN 190
180  NEXT T
190  HTAB 13: VTAB 1
200  FOR T = 1 TO 7: PRINT  CHR$ (A(T));" ";
205  FOR I = 0 TO 100: NEXT I
210  NEXT T
220  PRINT : PRINT "PLAY AGAIN     (Y/N)": GET A$: IF A$ = "N" THEN  END

230  RUN
```

SOFTWARE — Main Players

ALL ELECTRONIC COMPONENTS
118-122 Lonsdale St,
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(03) 662-3506

ARCOM PACIFIC
252 Abbotsford Rd,
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(07) 52-7820

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62 Atchison St,
St Leonards, NSW 2065
(02) 439-8400

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117 York St,
Sydney, NSW 2000
(02) 261-1611

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35 West Pde,
Eastwood, NSW 2121
(02) 85-3050

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Sydney, NSW 2000
(02) 212-4599

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PO Box 34,
Fyshwick, ACT 2609
(062) 31-0728

FBN SOFTWARE
16 Coles Pl,
Torrens, ACT 2607
(062) 86-1102

GOAL SYSTEMS AUST
Suite 87 Chatswood Village,
Neridah St,
Chatswood, NSW 2067
(02) 411-3622

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6/161 Military Rd,
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(02) 908-3458

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11 Pavonia St,
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(08) 46-7427

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77 Dunning Ave,
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(02) 569-0232

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Sydney, NSW 2000
(02) 29-2866

SOFTWARE EXPRESS
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Melbourne, Vic 3000
(03) 663-6580

SOFTWARE SUPPLIERS
7 Avon Rd,
North Ryde, NSW 2113
(02) 888-1955

STC PERSONAL COMPUTER DIVISION
5 Blue St,
North Sydney, NSW 2060
(02) 925-7272

STRATEGIC SOFTWARE SERVICES
169 Miller St,
North Sydney, NSW 2060
(02) 957-6667

TECHNICAL IMPORTS
220 Pacific Hwy,
Crows Nest, NSW 2065
(02) 922-6833

THE COMPUTER FACTORY
214 Harbord Rd,
Brookvale, NSW 2100
(02) 938-2522

This list is representative only. Omission implies that our records were incomplete at printing.

ETI PROJECTS

186 months of projects

June 1971-December 1986

KEY TO KIT SUPPLIERS
AEC All Electronic Components (03) 662-3506
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App Applix (02) 758-2688
DSE Dick Smith Electronics (02) 888-3200
EC Energy Control (07) 288-2455
ED Electronic Discounters (08) 212-1799
FE Force Electronics (08) 212-2672
HIC Hi Com Unitronics (02) 524-7878
Jay Jaycar (02) 747-2022
LE Laser Electronics (075) 532-2066
RIE Rod Irving Electronics (03) 663-6580

In addition, the following companies advise that they make an effort to keep a selection of parts for all projects:
Eagle Electronics (08) 271-2885
Geoff Wood (02) 427-1676
Magraths (03) 663-1122
Prepak (02) 569-9797

Circuit boards and some front panels are available from the following:
Jemal (09) 350-5555
RCS Radio (02) 587-3491

The following services are available direct from ETI:
Artwork for all our projects: $5 for boards up to 10 cm square
$10 for larger boards
Back issues if available: $4
Photocopies of articles: $4, or $8 if more than one part.
Send orders to **Reader Services, ETI magazine, 180 Bourke Road, Alexandria NSW 2015. Sydney, Australia.** Please note that phone orders cannot be accepted.

SIMPLE PROJECTS

No.	Name	Date	Suppliers
043	Heads or tails	Oct 76	AEC, RIE
044	Doorbell	Oct 76	AEC, RIE
061	Simple amp	Oct 76	RIE
062	Simple AM tuner	Mar 77	
064	Intercom	Nov 76	RIE
066	Temp alarm	Dec 76	RIE
068	LED dice	Oct 76	AEC, RIE
070	Tie breaker	Jan 77	
071	Tape noise limiter	Jun 78	RIE
072	Two octave organ	Jun 78	RIE
081	Tacho	Mar 77	AEC
801	LINC	May 75	
802	Windicator	Feb 75	
803	Cannonballs and missionaries	Dec 75	
804	TV game	Nov 76	
805	Drunken sailor	Oct 77	
806	Skeet	Jan 78	
807	Tug o'war	Aug 84	
810	TV game	Jun 78	
811	Tank game	Oct 78	
812	Wheel of fortune	Dec 78	
813	Race track	Jan 79	
814	Electronic dice	Aug 79	AEC
824	Slot car controller	Dec 81	
905	Organ	Jan 83	
918	Polyphone light beam transceiver	Sep 82	
201	Current limiter	Apr 71	
202	Stereo balance meter	May 71	
203	10 c moisture meter	Jun 71	
204	Elapsed time indicator	Aug 71	
205	Doorbell	Sep 71	
206	Audio visual metronome	Oct 71	
207	Emergency lighting unit	Oct 71	
208	Loudhailer	Nov 71	
209	Meter mount	Oct 72	
210	Decision-maker	Jan 73	
211	Audio frequency meter	May 73	
212	Earth resistivity meter	May 73	
213	The revealer	Jun 73	
215	Cyclone detector	Nov 73	
216	TV ghost eliminator	Feb 74	
217	12 V power supply	Feb 74	
218	Mono organ	May 74	
219	Hee-haw siren	May 74	
220	Wailing siren	May 74	
221	Basic power supply	May 74	
222	Transistor tester	May 74	
223	Multi vibrator	May 74	
224	Temp alarm	May 74	
225	Simple amplifier	May 74	
226	Temp meter	May 74	
227	Crystal radio	May 74	
228	Pocket metronome	Aug 74	
229	Metre beater	Nov 74	
230	The family ferry	Sep 74	
231	Flip-flop flasher	Jan 75	
232	Courtesy light reminder	Oct 74	
233	Combination lock	Oct 74	
234	Intercom	Oct 74	

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Jay Jaycar (02) 747-2022
LE Laser Electronics (075) 532-2066
RIE Rod Irving Electronics (03) 663-6580

No.	Name	Date	Suppliers
235	Bicycle speedo	Mar 75	
236	Code practice oscillator	Aug 75	
237	Loudness control	May 75	
238	Headphone adaptor	Dec 75	
239	Breakdown beacon	May 76	
240	High power rescue signal	May 76	AEC
241	Electronic dice	Jul 76	
242	Neo nim	Aug 76	
243	Pip beacon	Apr 77	
244	Car alarm	Feb 77	
245	White line follower	Nov 77	
246	Rain alarm	Apr 78	
247	Soil moisture indicator	Nov 80	AEC
248	12 V-22 V converter	Jul 78	
249	Combination lock	Apr 79	AEC
250	House alarm	Aug 80	AEC
251	Op-amp power aupply	Aug 85	AEC
252	Passionmeter	Apr 85	
253	Grenade/hot potato game	May 79	
254	Egg timer	Jun 79	
255	Temperature meter	Nov 80	AEC
256	Humidity metre/controller	May 81	RIE, AEC
257	Universal relay board	May 81	RIE, AEC
258	Mini-drill sped controller	Jul 81	
259	Low-cost timer	Jan 82	
260	CMOS flasher	Dec 79	Jay, ED
261	Fog horn	Dec 79	
262	Intercom	Dec 79	
263	Egg timer	Dec 79	
264	Siren	Mar 80	
265	Mains appliance timer	Jul 83	RIE, AEC
266	Crystal set	Dec 79	
267	Voltage multiplying crystal set	Dec 79	
268	Nicad float charger	Nov 83	RIE, Jay, ED
270	Solar-powered radio	Dec 79	
271	Solar intensity meter	Dec 79	
272	LED amp output indicator	Nov 83	RIE
273	Let caller for tennis	Jan 84	
274	Fast Nicad charger	Feb 84	
275	Bathroom heater timer	Jun 84	
277	Ready-set-go timer	Oct 84	
278	Door minder	Nov 84	RIE
279	Darkroom exposure meter	Jan 85	AEC
280	Low battery voltage indicator	Mar 85	RIE, Alt, FE, AEC, ED
281	Power supply	Dec 86	
282	Telephone screamer	Sep 86	Jay, ED
283	Lotto selector	Dec 86	

TEST EQUIPMENT

No.	Name	Date	Suppliers
101	Logic power supply	Jun 71	
102	Audio signal gen	Jun 71	
103	Logic probe	Jul 71	
104	Soldering iron control	Aug 71	
105	Dual power supply	Nov 71	
106	CRO calibrator	Feb 72	
107	Voltmeter	Feb 72	
108	Decade resistance box	Sep 72	
109	Digital frequency meter	Sep 72	
110	FET voltmeter	Oct 72	
111	IC power supply	Nov 72	
112	Audio attenuator	Mar 73	
113	Thermocouple meter	Sep 73	
114	Dual beam adaptor	Jul 74	
115	Linear IC tester	Aug 74	
116	Impedance meter	Mar 75	
117	Digital voltmeter	Aug 75	
118	Frequency meter	Sep 75	
119	Switching regulator	Dec 75	
120	Logic probe	Sep 75	AEC
121	Logic pulsar	Sep 75	AEC
122	Logic tester	Oct 75	
123	CMOS tester	Nov 75	
124	Tone burst gen	Nov 75	AEC
125	Oscillator	Jun 75	
126	rf power control	Jan 75	
127	TTL super test	Feb 75	
128	Audio mV meter	Jan 76	
129	rf signal generator	Jan 76	
130	Temp meter	Feb 76	AEC
131	Power supply	Apr 76	
132	Power supply	Feb 77	AEC
133	Phase meter	Apr 77	AEC
134	RMS voltmeter	Aug 77	
135	Intersil panel meter	Oct 77	AEC
136	Linear scale panel meter	Mar 78	
137	Audio oscillator	May 78	
138	Audio wattmeter	Nov 78	
139	SWR meter	May 78	
140	1 GHz frequency counter	Mar/Apr 78	
141	Logic trigger	Jan 79	
142	Power supply	Feb 79	AEC
143	Curve tracer	Jan 79	
144	True RMS voltmeter	Jun 79	
145	Test board	Jul 82	AEC
146	Mains master	Nov 79	
147	Electronic load	Oct 80	RIE
148	Logic probe	Jul 79	AEC
149	Two tone tester	Jul 80	RIE
150	Frequency meter	Dec 79	AEC
151	Ohm meter	Jan 80	
152	Capacitance meter	Feb 80	
153	Temperature probe	Jan 83	RIE, Jay, ED
154	Digital logic pulsar	Jul 81	
155	4/8/16 ohm audio dummy load	Jun 81	
156	100 MHz hi impedance probe	Jun 81	
157	Crystal marker	Oct 81	AEC
158	Low ohm meter	Nov 81	RIE
159	10-15 V expanded scale meter	Dec 81	AEC, RIE
160	13.8 V/10 A power supply	Jul 82	Alt, FE, ED
161	Digital panel meter	Aug 82	AEC
162	30 V/1 A power supply	Dec 82	AEC, RIE, DSE
163	40 V/5 A power supply	May/Jun 83	AEC, RIE
164	Zener tester	May 83	RIE, Alt, FE, ED
165	Tacho calibrator	Nov 82	

Continued on page 93

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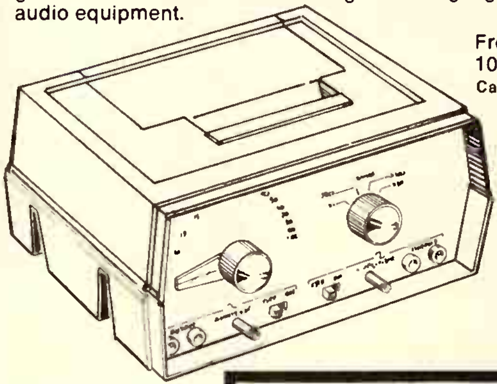

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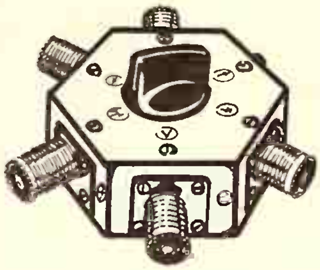

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The Cantenna eliminates unnecessary QRM during tune-up and minimizes mistakes while performing 'hot' gear maintenance or alignment. Handles 1kW of RF with VSWR less than 1.5:1 up to 450MHz.
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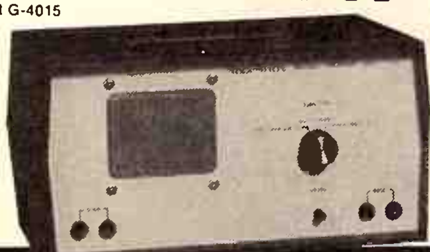

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No.	Name	Date	Suppliers
166	Function generator	Jul/Aug/ Sept/Oct 83	AEC
168	Continuity tester	Sep 85	
169	Low distortion oscillator	Oct/Nov 85	
170	CRO calibrator	Feb 85	
171	Arbitrary waveform generator	Feb 86	
172	Bit pattern detector	Apr 86	RIE
173	Electro static hazard detector	Jun 86	RIE
174	Timebase standard	Jul 86	RIE
175	20 MHz DFM	Sep/Oct 85	AEC
182	Digital luxmeter	Mar 85	AEC
183	Op amp tester	Apr 85	AEC, RIE

AUTOMOTIVE

No.	Name	Date	Suppliers
301	Variwiper	May 71	
302	Tacho/dwell	Jul 71	
303	Brake light indicator	Oct 71	
304	Light-operated switch	Nov 71	
305	Car alarm	Jan 72	
307	Headlight reminder	Oct 72, Oct 74	
308	Turn indicator	Feb 73	
309	Battery charger	Aug 73	
310	Ignition timing light	Jun 74	
311	Tacho — timing light	Sep 74	
312	CDI	Dec 74, Jan 75	AEC
313	Car alarm	Nov 74	AEC
314	Auto amp	Feb 75	
315	Solid state flasher	Feb 75	
316	Transistor ignition	May 77	AEC
317	Tacho warning light	Jul 77	AEC
318	Tacho digital	Jul 78	AEC
319	Variwiper Mk2	Sep 78	AEC
320	Battery indicator	Apr 79	AEC
321	Fuel level warning	Jan 80	AEC
322	Over-rev alarm	Mar 80	AEC
323	Headlight delay	May 83	RIE
324	LED tacho	Aug 80	RIE, DSE, Alt, FE, AEC, ED
325	Auto probe	May 80	RIE, AEC
326	Expanded LED voltmeter	Sep 80	RIE, Alt, FE, AEC, ED
327	Hazard flasher	Oct 80	RIE, AEC
328	Oil temp meter	Jan 81	RIE, AEC
329	Expanded scale car ammeter	Feb 81	AEC
330	Car alarm	Jul 81	RIE, DSE, AEC
332	Engine stethoscope	Aug 81	AEC
333	Vehicle reversing alarm	Jan 82	RIE, AEC
334	Auto tester	Jan 83	
335	Programmable wiper controller	Mar 83	RIE, AEC
336	Dwell meter	Aug 83	
337	Auto car antenna driver	Sep 84	AEC
340	Car alarm	Apr 84	Jay, ED, AEC
341	Electronic jumper leads	Aug 85	AEC
342	Pulse-shaped CDI	Feb/Mar 85	Jay, ED
343	Optical car alarm switch	Sept/Oct 85	HIC
345	Demister timer	Jun 86	AEC

AUDIO

No.	Name	Date	Suppliers
400	Speaker	Jun 75	
401	FET 4 channel mixer	Sep 71	
402	Simple channel sound	Apr/Aug 71	
403	Guitar sound box	Apr 71	
404	FM conversion unit	Apr 71	
405	Magna ray 8-30	Jul 72, Aug 71	
406	Single transistor radio	Dec 71	
407	Bass booster	Dec 71	
408	Reverb unit	Mar 72	
409	TV sound	Mar 72	
410	Super stereo	May 72	
411	Small speakers	Aug 72	
412	LED peak program meter	Oct 83	RIE, Alt, FE, AEC, ED
413	100 W guitar amp	Sept 75, Dec 72	
414	Stage mixer	Feb/Apr 73, Mar 75	
415	Quadreflect speakers	Jan 73	
416	25 W amp	Jan/Jul 73	
417	Over LED	Aug 73	
418	Music synth	Oct 73	
419	Preamp	Sept 73	
420	4 channel amp	Jan/Feb 74, Dec 75	
421	Low-cost stereo speaker system	Sept 83	
422	50 W stereo	May/Jun 74, Oct 75	
423	Add-on 4-channel amp	Apr 74	
424	Spring reverb	Sep 74	
425	Integrated amp	Jun-Sep, Dec 72	
426	Rumble filter	Oct 74	AEC
427	Graphic equalizer	Oct 74	
428	Amplifier	Dec 74	
429	Colour organ	Nov 74	
430	Line amplifier	Mar 75	
431	FM antenna	Apr 75	
432	Ceramic preamp	Jun 75	
433	Active crossover	Sep 75	
434	Two tape facility	Oct 75	
435	Crossover amplifier	Oct 75	
436	Dynamic noise amplifier	Sep 75	
437	Simple speaker	Nov 75	
438	Audio level meter	Dec 75	AEC
439	3-way speakers	Dec 75	
440	25 W amplifier	Jul 75	
441	Noise generator	Jan 76	AEC
442	Masterplay stereo	Sep 84	AEC
443	Expander compresser	Apr 76	AEC
444	5 W amp	Jun 76	
445	Stereo preamp	Jul 76	RIE, DSE, Alt, AEC, FE, ED

Continued on page 98

GREAT NEW PRODUCTS FOR 1987 ONLY FROM JAYCAR

I.C. SUBSTITUTION MANUAL

We believe that this book on IC substitution is about as good as they come - for any price. How would you like a single book to list all of the current IC product from 108, yes one hundred and eight of the western Worlds IC manufacturers! National Semiconductor, for example, lists 19 pages (4 columns/page) of their products, with the recommended substitutions. The other majors: Motorola 19 pages, RCA 9 pages and Texas 18 pages. The total list runs for 189 pages/4 columns to a page!

Many obscure (to Australia) manufacturers are listed including: Burr-Brown, Cherry Semiconductor, Harris Semiconductor, Hughes Aircraft, Datel, Exar, Ferranti, General Instrument, Inmos, Intersil, Monolithic Memories, OKI, Raytheon, Rockwell, Solid State Scientific, Telefunken, SEEQ, Silicon General, etc. And that's only 1/2 the book! The other half of the book lists the generic number of the IC.

Manufacturers of the IC are listed alongside with their full part number shown. Would you believe that there is an IC number zero! (Made by ITT and 2 second sources).

The 741 op-amp IC, for example, lists 35 equivalent types. We are convinced that you will be absolutely delighted with this excellent reference.

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Not a table - a great thick book! 784+ pages of transistor equivalents. The book lists all transistors in strict alpha-numeric order, starting with Pro-Electron types (AC, BC, BF, BUX - etc) thru manufacturers numbers (e.g. Motorola MPS series etc), thru the old 'OC' series, finally to the Ferranti ZTX series. The 2N-series follows that - (this is the largest section of the book, of course), with the Japanese series (2SA, 2SB, 2SC, 2SD, 2SJ & 2SK) following with 3N and the large number series (e.g. RCA 40--- series) finishing. Each device is described briefly by its prime maker, material, polarity, case type and lead configuration, function and whether a complimentary version exists. Suggested equivalent parts are also listed. Case drawings with pin connection details are listed in the back as well as definitions of the symbols used. This book **stands apart** from other equivalent books because it actually **gives data** on the component in question. This enables you to work out for yourself a reasonable equivalent from what you have available. Too often equivalent books simply give another obscure part number to the part you already have!

Like us, we are sure that you will be absolutely delighted with this book. If you are a professional it will probably pay for itself the first time that you successfully use it.

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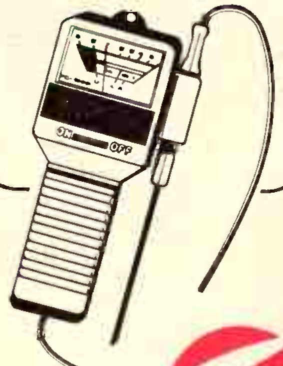
Cat. QM-6135

ONLY $39.95



AUSTRALIAN MADE

MEGAMODEM is here - other Smartmodems can't compete

The Avtek Megamodem provides complete compatibility with the industry standard Hayes SM300 and SM2400 modems, while also providing a very easy to use menu driven mode where suitable software is not available.

Full auto recognition of both ingoing and outgoing baud rates makes correct connection very easy. Full autoanswer with accurate ring detect circuitry means reliable remote operation. For high speed operation, an internally fitted 1200/1200 V22 option is available.

Megamodem 300/300, 1200/75 V21/V23 **ONLY $499.00**
Cat. XC-4832

Megamodem V21/V22/V23 (1200/1200 baud option fitted)
Cat. XC-4834 **ONLY $699.00**

MULTIMODEM II

AUSTRALIA'S No.1 modem

Australia's top selling modem now offers even more. You get

Reliability. State of the art digital filters for reliable data transfer, even on noisy lines.

The Expansion Bus - an Avtek exclusive. Developments can be plugged straight in.

Total flexibility. Both 300/300 and 1200/75 (Viatel) at the flick of a switch.

Autoanswer as standard. A reliable and instant "ring detect" circuit is completely independent of the strength of the ring.

A 1200 baud full duplex option. At the lowest price in the country.

Multimodem II **$349.00**
Cat. XC-4822

Multimodem II with 1200/1200 option
Cat. XC-4823 **$585.00**

MINIMODEM II

leader in the value stakes

Superb performance for those on a limited budget. The Minimodem II offers the same digital filtering and error correction as the Multimodem but at a much lower price.

Full 300/300 baud *and* 1200/75 (Viatel standard) are provided at lower cost than some 300 baud only modems - check for value and you'll find Minimodem wins every time.

Cat. XC-4825

ONLY $199.00

SPEAKER CORNER

FOSTER SPEAKERS

WHITE CONE WOOFER $24.95

Best value 8" woofer we've seen. Excellent sound and a beautifull looker. Ferrofluid 30 watts r.m.s., frequency response 50 - 3000Hz, resonance frequency 50Hz.
Cat. CW-2111

4" WIDERANGE C100K03 $21.50

This ever popular widerange/midrange is now available. Ideal where high quality is needed, but where space is a premium.

SPECIFICATIONS

Impedance	8 ohms
Power	3 watts
Max Power	10 watts
Resonant Frequency	80 ± 15Hz
Frequency Range	fo to 17,000Hz
SPL	90 ± 2dB/W
Flux Density	10,000 Gauss

Cat. CE-2312

MAGNAVOX

12MV-012

The 12MV is a high power high fidelity woofer utilising a 38mm diameter long throw voice coil wound on an aluminium former and high compliance suspension with a polyurethane foam roll surround, resulting in excellent linearity at very high input powers.

Power Handling	100 watts r.m.s.
Resonant Freq.	23Hz
Freq. Range	fo - 3000Hz
Sensitivity	96dB

Cat. CW-2125

$69.50 ea

8JX

The 8JX is a 8" twin cone speaker suitable for medium power handling applications.

Power Handling	30 watts r.m.s.
Resonant Freq.	44Hz
Freq. Range	fo - 14kHz
Sensitivity	93dB

Cat. CE-2333

$26.50 ea

POLYPROPYLENE CONE WOOFERS

HIGH QUALITY AT LOW COST

12" WOOFER $79.50

Power Handling	80 watts rms system
Impedance	8 ohms
Resonant Frequency	23.2Hz
Sensitivity	92.3dB 1 watt 1 metre
Eff. Freq. Response	23Hz - 5kHz
Electromagnetic Q	QES 0.481
Peak Cone Excursion	2 x/max x 1.6mm

Cat. CW-2130

10" WOOFER $69.50

Power Handling	70 watts rms system
Impedance	8 ohms
Resonant Frequency	24.3Hz
Sensitivity	91.9dB 1 watt 1 metre
Eff. Freq. Response	24Hz - 6kHz
Electromagnetic Q	QES 0.398
Peak Cone Excursion	2 x/max x 1.25mm

Cat. CW-2116

8" WOOFER $42.50

Power Handling	60 watts rms system
Impedance	8 ohms
Resonant Frequency	23.2Hz
Sensitivity	88.2dB 1 watt 1 metre
Eff. Freq. Response	23Hz - 5kHz
Electromagnetic Q	QES 0.481
Peak Cone Excursion	2 x/max x 1.6mm

Cat. CW-2114

5" MIDRANGE FERROFILLED Cat. CM-2085 $29.50

LOUD PLATE TWEETER Cat. CT-2030 $39.50

10" PASSIVE RADIATOR Cat. CR-2180 $36.50

12" PASSIVE RADIATOR Cat. CR-2190 $47.50

AM/FM STEREO TUNER SYNTHESISED

Ref: EA December '85 - Feb '86
Cat. KA-1635

$499.00

REMOTE CONTROL

Ref: EA April 1986
Cat. KA-1636

$89.50

COMPUROBOTS 1987 RANGE

Jaycar is proud to announce our 1987 'Turtle' robot line-up. We have expanded our range to 3 models - selected for value-for-money and performance from a large number of overseas types.
Prices start from a modest $49.95! All robots are supplied in attractive gift packaging.

ECONOMY Model CR-400 "FRIENDLY LITTLE ROBOT"

This unit is roughly 150mm diameter and 210mm high. The CR-400 is programmed via a 8-key membrane keypad on its 'chest'. Programmable actions include: Music sound, flash 'eye' (light on head), turn in either direction, circle, etc. Up to 18 consecutive entries are permissable. This robot also features a very effective tactile bumper switch and movable arms which can grip small objects.
Uses 4 x AA & 1 x 9V x cell (not supplied)
Cat. XR-1020

ONLY 49.95 PIC 'A'

VALUE - MODEL CR-100 "COMPUROBOT"

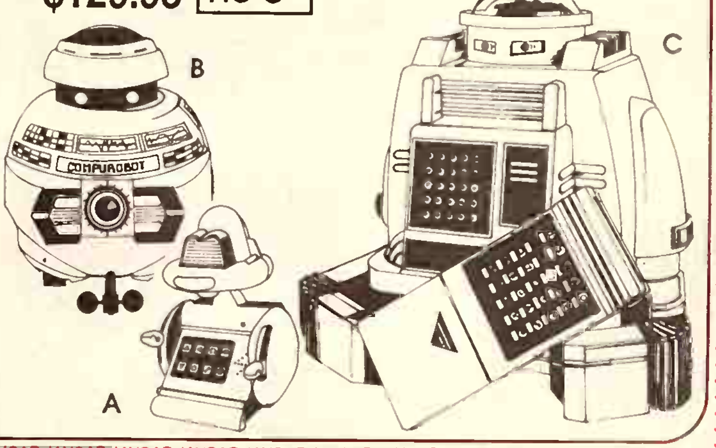
A very sophisticated robot for the price. This unit which measures roughly 150mm diameter and 1650mm high. This microprocessor controlled unit is programmed via a 25 key keypad on the 'head' of the robot. Up to 48 separate routines can be entered into a program. The robot has a multi-speed gearbox, can travel in 4 separate directions as well as at angles and curves. It has lights and can make sounds. Hundreds have been sold to primary schools throughout Australia. Requires 4 x AA & 1 x 9V cell (not included).
Cat. XR-1024

$69.95 PIC 'B'

PERFORMANCE - MODEL CR-200 COMPUROBOT II

This highly sophisticated robot has it all. The robot is programmed via a wireless infra-red hand held controller with a 25 key keypad. A very comprehensive 30 page instruction booklet is also provided. Up to 64 program steps can be accommodated in the robot memory. Simple editing functions are a feature of this unit, which uses LOGO-type commands. The unit will go in any direction as well as make a number of different noises, flash lights etc. It beeps every time a key entry has been entered so that it verifies entry.
The robot has two (non motorised) mechanical arms to actually carry a payload. A crayon attachment is also provided to enable the robot to "draw".
When the I.R. controller is not in use the robot has a holder to carry it about. Another very valuable feature is an auto-turn-off facility, which conserves battery life.
A highly recommended product.
Measures 230(H) x 210(W) x 175(D)mm
Rugged ABS plastic case. Uses Japanese quality Mabuchi motors.
Batteries required 4 x C (for robot); 4 x AA (for controller)
Cat. XR-1028

$129.95 PIC 'C'



DELUXE CURRENT SENSE CAR ALARM

Ref: AEM October 1986 AEM 8501
This high quality Tillbrook designed unit includes case and Scotchcal front panel.
Cat. KM-3048 ONLY $98.50

JAYCAR JAYCAR

New Digital Multimeters for '87! SENSATION! Digital Multimeter with Frequency Counter & Capacitance Meter!

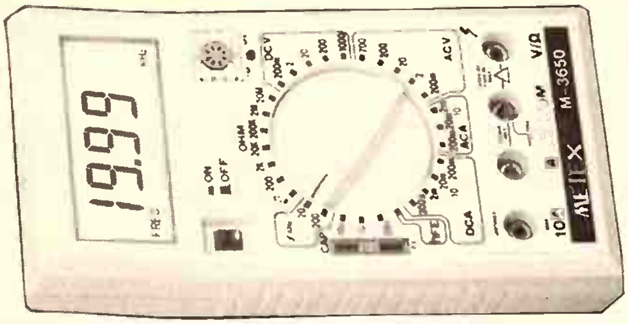
ONLY $159.00

That's right! A compact DMM which not only has impressive voltage current and resistance ranges (see chart) BUT is a capacitance meter & digital frequency meter to boot! Oh, and we almost forgot it's a diode and transistor checker as well!

You will be proud to own this attractive meter moulded in yellow high impact plastic. Quality shrouded test leads, PVC case, instructions and battery are provided as well.

If you are not completely satisfied with this amazing meter return it to us in original condition in 7 days and we will refund your money in full (less p&p charges).

Cat. QM-1555



DC Voltage	Range	200mV, 2V, 20V, , 1000V
	Resolution	100uV, 1mV, 10mV, 100mV, 1V
	Accuracy	200mV-1000V±(0.3%rdg+1 dgts)
	Input Impedance	10M ohm
AC Voltage	Range	200mV, 2V, 20V, 200V, 750V
	Resolution	100uV, 1mV, 10mV, 100mV, 1V
	Accuracy	200mV-200V±(0.8% rdg+3 dgts) 750V±(1.2%rdg+3 dgts)
	Input Impedance	10M ohm
DC Current	Range	200uA, 2mA, 20mA, 200mA, 20A, 10A
	Resolution	100nA, 1nA, 10uA, 100uA, 10mA
	Accuracy	200uA-20mA±(0.5%rdg+1 dgt), 200mA±(1.2%rdg+gt) 10A±(2.0%rdg+5 dgts), (10A range unfused)
	Max Input Current	10A (20A up to 60 sec)
AC Current	Range	2mA, 20mA, 200mA, 10A
	Resolution	1uA, 10uA, 100uA, 10mA
	Accuracy	2mA-20mA±(1.0%rdg+3 dgts), 200mA±(1.8%rdg+3 dgts) 10A±(3.0%rdg+7 dgts), (10A range unfused)
Resistance	Range	200, 2k, 20k, 200k, 2M, 20M ohms
	Resolution	0.1, 1, 10, 100, 1k, 10k ohms
	Accuracy	200 ohm ±(0.5%rdg+3 dgts) 2k ohm - 2M ohm ±(0.5%rdg+1 dgt) 20M ohm ±(0.5%rdg+2 dgts)
	Overload Protection	200 ohm 250V DC/ACrms, 2k - 20M ohm 500V DC/ACrms
Capacitance	Range	200nF, 2uF, 20uF
	Resolution	100pF, 1nF, 10nF
	Accuracy	200nF-uF ±(3.0%+5 dgts)
Frequency	Range	0-20kHz 0-200kHz

Full overload protection is provided.

Don't keep wasting money buying throwaway batteries - step up to rechargeable NiCads.

Cat. SB-2452

$2.95 each

SPECIAL 4 for $10

from as low as 7.5¢!

1N 4004's & 1N4007's

Jaycar now has bulk packs of popular 1N4004 & 1N4007. Buy in bulk and SAVE!

Cat. ZR-1005 100 pieces of brand new, prime spec 1N4004 diodes

$7.50/pack

Cat. ZR-1008 100 pieces of brand new prime spec 1N4007 1000 P.I.V. 1 AMP diodes

$14.00/pack

AND DIGITAL HOLD TO BOOT!

Just think a multimeter with 0.15% accuracy on most ohms ranges. 0.05% on DC volts and 0.5% MAX on DC current!! STAGGERING, plus, continuity buzzer and LED symbol, auto polarity, auto zero, vinyl case and DATA HOLD as well!! NOT TO MENTION the transistor and diode tester!!

SPECIFICATIONS

• 0 - 1kV DC 0.05% • 0 - 750V AC 0.8% (max) • 10A DC 0.5% (max) • 0 - 10A AC 1% (max) • 20M ohm 0.5% (max)

FEATURES

• All ranges fully protected • Auto zero • 0.5" high LCD • Diode test (1mA fixed current) • LCD display feature • Functional annunciators • Extremely accurate • 20 page instruction manual included

Cat. QM-1550

$179.00

This is the obvious successor to the fabled ETI480 amps. This kit will give around 100W rms into 4 ohms with recommended transformer. It is actually cheaper than the 480 which required an expensive power supply. The AEM 6506 has power supply filter caps INCLUDED! You only need to connect up a power transformer and bridge rectifier. It is very easy to build - even for a novice. No bias adjustment!

Cat. KM-3050 ONLY $35.00 Transformer extra

The big daddy - this superb unit features 0.5" high digits, CMOS logic, auto polarity etc.

Cat. QM-1540

A BARGAIN AT

$129.00

for under $50!!

A car many of us dream about that you can now own!!

How would you like a gleaming Porsche RC928 in black or pink - all 7 inches of it - gleaming at you on your desk. Not only does it fill you with pride but you can talk to it and it will talk back! Because it's really a telephone!

Thta's right! Impress your friends with your new-found wealth. Comes complete with generous cord with Telecom plug already fitted. Features pushbutton dialling, on/off ringer switch, mute (removes your voice) button, redial (up to 17 digits) button and instructions. Uses no batteries. Simply plug in and you're away!

Cat. YT-7070

$49.95

• Very compact • Powered by one 1.5V AA battery that lasts for 1 year • 56mm square, 15mm deep • Very accurate

Fit your own custom clock face. Great for novel applications such as fitting to pictures. Supplied with 3 sets of hands.

Cat. XC-0100

$12.95

Includes 3 sets of hands

Superb features and specifications. Includes 0.5" high digits, single function range switch, long battery life, etc.

Size: 170(H) x 90(W) x 35(D)mm.

SEE THE JAYCAR 1986 CATALOGUE FOR FULL SPECS

Cat. QM-1530

$89.95

TELEMAIL PHONE NUMBERS

(008) 022 888

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FOR ORDERS ONLY

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HOTLINE

TURN YOUR SURPLUS STOCK INTO CASH!!!

Jaycar will purchase your surplus stocks of components and equipment. We are continually on the lookout for sources of prime quality merchandise. CALL GARY JOHNSTON OR BRUCE ROUTLEY NOW

(02) 747 2022

GORE HILL STORE OPEN SATURDAYS UNTIL 4 p.m.

THE ULTIMATE

AEM 6000 POWER AMPLIFIER

The 6000 series power amplifier by David Tillbrook is the culmination of over 7 years work on power amp design using Mosfet technology.

SPECIFICATIONS:

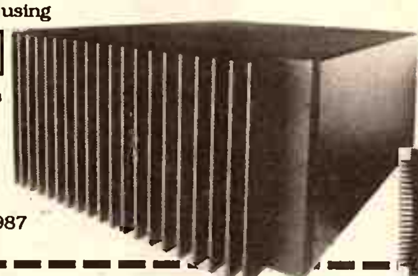
$998.00

Output Power	240W RMS per channel into 8 ohms (360W RMS into 4 ohms)
Damping Factor	>300 (100Hz 8 ohms)
THD	<0.005% @ 1kHz @ 200 watts
S/N Ratio	400Hz - 20kHz noise bandwidth >118dB 'A' - weighted

WE WILL NOT BE RELEASING THIS KIT UNTIL FEB 1987

The Jaycar kit includes:
- 300VA toroids (pre-amp toroid extra)
- Metal work identical to prototype
- Original diecast heatsink

Commercial equivalents cost between $2,500 & $3,500
Cat. KM-3020



"ULTRA FIDELITY" PREAMPLIFIER

Ref: AEM Oct - Dec 1985

Cat. KM-3030

$319.00

THE STUNNER

If you want a really potent electric fence for long fence runs, this is the one. It has a much lower output impedance for fences more than 1km long. It's our "industrial strength model". 240V operated.
Cat. KA-1678

$229.00

See EA October 1986

ELECTRIC FENCE KITS

THE BABY

Mains or battery powered. This electric fence controller is both inexpensive and versatile. It should provide an adequate deterrent to all manner of livestock. Additionally, its operation conforms to relevant clauses of AS 3129. (Kit does not include auto ignition coil which is required).
Cat. KA-1109 **$21.50**
See EA September 1982

THE STOPPER

Because this circuit uses a special output transformer it is far more likely to work into false loads such as tall grass or dirty insulators & has less current drain. Needs no auto coil and is supplied with HT cable and heavy duty clip.
Cat. KA-1660 **ONLY $49.95**
See EA December 1985

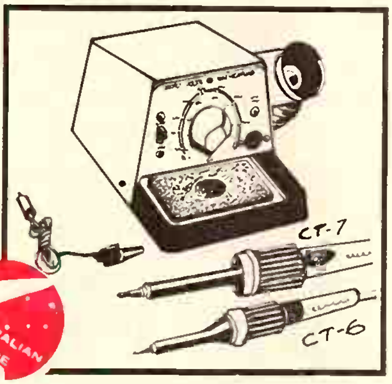
SPECIAL ANNOUNCEMENT

Jaycar is proud to advise that we have recommenced distribution of quality Australian made 'Adcola' soldering irons. Adcola soldering equipment is made in Australia & sold all around the world.
Whilst Adcola equipment is very high quality, the fact that it is locally made is now a great benefit. The downward movement of the A$ has made Adcola products very competitive - even against low cost Asian imports!
We therefore strongly recommend that you seriously consider Adcola products - especially their temperature controlled soldering equipment before you buy inferior imported units.

THE HEART OF THE TEMPERATURE CONTROLLED SYSTEM

The Adcola E024 power controller is basically an SEC approved power supply. But it's a lot more sophisticated than that of course! The unit will power either the CT-6, CT-7 or desoldering pencil. The E024 accurately monitors a temperature element wound in each of these irons. An electronic control circuit then meters power to the pencil in accordance with the temperature selected on the front panel of the E024. The temperature is continuously adjustable from 200 - 400°C (400 - 750°F), accurate to an amazing ±5°C! Power is supplied to the pencils via a 'zero crossing' controller. This effectively means that power to the pencils is switched on and off only at the point on the AC power supply where the voltage passes through zero. By switching power in this sophisticated way spikes caused by commutating AC are avoided. (the major competitors electro-mechanical switch operates randomly at ANY POINT of the AC!)
An extra special electrostatic shield is wound between the primary and secondary of the power transformer to virtually eliminate mains-borne spikes - no damage to MOS devices! To further reduce static voltage effect an optional auxiliary ground lead is provided to earth the equipment to be soldered to the same potential as the soldering equipment. In this way the effective tip EMF is limited to around 10 millivolts! This is far below the damage level for all MOS devices of course. We believe that the E024 unit has by far the best static control in its class! The E024 is supplied with generous mains cord, soldering guide, technical instructions (including internal schematic and parts list), soldering iron stand, tip cleaning sponge and ground lead. It is fused on the AC mains. It is guaranteed for 12 months.
Cat. TS-1475 **$139.50**

E024



ADCOLA T.C. DESOLDERING SYSTEM! 10% OFF!! SPECIAL JANUARY OFFER

Buy the E024 power unit and CT-207 desoldering iron this month and get a professional temperature controlled desoldering system for under $200.00!!
That's right, the package deal for the 2 is only $199.00 - and that includes sales tax!!

SAVE 10% - ONLY $199 THE TWO

You get a choice - - -
DIAL YOUR SOLDERING at a great low price!
Jaycar's philosophy is to give you a CHOICE by providing you with a range of great products! So with Jaycar you can choose from many soldering products. The Adcola range is shown below:
40 WATT The CT-6 is a light-weight pencil with a very high capacity heating element for very low thermal inertia. It is supplied with a #20415 1.5mm tip as standard. Also supplied standard are: burn proof silicone rubber cord, thermal shield and plug for connection to E024 controller unit. Cat. TS-1478 $39.95
80 WATT The CT-7 is similar to the above unit but with 80 watt thermal capacity. Cat. TS-1480 $42.50
DESOLDERING PENCIL Type CT-207. This is similar to the pencils above except that it has a hollow temperature controlled tip (replaceable) which is connected to a vacuum bulb located on the handle. The bulb is placed conveniently so that it can be depressed by the operators index finger.

PROFESSIONAL IRON CLAD SOLDERING IRON TIPS
Spare tips for the Adcola CT-6 and CT-7 are available from Jaycar. Each tip is N.C. machined from pure copper, clad with iron (actually thicker at the point!) then Nickel-Chrome plated and pre-tinned with 60/40 solder. Each tip is supplied with an anti-sieze ferrule at no extra charge.

For CT-6 and S-30 Irons		
#20407 0.7mm Chisel point	Cat. TS-1484	$4.95
#20415 1.5mm Chisel (standard)	Cat. TS-1485	$4.95
#20430 3mm Chisel point	Cat. TS-1486	$4.95
For CT-7 and S-50 Irons		
#50407 0.7mm Chisel point	Cat. TS-1488	$5.95
#50425 2.5mm Chisel point	Cat. TS-1487	$5.95
#50430 3mm Chisel point	Cat. TS-1490	$5.95

FAMOUS ADCOLA S-30 & S-50 REINTRODUCED

Jaycar's policy is to support Australian manufacturers where possible. This, along with the fact that the Adcola models are now internationally competitive has enabled us to reintroduce these popular models.

S-30

A high quality 30 watt non T.C. iron suitable for general hobby use. Idles at the correct temperature for PCB work. Tips will not seize in iron. Uses same tips as CT-6 pencil.
Cat. TS-1492
240V mains operation **$27.95**

S-50

Similar to the above unit but with a 50 watt thermal capacity. Uses same tips as CT-7 pencil.
Cat. TS-1494 **$29.95**

SHOWROOMS

SYDNEY 117 York St (02) 267 1614
Mon Fri 8 30 am 5 30 pm
Thurs until 8 30 pm Sat 9 am 12 noon

CARLINGFORD Cnr Carlingford & Pennant Hills Rd
(02) 872 4444 Mon Fri 9 am 5 30 pm
Thurs until 8 30 pm Sat 9 am 12 noon

CONCORD 115 Parramatta Rd (02) 745 3077
Mon Fri 8 30 am 5 30 pm only

HURSTVILLE 121 Forest Rd (02) 570 7000
Mon Fri 9 am 5 30 pm
Thurs until 8 30 pm Sat 9 am 12 noon

GORE HILL 188 Pacific Hwy (Cnr Bellevue Ave)
(02) 439 4799 Mon Fri 9 am 5 30 pm
Sat 9 am 4 pm

Jaycar ELECTRONICS
INCORPORATING ELECTRONIC AGENCIES

QLD. BURANDA 144 Logan Rd (07) 393 0777
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Thurs until 8 30 pm Sat 9 am 12 noon

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Concord 21?7
(02) 747 2022 Telex 72293

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$25	$49 99	$ 4 50
$50	$99 99	$ 6 50
OVER $100		$10 00

PROJECT INDEX

From page 93

KEY TO KIT SUPPLIERS
AEC All Electronic Components (03) 662-3506
Alt Altronics (09) 381-7233
App Applix (02) 758-2688
DSE Dick Smith Electronics (02) 888-3200
EC Energy Control (07) 288-2455
ED Electronic Discounters (08) 212-1799
FE Force Electronics (08) 212-2672
HIC Hi Com Unitronics (02) 524-7878
Jay Jaycar (02) 747-2022
LE Laser Electronics (075) 532-2066
RIE Rod Irving Electronics (03) 663-6580

No.	Name	Date	Suppliers
446	Audio limiter	Aug 76	AEC
447	Audio phaser	Sep 76	AEC
448	Disco mixer	Nov 76	
449	Balanced mic	Nov 76	RIE, AEC
450	Bucket brigade	Dec 77	AEC
451	50 Hz/100 Hz hum filter	Jul 79	AEC
452	Guitar practice amp	Jan 80	AEC
453	Class B amp	Apr 80	RIE, Alt, FE, AEC, ED
454	Fuzz board	Apr 80	AEC
455	Loudspeaker protection unit	Mar 80	RIE, AEC
456	140 W amp	May 80	
457	Scratch and rumble filter	Sep 80	AEC
458	Peak/average LED level meter	Jun 81	RIE, AEC
459	Third octave graphic equalizer	Nov 82	RIE
460	Third octave analyzer	Nov 82	
461	Balanced input preamp	Dec 82	RIE, Alt, FE, AEC, ED
462	Headphone monitor/splitter	Apr 84	
463	Master play 2-way speakers	Oct 84	
464	IC audio amp	Jul 83	RIE, AEC
465	Loudhailer using the 464	Jul 83	
466	300 W amp	Feb 80	RIE, AEC
467	Guitar/mic preamp for 466-4	Jul 80	RIE, AEC, Jay, ED
469	Drum machine (precision synth)	Apr 82	AEC
470	60 W amp	May 79	RIE, AEC
471	Pre-amp	Jun 79	RIE, AEC
472	Power supply	Jul 80	AEC
473	Moving coil amp	Oct 80	AEC
474	4000 power amp interface	Feb 80	AEC
475	AM tuner	Aug 80	AEC
476	Series 3000 amp 'compact'	Nov 80	AEC
477	Series 5000 power module	Jan/Feb/ Mar 81	RIE, Alt, FE, AEC, HiC, Jay, ED
478	Series 5000 Stereo preamp	Jul/Sept/ Oct 81	RIE, Alt, FE, AEC, HiC, Jay, ED
479	Series 5000 power amp adaptor	Mar 82	RIE, Alt, FE, AEC, HiC, Jay, ED
480	50/100 W amp	Dec 76	RIE, DSE, AEC, Jay, ED
481	12 V 100 W amp	Jun 77	AEC
482	50 W stereo amp	Jan/Feb 77	AEC
483	Sound level meter	Feb 78	AEC
484	dBX	Jul 77	AEC
485	New equalizer with gyrator	Jun 77	AEC
486	Frequency shifter	Nov 77	AEC
487	Real-time audio analyzer	Feb 78	AEC
488	60 W 2-NDFL module	Jan 83	
489	Mk2 real-time analyzer	Apr 78	AEC
490	Speech compressor	Dec 78	AEC
491	Graphic equalizer	Mar 79	
492	Sound bender	Feb 82	RIE, DSE, AEC
494	Loudspeaker protector	Oct 82	RIE, Alt, AEC, Jay, ED
495	TL speakers	Aug 77	
496	4-way 4000/1 speakers	Feb 80	RIE
497	3-way 4000/2 speakers	Jun 80	
498	PA system using the 499	Jun 82	AEC
499	MOSFET amp	Mar 82	AEC, Jay, ED
1401	DI box	Sep 85	Jay, ED
1402	Sampler	Apr/May/ Jun 86	RIE, AEC
1404	4/channel mixer	Jul 85	AEC
1405	Stereo enhancer	Mar 85	RIE, AEC
1406	Parametric equalizer module	Aug 86	Jay, ED
1407	dBNH noise reduction	Dec 86	
1410	Bass guitar amp	Aug/Sept 84	AEC
1420	Indoor paging amp system	Jul 84	
1421	Input and tone cont preamp	May 84	RIE
1422	Budget column speakers	Dec 84	

MISCELLANEOUS

No.	Name	Date	Suppliers
501	Soil moisture meter	Apr 71	
502	Emergency flash	May 71	
503	Intruder alarm	May/Jun 71	
504	Fastest finger	Jul 71	
505	Hi-powered strobe	Aug 71	
506	Infrared alarm	Sep 71	
507	The farmer's problem	Sep 71	
508	Fluoro light dimmer	Oct 71	
509	50-day timer	Dec 71	
510	Safety crossing	Jan 72	
511	Battery savers	Feb 72	
512	Photographic timer	Mar 72	
513	Tape-slide synchronizer	Apr 72	
514	Sound-operated flash	May 72, May 76	AEC
515	Slave flash	May 72	
516	12 V fluorescent light	Nov 72	
517	Electronic decision-maker	Jan 73	
518	Door monitor	Apr 73	
519	Nicad	Feb 74	
520	Digital stopwatch	Oct 73	
521	Digital clock	Jul 73, Mar 74	
524	Laser	Dec 73	
525	Drill speed controller	Oct 74	AEC
526	Print timer	Aug 74	
527	Pushbutton dimmer	Nov 75	
528	House alarm	Jan 75	AEC
529	Poker machine	May/Jun 75	
530	Temp controller	Oct 74	
531	Coin collector Mk1	Dec 74	
532	Photo timer	Jun 75	AEC
533	3-digit display	Jul 75, Aug 76	
534	Cal stopwatch	Jan 76	
535	Swimming pool alarm	Nov 75	
536	Low-cost digital clock	Jan 75	
537	Low batt warning	Feb 75	
538	Hornet power supply	Mar 75	
539	Touch switch	Mar 76	AEC
540	Universal timer	May 76	AEC

Continued on page 100

ALL ELECTRONIC COMPONENTS

Division of DOTHAIN Pty. Ltd.

118-122 LONSDALE STREET, MELBOURNE, VIC. 3000. TEL: 662-3506 FAX (03) 663-3822

TALK ABOUT A HUGE RANGE OF KITS!

STEREO UNITS
S1 ETI 484 Compressor Expander
S2 ETI 482 50 watt per channel Amplifier
S3 ETI 482A Preamp Board
S4 ETI 482B Tone Control Board
S5 ETI 485 Graphic Equalizer
S6 ETI 480 50 watt Amplifier
S7 ETI 480 100 watt Amplifier
S9 ETI 443 Expander Compressor
S10 ETI 444 Five watt stereo
S12 ETI 438 Audio Level Meter
S18 ETI 426 Rumble Filter
S35 ETI 470 60 watt audio amplifier module
S36 ETI 4000 Series 60 watt stereo amplifier
S37 ETI 451 Hum Filter for Hi-Fi systems
S38 E.A. Stereo Infrared Remote Switch
S39 ETI 455 Stereo Loudspeaker Protector
S40 E.A. Super-Bass Filter
S42 E.A. Stylus Timer
S43 ETI 3000 Series Amplifier 25 w/ch
S44 ETI 477 Mosfet power amp module inc. brackets
S45 ETI 457 Scratch/Rumble Filter
S46 ETI 458 VU Level Meter
S47 ETI 479 Bridging Adaptor
S48 ETI 5000 Series Power Amplifier
S49 ETI 494 Loudspeaker Protector
S50 EA Infrared TV Sound Control
S51 HE 121 Scratch & Hiss Filter
S52 EA 100W Sub Woofer Module
S53 EA Stereo Simulator
S54 EA Headphone Amp.
S55 AEM 6500 60W Utility Amp Module
S56 AEM 6500 100W Utility Amp Module
S57 ETI 1405 Stereo Enhancer
S58 ETI 442 Master Play Stereo
S59 EA Led Bar Graph Display (Stereo)
S60 EA FM Stereo Decoder
S61 EA 1 Watt Utility Amp
S62 ETI 453 General Purpose Amp
S63 EA Bridge Adaptor
S64 AEM 6503 Active Cross-Over

STAGE
ST1 ETI 592 Light Show Controller (3 ch.) (1000 w/ch)
ST2 ETI 593 Colour Sequencer (for use with ETI 592)
ST3 ETI 551 Light Chaser 3 ch. 1000 w/ch
ST4 E.A. Light Chaser 3 channel
ST5 E.A. Twin Tremolo for Organs/Stage Amps
ST7 ETI 499 150 w Mosfet P.A. Module
ST8 ETI 498/499 150 w Public Address Amplifier
ST9 E.A. Musicolor IV
ST10 EA Musicolour III
ST11 ETI 1404 A Channel Mixer

PRE-AMPLIFIER AND MIXERS
P1 ETI 445 Stereo Pre-amplifier
P2 ETI 449 Balance Mic Pre-amplifier
P6 ETI 419 Mixer Pre-amplifier — 4Ch or 2Ch
P11 ETI 446 Audio Limiter
P12 ETI 471 High Performance Stereo Pre-amplifier
P13 ETI 473 Moving Coil Cartridge Pre-Amp
P14 ETI 474 High to low Impedence Interface
P15 ETI 467 4 Input Guitar/Mic. Pre-amp suits ETI 466
P16 E.A. Moving Coil Pre-Amplifier (Battery)
P17 E.A. Moving Coil Pre-Amplifier (Plug pack)
P18 ETI 478 MM Moving Magnet Pre-amp (Series 5000)
P19 ETI 478MC Moving Coil Pre-amp (Series 5000)
P20 ETI 478 Series 5000 Pre-Amplifier
P21 E.A. Vocal Cancellor
P22 ETI 461 Balanced Preamplifier
P23 HE 112 Micromixer
P24 EA Effects Unit

GUITAR UNITS
G1 ETI 447 Audio Phaser
G14 ETI 452 Guitar Practice Amplifier
G15 ETI 466 300 watt Amp module
G16 ETI 454 Fuzz Sustain
G17 HE 102 Guitar Phaser
G18 ETI 450A Bucket Brigade
G19 ETI 450B Mixer for above
G20 E.A. guitar Pre-amplifier
G21 Sonics ME2 Sonics ME2 Wah Wah Pedal-less pedal
G22 EA Effects Unit
G23 ETI 1410 Bass Guitar Amp (150W)

AUDIO TEST UNITS
AT1 ETI 441 Audio Noise Generator
AT2 ETI 128 Audio Millivolt Meter
AT7 ETI 137 Audio Oscillator
AT9 HE 105 Bench Amplifier
AT10 E.A. Audio Test Unit
AT11 E.A. Function Generator
AT12 ETI 464 Audio Test Unit

TIMERS
T1 ETI 650 STAC Timer
T2 ETI 564 Digital Wall Clock
T4 ETI 540 Universal Timer
T5 ETI 265 Power Down
T6 EA 4 Digit L.C.D. Clock or Control Timer

COMMUNICATION EQUIPMENT
CE1 ETI 711 Remote Control Transmitter Switch
CE2 ETI 711R Remote Control Receiver
CE3 ETI 711D Remote Control Decoder
CE4 ETI 711B Single Control
CE5 Double Control
CE6 ETI 711P Power Supply
CE9 ETI 708 Active Antenna
CE11 ETI 780 Novice Transmitter
CE12 ETI 703 Antenna Matching Unit
CE33 ETI 718 Shortwave Radio
CE34 ETI 490 Audio Compressor
CE35 ETI 721 Aircraft Band Converter (less XTALS)
CE37 ETI 475 Wide Band A.M. Tuner
CE38 E.A. Masthead Pre-amplifier
CE39 ETI 731 R.T.T.Y. Modulator
CE40 ETI 729 UHF TV Masthead Preamp.
CE41 ETI 735 UHF to VHF TV Converter
CE42 HE 104 AM Tuner
CE43 HE 106 Radio Microphone
CE44 E.A. R.T.T.Y. Demodulator
CE45 E.A. Voice Operator Relay
CE46 ETI 733 RTTY Converter for Microbee
CE47 ETI 1517 Video Distribution Amp.
CE48 EA Video Enhancer
CE50 ETI 1518 Video Enhancer
CE51 EA VCR Sound Processor
CE 52 EA Motorcycle Intercom
CE 53 ETI 1405 Stereo Enhancer
CE 56 ETI 755 Computer Driven RTTY Transceiver

METAL DETECTORS
MD1 ETI 549 Induction Balance Metal Detector
MD2 ETI 561 Metal Locator
MD3 ETI 1500 Discriminating Metal Locator (undrilled case)
MD5 ETI 562 Geiger Counter with ZP 1310 Tube
MD6 ETI 566 Pipe and Cable Locator
MD7 E.A. Prospector Metal Locator including headphones

TEST EQUIPMENT
TE2 ETI 133 Phase Meter
TE9 ETI 124 Tone Burst Generator
TE16 ETI 120 Logic Probe
TE17 ETI 121 Logic Pulser
TE34 ETI 487 Real Time Audio Analyser
TE35 ETI 483 Sound Level Meter
TE36 ETI 489 Real Time Audio Analyser
TE37 ETI 717 Cross Hatch Generators
TE38 E.A. 3 Mhz Frequency Counter
TE42 E.A. Transistor Tester incl. BiPolar & F.E.T.S.
TE43 ETI 591 Up Down Pre-setable Counter
TE44 ETI 550 Digital dial (less case) includes ETI 591
TE46 ETI 148 Versatile Logic Probe
TE47 ETI 724 Microwave Oven Leak Detector
TE48 ETI 150 Simple Analog Frequency Meter
TE51 E.A. Digital Capacitance Meter
TE52 ETI 589 Digital Temp. Meter
TE53 E.A. T.V. C.R.O. Adaptor
TE54 E.A. XTAL Locked Pattern Generator
TE55 E.A. Decade Resistance Sub Box
TE56 E.A. Capacitance Sub Box
TE57 E.A. Decade Capacitance Sub Box
TE58 E.A. Tantalum Capacitance Sub Box
TE60 ETI 572 PH Meter
TE61 ETI 135 Panel Meter
TE62 E.A. Modulated Signal Injector
TE63 HE 103 Transistor Tester
TE64 HE 111 Ohm meter
TE65 ETI 157 Crystal Marker
TE66 ETI 161 Digital Panel Meter
TE67 ETI 255 Analog Thermometer
TE68 EA Transistor Tester
TE69 ETI 175 20 MHz Dig. Frequency Meter (Hand held)
TE70 ETI 166 Function Pulse Generator
TE 71 ETI 1523 Digital Electronic Scales
TE 72 AEM 5505 Hash Harrier
TE 73 EA Event Counter
TE 74 ETI 183 OP-Amp Tester

MODEL TRAIN UNITS (see also "SOUND EFFECTS")
MT1 ETI 541 Model Train Control
MT2 E.A. 1974 Model Train Control
MT3 EA Railmaster — Including Remote

SOUND EFFECTS
SE1 E.A. Sound Effects Generator*
SE3 E.A. Cylon Voice
SE4 E.A. Steam Whistle
SE5 ETI 607 Sound Effects
SE6 E.A. 492 Audio Sound Bender
SE7 E.A. Electronic Sea Shell Sound Effects
SE8 ETI 469A Percussion Synthesiser
SE9 ETI 469B Sequencer for Synthesiser
SE10 EA Effects Unit
* set as for Steam Train and Prop Plane noise

VOLTAGE/CURRENT CONTROLS
V1 ETI 481 12 volt to ± 40v D.C. 100 watt Inverter
V2 ETI 525 Drill Speed Controller
V6 E.A. 1976 Speed Control
V10 E.A. Zero-voltage switching heat controller
V11 E.A. Inverter 12v D.C. input 230v 50 hz 300VA output
V12 ETI 1505 Flourescent Light Inverter
V13 EA Electric Fence
V14 ETI 1506 Xenon Push Bike Flasher
V15 ETI 1509 DC-DC Inverter
V16 ETI 1512 Electric Fence Tester
V17 EA Fluro Light Starter
V18 ETI 1524 Electronic Mouse Trap
V19 HE126 Nicad Charger
V20 ETI 578 Simple Nicad Charger
V21 EA Heat Controller
V22 ETI 563 Fast Ni-Cad Charger
V23 EA High Voltage Insultation Tester
V24 EA Electric Fence Controller
V25 ETI 1532 Temp Control For Soldering Irons

WARNING SYSTEMS
WS1 ETI 583 Gas Alarm
WS3 ETI 528 Home Burglar Alarm
WS4 ETI 702 Radar Intruder Alarm
WS7 ETI 313 Car Alarm
WS12 ETI 582 House Alarm
WS14 E.A. 1976 Car Alarm
WS15 E.A. 10 Ghz Radar Alarm
WS16 E.A. Light Beam Relay
WS17 ETI 247 Soil Moisture Indicator
WS18 ETI 250 Simple House Alarm
WS19 ETI 570 Infrared 'Trip' Relay
WS20 ETI 585 T&R Ultrasonic Switch
WS21 ETI 330 Car Alarm
WS22 ETI 322 Over Rev Car Alarm incl. case
WS24 ETI 1506 Xenon Bike Flasher
WS25 ETI 340 Car Alarm
WS26 EA Deluxe Car Alarm
WS27 EA Ultrasonic Movement Detector
WS28 ETI 278 Directional Door Minder
WS 29 EA Multisector Home Security System
WS30 EA Infra-Red Light Beam Relay
WS31 EA Deluxe Car Alarm
WS32 EA Doorway Minder
WS33 EA "Screecher" Car Alarm
WS34 ETI 1527 4 Sector Burglar Alarm

PHOTOGRAPHIC
PH1 ETI 586 Shutter Speed Timer
PH3 ETI 514B Sound Light Flash Trigger
PH4 ETI 532 Photo Timer
PH7 ETI 513 Tape Slide Synchronizer
PH12 EA Sync-a-Slide
PH15 ETI 553 Tape Slide Synchronizer
PH16 E.A. Digital Photo Timer
PH17 ETI 594 Development Timer
PH18 ETI 568 Sound or light operated Flash Trigger including optional parts
PH19 E.A. Sound Triggered Photoflash
PH20 HE 109 Extra Flash Trigger
PH21 E.A. Photographic Timer
PH22 ETI 182 Lux Meter
PH23 ETI 1521 Digital Enl Exposure Meter
PH24 ETI 279 Exposure Meter

POWER SUPPLIES
PS1 ETI 132 Experimenters Power Supply
PS2 ETI 581 Dual Power Supply
PS3 ETI 712 CB Power Supply
PS4 ETI 131 Power Supply
PS9 E.A. 1976 Regulated Power Supply
PS11 E.A. C.B. Power Supply
PS12 ETI 142 Power Supply 0-30 V 0-15 A (fully protected)
PS13 ETI 472 Power Supply
PS15 ETI 577 Dual 12V supply
PS16 E.A. Power Saver
PS17 ETI 480 PS Power Supply for ETI 480 (100 watt Amp.)
PS18 E.A. Bench Mate Utility Amplifier/Power Supply
PS20 ETI 163 0-40 V, 0-5 A
PS21 EA Dual Tracking Power Supply
PS22 ETI 162 1,3-30 Volt, Fully Adjustable
PS23 ETI 251 OP-AMP Power Supply

COMPUTER AND DIGITAL UNITS
C1 ETI 633 Video Synch Board*
C2 ETI 632M Part 1 Memory Board V.D.U.*
C3 ETI 632P Part 1 Power Supply V.D.U.*
C4 ETI 632A Part 2 Control Logic V.D.U.*
C5 ETI 632B Part 2 Control Logic V.D.U.*
C6 ETI 632C Part 2 Character Generator V.D.U.*
C8 ETI 632 U.A.R.T. Board*
C9 ETI 631-2 Keyboard Encoder*
C10 ETI 631 A-Sch. Keyboard Encoder
C14 ETI 638 Eprom Programmer
C15 ETI 637 Cuts Cassette Interface
C16 ETI 651 Binary to Hex Number Converter
C17 ETI 730 Getting Going on Radio Tele Type
C24 ETI 760 Video RF Modulator
C25 E.A. Eprom Programmer
C26 ETI 668 Microbee Eprom Programmer
C27 ETI 733 RTTY Computer Decoder
C28 EA Video Amp for Computers
C29 ETI 649 Microbee Light Pen
C30 ETI 675 Microbee Serial — Parallel Interface
C31 ETI 688 Programmer for Fusable — Link Bipolar Proms
C32 ETI 676 RS232 for Microbee
* all V.D.U. projects priced less connectors
C33 ETI 678 Rom Reader For Microbee
C34 ETI 659 VIC 20 Cassette Interface
C35 ETI 683 Mindmaster — Human Computer Link
C36 EA Eprom Copier/Programmer
C37 ETI 699 300 Band Direct-Connect Modem
C38 AEM 3500 Listening Post
C39 AEM 4600 Dual Speed Modem
C40 ETI 1601 RS 232 For Commodore
C41 AEM 4504 Speech Synthesizer

BIO FEEDBACK
BF1 ETI 546 G.S.R. Monitor (less probes)
BF2 ETI 544 Heart Rate Monitor
BF3 ETI 576 Electromyogram

AUTOMOTIVE UNITS
A1 ETI 317 Rev. Monitor
A2 ETI 081 Tachometer
A3 ETI 316 Transistor Assisted Ignition
A4 ETI 240 High Power Emergency Flasher
A6 ETI 312 Electronic Ignition System
A7 ETI 301 Vari-Wiper
A14 E.A. Dwell Meter
A22 ETI 318 Digital Car Tachometer
A23 ETI 319A Variwiper Mk. 2 (no dynamic Braking)
A24 ETI 319B Variwiper Mk. 2 (for dynamic braking)
A25 ETI 555 Light Activated Tacho
A26 ETI 320 Battery Condition Indicator
A27 E.A. Transistor Assisted Ignition
A28 ETI 324 Twin Range Tacho less case
A29 ETI 328 Led Oil Temp Meter less V.O.O. probe
A30 ETI 321 Auto Fuel Level Alarm
A31 ETI 332 Stethoscope
A32 ETI 325 Auto Probe Tests Vehicle Electricals
A33 ETI 333 Reversing Alarm
A34 E.A. Low fuel indicator
A35 ETI 326 Led Edpanded Voltmeter
A36 ETI 329 Ammeter (expanded scale)
A37 ETI 327 Turn and Hazard Indicator
A38 ETI 159 Expanded Scale Voltmeter
A39 EA Optoelectronic Ignition
A40 ETI 335 Wiper Controller
A41 EA Ignition Killer for Cars
A42 EA L.C.D. Car Clock
A44 ETI 337 Automatic Car Aerial Controller
A45 ETI 280 Low Battery Volt Indicator
A46 ETI 322 Over Rev Alarm
A47 ETI 345 Demister Timer

ELECTRONIC GAMES
EG1 ETI 043 Heads and Tails
EG2 ETI 068 L.E.D. Dice Circuit
EG3 E.A. Electronic Roulette Wheel
EG4 ETI 557 Reaction Timer
EG5 ETI 814 Dinky Die
EG6 E.A. Selectalott
EG7 HE 107 Electronic Dice
EG8 E.A. Photon Torpedo
EG9 HE 123 Alien Invaders
EG10 EA Roulette Wheel

MISCELLANEOUS KITS
M1 ETI 604 Accentuated Beat Metronome
M4 ETI 547 Telephone Bell Extender
M7 ETI 044 Two Tone Doorbell
M10 ETI 539 Touch Switch
M25 E.A. Digital Metronome
M37 ETI 249 Combination lock (less lock)
M46 E.A. Power Saver for induction motors
M48 E.A. Lissajous Pattern Generator
M53 ETI Soil Moisture Alarm
M55 E.A. Pools/Lotto Selector
M56 ETI 256 Humidity Meter
M57 ETI 257 Universal Relay Driver Board
M58 E.A. Simple Metronome
M59 ETI 1501 Neg. Ion Generator
M60 ETI 1516 Sure Start for Model Aeroplanes
M61 ETI 412 Peak Level Display
M62 ETI 1515 Motor Speed Controller
M63 ETI 1520 Wideband Amplifier
M64 EA Phone Minder
M66 EA Simple L.C.O. Clock
M67 EA Ultrasonic Rule
M68 AEM 1500 Simple Metronome
M69 AEM 5501 Negative Ion Generator
M70 AEM 4501 8-Channel Relay Interface
M71 EA Pest Off

PLUS MANY, MANY MORE KITS WHICH WE CANNOT LIST HERE!!!
JUST CONTACT US FOR PRICE & AVAILABILITY.

PLUS — A HUGE RANGE OF COMPONENTS
COMPANY & SCHOOL ACCOUNTS AVAILABLE.

PROJECT INDEX

From page 98

KEY TO KIT SUPPLIERS
AEC All Electronic Components (03) 662-3506
Alt Altronics (09) 381-7233
App Applix (02) 758-2688
DSE Dick Smith Electronics (02) 888-3200
EC Energy Control (07) 288-2455
ED Electronic Discounters (08) 212-1799
FE Force Electronics (08) 212-2672
HIC Hi Com Unitronics (02) 524-7878
Jay Jaycar (02) 747-2022
LE Laser Electronics (075) 532-2066
RIE Rod Irving Electronics (03) 663-6580

No.	Name	Date	Suppliers
541	Train controller Mk1	Jun 76	AEC
543	STD timer	Jul 76	AEC
544	Heart rate monitor	Sep 76	AEC
546	Bio resistance	Mar 77	AEC
547	Bell extender (telephone)	Jun 77	RIE
548	High power strobe	May 77	AEC
549	Metal detector	May 77	AEC
550	AM digital dial	Aug 78	AEC
551	Chaser	Sep 78	AEC
552	LED pendant	Sep 78	
553	Tape-slide synchronizer	Oct 78	AEC
555	Light activated tacho	Nov 78	AEC
556	Windspeed	Dec 78	
557	Reaction timer	Feb 79	AEC
558	Masthead flasher	Feb 79	
559	Cable tester	Mar 79	
560	Mains cable seeker	May 80	
561	Metal detector	Mar 80	RIE, AEC
562	Geiger counter	Apr 80	AEC
563	Fast Nicad charger	Jul 80	AEC, RIE
564	Digital clock (large)	Aug 80	AEC
565	Laser	Jul 80	LE
566	Pipe and cable locator	Apr 80	AEC
567	Core balance relay	Apr 81	RIE
568	Sound and light operated flash	Oct 80	AEC
570	Infrared 'trip' relay	Jan 82	RIE, AEC
572	ph meter	Dec 80	AEC
573	Process timer	Oct 79	
575	Fluoro light wand	Aug 79	
576	EMG (electromyagram) monitor	Sep/Oct 79	AEC
577	Simple Nicad charger	Jun 80	AEC
574	Disco strobe	Sep 79	
577	Moving coil power supply	Oct 79	
581	15 V power supply	Jun 77	RIE, AEC, Jay, ED
582	House alarm Mk3	Jul/Aug 77	AEC
583	Gas detector	Aug 77	AEC
585	Ultrasonic beam switch	Sep 77	RIE, AEC
586	Shutter timer	Oct 77	AEC
587	UFO detector	May 78	
588	Dimmer	Nov/Dec 77, Jan 78	
589	Temp meter	Dec 77	AEC
590	6-digit LCD stopwatch	Oct 78	
591	4-digit up/down counter	Jul 78	AEC
592	3-channel light dimmer	Aug 78	AEC
593	Colour sequencer	Dec 78	AEC
594	Development timer	Apr 79	AEC
595	Aquarium light timer	May 79	
596	White noise generator	Nov 81	
597	Emergency light unit	Dec 80	
598	Sequential touch switch	Feb 81	
599	Infrared remote controller	Apr 81	
1500	Metal detector	Dec 80, Apr 81	AEC
1501	Negative ion generator	Apr 81	AEC
1502	Sling psychrometer	Dec 83	
1503	Standby battery charger	Aug 81	
1505	Emergency fluoro light unit	Aug 82	
1506	Bicycle flasher (xenon)	Jul 82	AEC
1507	Lightbulb saver	Nov 85	
1508	Model train controller	Dec 82, Dec 83	
1509	Universal dc-dc inverter	Sep 82	AEC
1510	Model train controller	Jan 83	
1511	Zero crossing temp controller	Feb 83	
1512	Electric fence tester	Feb 83	RIE, AEC
1513	Digital frequency doubler	Jan 86	
1514	Solid state relays	Nov 83	
1515	Drill speed controller	Apr 83	RIE, AEC
1516	Model engine ignition	Jun 83	RIE, AEC
1517	Video distributor board	Sep 83	RIE, AEC
1518	Video enhancer	Dec 83	RIE, AEC
1520	Wide band amp	Jul 83	AEC
1521	Digital exposure meter	Mar 84	AEC
1522	Multiple light controller	Mar/Apr 84	
1523	Electronic scales	Jun/Jul 84	AEC
1524	Electronic mousetrap	Aug 84	AEC, RIE
1526	Fibre optic link	Apr 85	
1527	Burglar alarm module	May/Jun 85	DSE, AEC, Jay, ED
1528	Door controller	Jul 85	HIC
1530	Noise detector	Feb 86	
1531	Brown out protector	May 86	
1532	Iron temp controller	Sep 86	Alt, FE, AEC, Jay, ED
1533	300 W power supply	Nov/Dec 86	

MUSIC

No.	Name	Date	Suppliers
601	Music sync	Oct 83	
602	Mini organ	Aug 76	AEC
603	Sequencer Mk1	Aug 77	
604	Metronome	Sep 77	AEC
605	Lin-exp converter	Sep 78	
606	Tuning fork	Nov 79	
607	Sound effects unit	Jul-Sep 81, Mar 82	AEC
609	MIDI thru box	Mar 86	
610	Drum synth module	Oct 74	
611	MIDI matrix	Sep 86	

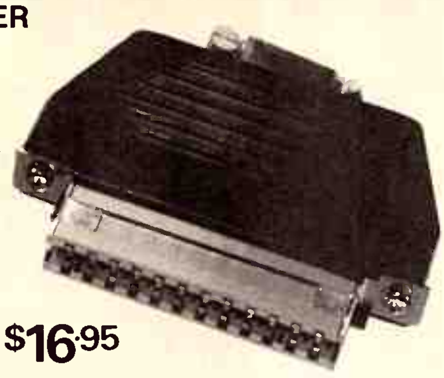
COMPUTERS

No.	Name	Date	Suppliers
630	HEX display	Dec 76	
631	ASCII keyboard	Dec 76, Apr 77	AEC
632	VDU	Jan/Feb/ Mar 77	AEC
633	Video sync	Jan 77	AEC
634	8080 EDU interface	July 78	
635	Micro power supply	Sep 77	
636	S100 mother board	May 80	
637	Cassette interface	Jan 78	AEC
638	2708 EPROM programmer	Jul 78	AEC
639	Doorbell	Mar 78	
640	VDU Mk2 S100	Apr/May Jun 78	
641	Philips printer interface S100	Sept 78	
642	RAM card 16K	Feb 79	
643	S100 EPROM programmer	Dec 79	

Continued on page 104

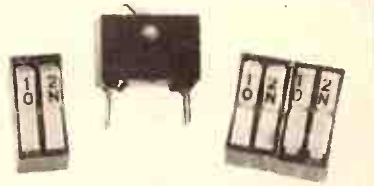
COMMODORE COMPUTER EDGE CONNECTOR

Geoff is actually putting these connectors together himself because no one can supply a proper connector for the Commodore expansion port. Yes this connector has the two polarising keys so you can't plug it in the wrong way round and blow things up!! Also has a posh U.S. made back shell. Needless to say the two rows of 12 contacts are gold plated and of the correct pitch. The polarizing feature alone makes it well worth $16.95.



$16.95

MODULAR DIP-SWITCH SUPER SPECIAL 60c



What would you expect to pay for quality EECO rocker DIP switches? Would you believe 30cents per actuator? We've secured a quantity of two pole switches which can be stacked to get any even number of switches you like on the same PCB pitch - yes a 20 SPST gang or more if you like.

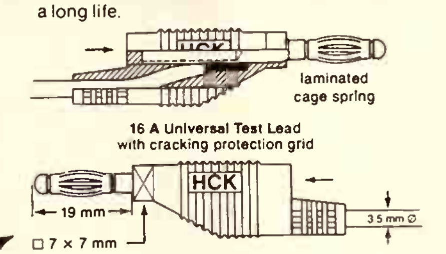
They're rated at 1Amp, 28V non-switching or 125mA switching. Gold over copper alloy switch contacts and tin-lead over copper alloy terminals. Rugged sealed construction. Actuators can be locked against accidental actuation. 60 cents each (twin actuators blocks) but hurry.

NEW RANGE OF HIGH QUALITY TEST LEADS

Sick of those stiff plastic test leads that come with most multimeters? You know the ones that kink and produce pungent smoke when you touch them with a soldering iron? Well we've done something about it and proudly introduce the HCK range of quality silicone leads.

It's impossible to describe how flexible they are. You wouldn't believe that a 1000V/16Amp rating cable could be so er, floppy (?). Cable has soldering-iron proof silicon rubber insulation with 512 strands of copper inside. -100 C to 300 C temperature range. Plugs are stackable, extremely hard-wearing. Choice of black, red, blue, yellow, green and violet.

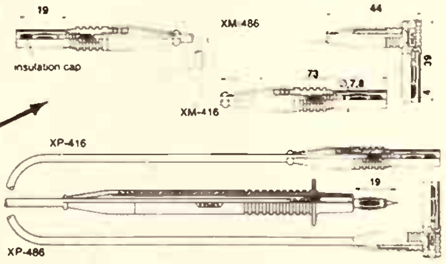
We will also be stocking the cable cut to length. Not cheap but an investment in real quality and a long life.



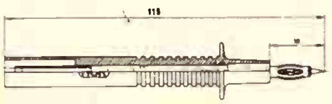
4mm Test Leads
Stackable with special cracking protection grid. Laminated cage spring contact with virtually no contact resistance. Available in three lengths - 500mm **$5.66**, 1.0m **$7.21** and 1.5m **$8.66** with exposed plug on each end.

4mm Safety Shrouded Leads
Available with straight or 90 plugs. Available in 1 metre length only. Straight **$9.43** 90 **$9.99**

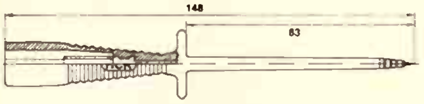
4mm Safety Prod Leads
Available with straight or 90 plug. Available in 1 metre length only. Straight **$10.15** 90 **$10.60**



4mm Plug-On Test Prods



With 4mm plug tip **$3.05**

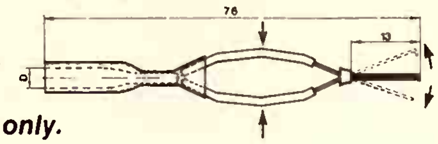


With quality steel tip $3.92

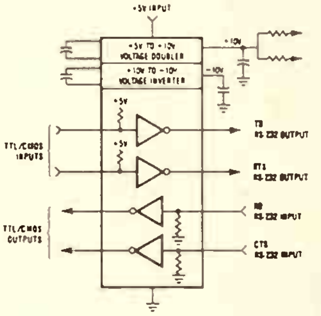
250V rated 130mm with steel tip $2.66

4mm Safety Hook Grip
Accepts 4mm plug and features quality steel hook **$9.43**

4mm Plug-On Clip Test Tweezers
No exposed parts. Fully epoxy-resin insulated. Grips down to 1mm and won't fall off **$10.54**.



Prices are for single items only.



5V POWERED DUAL RS232 TRANSMITTER/RECEIVER MAX232

Yes it meets all RS232C specs but only needs a 5V supply because it has built-in converters for the +10V and -10V power supplies. Can also be used as a voltage quadrupler for input voltages up to 5.5V.

Also contains 2 drivers and receivers. Uses low power CMOS. Handles 30V input level and provides a +9V output swing. Ideal for battery powered systems. **$12.96**

OPEN FRAME LOW PROFILE IC SOCKETS

Highest quality glass filled polyester with MACHINED contacts. Four finger GOLD PLATED contact. Terminals are tin plated for easy soldering. Open frame ensures good cooling, easy cleaning and checking. Available in 8 to 40 pin configurations
8 pin **56c**, 14 pin **98c**, 16 in **$1.12**, 18 pin **$1.26**, 20 pin **$1.40**, 24 pin **$1.68**, 28 pin **$1.96**. 40 pin **$2.80**.

8.30 to 5 Monday to Friday, 8.30 to 12 Sat.
Mail Orders add $5.00 to cover postal charges.

All prices INCLUDE sales tax.

Tax exemption certificates accepted if line value exceeds $10.00.

BANKCARD, MASTERCARD, VISA, CHEQUES

GEOFF WOOD ELECTRONICS P/L
INC IN NSW
(02) 427 1676
229 BURNS BAY RD. (CORNER BEATRICE ST.) LANE COVE WEST N.S.W.
TWX 71996
P.O. BOX 671
LANE COVE N.S.W. 2066

OR CASH CHEERFULLY ACCEPTED

specialising in electronic components for the professional and hobbyist.

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TOLL FREE MAIL ORDER NUMBER 008 33 5757 (STRICTLY ORDERS ONLY) INQUIRIES TO (03) 543 7877

SERIES 5000

INDIVIDUAL COMPONENTS TO MAKE UP A SUPERB HIFI SYSTEM!

By directly importing and a more technically orientated organisation, ROD IRVING ELECTRONICS can bring you these products at lower prices than their competitors. Enjoy the many other advantages of RIE Series 5000 kits such as "Superb Finish" front panels at no extra cost, top quality components supplied throughout. Over 1,000 sold!

For those who haven't the time and want a quality hi-fi, we also sell the Series 5000 kits assembled and tested.

POWER AMPLIFIER

WHY YOU SHOULD BUY A "ROD IRVING ELECTRONICS" SERIES 5000 POWER AMPLIFIER

- 1% Metal Film resistors ...

SPECIAL, ONLY $339
SAVE $50

... ELECTRONICS and is being supplied to other kit suppliers.

SPECIFICATIONS: 150 W RMS into 4 ohms (per channel)
POWER AMPLIFIER: 100W RMS into 8 ohms (+ − 55V Supply)
FREQUENCY RESPONSE: 8Hz to 20Hz +0 − .0.4 dB 2.8Hz to 65KHz, +0 − 3 dB. NOTE: These figures are determined solely by passive filters.
INPUT SENSITIVITY: 1 V RMS for 100W ouput.
HUM: 100 dB below full output (flat).
NOISE: 116 dB below full output (flat, 20KHz bandwidth).
2nd HARMONIC DISTORTION: ·0.001% at 1 KHz (0.0007% on Prototypes) at 100W ouput using a + − 56V SUPPLY rated at 4A continues ·0.0003% for all frequencies less than 10KHz and all powers below clipping.
TOTAL HARMONIC DISTORTION: Determined by 2nd Harmonic Distortion (see above).
INTERMODULATION DISTORTION: 0.003% at 100W. (50Hz and 7KHz mixed 4:1).
STABILITY: Unconditional.

Cat. K44771 .... **$389**
Assembled and tested $549
packing and post $10

PREAMPLIFIER

THE ADVANTAGES OF BUYING A "ROD IRVING ELECTRONICS" SERIES 5000 PREAMPLIFIER KIT ARE

- 1% Metal Film Resi...

SPECIAL, ONLY $319
SAVE $40

... available that sounds as

SPECIFICATIONS:
FREQUENCY RESPONSE: High-level input: 15Hz − 130KHz, +0. − 1dB Low-Level Input-conforms to RIAA equalisation + − 0.2dB
DISTORTION: 1KHz ·0.003% on all inputs (limit of resolution on measuring equipment due to noise limitation).
S/N NOISE: High-Level input, master full, with respect to 300mV input signal at full output (1.2V)·92dB flat ·100dB A-weighted. MM Input, master full, with respect to full output (1.2V) at 5 mV input 50ohms source resistance connected: ·86dB flat/92dB A-weighted MC input, master full, with respect to full output (1.2V) and 200uV Input signal: ·71dB flat ·75dB A-weighted.

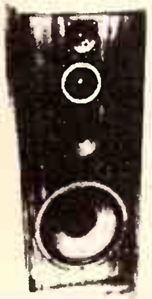
Cat. K44791 .... **$359**
Assembled and tested $599
packing and postage $10

THIRD OCTAVE GRAPHIC EQUALIZER

SPECIFICATIONS:
BANDS: 28 Bands ...

SPECIAL, ONLY $209
SAVE $30

Cat. K44590 .... 1 unit: **$239**
.... 2 units: **$429**
packing and postage $10



SERIES 4000 SPEAKERS

8 Speakers .... only $549
8 Speakers with Crossovers .. $795
Speaker Cabinet Kit (complete) $395
(Please specify cabinet to suit 7" or 8" mid range woofer)
Crossover Kits $295
Complete kit of parts (speakers, crossovers, screws, innerband boxes.) $1,095
Assembled, tested and ready to hook up to your system ... $1,295
(Approximately 4 weeks delivery)

Errors and Ommissions Excepted

PHILIPS SPEAKERS

For the month of January, we are offering 20% off these prices! But, you'd better be quick as this offer is for a limited time only.

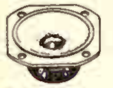
Description	Cat.No.	Price
AD01610T8	(C12030)	$24.95
AD02160SQ8	(C12040)	$69.95
AD80652W8	(C12042)	$69.95
AD070620M8	(C12045)	$69.95
AD12250W8	(C12050)	$129.00

P.A. SPEAKERS

Low dual cone, wide range. 200mm (8in.). Ideal for public address, background music, etc. Tremendous Value at these prices!
Cat. C12000 .... $7.95

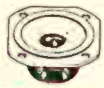
HI FI SPEAKERS

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.



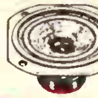
1½" TWEETER

SPECIFICATIONS:
Sensitivity: 90dB
Freq. Response: 1.2 - 20 kHz
Impedance: 8 ohms
Power RMS: 10 watts
Magnet Weight: 2 oz
Cat. C10200 .... $5.95



2½" TWEETER

SPECIFICATIONS:
Sensitivity: 94dB
Freq. Response: 1.1 - 17 kHz
Impedance: 8 ohms
Power RMS: 10 watts
Magnet Weight: 2 oz
Cat. C10202 .... $6.95



4" MIDRANGE WITH SEALED BACK

SPECIFICATIONS:
Sensitivity: 96dB
Freq. Response: 650 - 15 kHz
Impedance: 8 ohms
Power RMS: 15 watts
Magnet Weight: 3.6 oz
Cat. C10204 .... $11.95

4½" MIDRANGE WITH SEALED BACK

Clothed edge surrounds.
SPECIFICATIONS:
Sensitivity: 97dB
Freq. Response: 600 - 8 kHz
Impedance: 8 ohms
Power RMS: 20 watts
Magnet Weight: 5.4 oz
Cat. C10206 .... $14.95

6½" 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 .... $17.95

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 .... $20.95

12" WOOFER RIBBED CONE

Cloth edge roll surround.
SPECIFICATIONS:
Sensitivity: 92dB
Freq. Response: 32 - 4 kHz
Impedance: 8 ohms
Power RMS: 30 watts
Magnet Weight: 13.3oz
Cat. C10214 .... $49.95

Nows the time to build those kits!!

VIFA/AEM 3 WAY SPEAKER KIT!

This superb 3 way speaker kit competes with systems that cost 2 - 3 times the cost of these units! (which may even be using VIFA drivers etc.) Never before has it been possible to get such exceptional value in kit speakers! Call in personally and compare for yourself!

The system comprises...
2 x D19 dome tweeters
2 x D75 dome midrange
2 x P25 woofers
2 x pre-built quality crossovers

The cabinet kit consists of 2 knock-down boxes in beautiful black grain look with silver baffles, speaker cloth, innerbond, grill clips, speaker terminals, screws and ports.

D19 DOME TWEETER SPEAKER SPECIFICATIONS
Nominal Impedance: 8 ohms
Frequency Range: 2.5 - 20kHz
Free Air Resonance: 1,700Hz
Sensitivity 1W at 1m: 89dB
Nominal Power: 80 Watts
(fo: 5,000Hz, 12dB/oct)
Voice Coil Diameter: 19mm
Voice Coil Resistance: 6.2ohms
Moving Mass: 0.2 grams
Weight: 0.28kg

D75 DOME MIDRANGE SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 350 - 5,000Hz
Free Air Resonance: 300Hz
Sensitivity (1W at 1m): 91dB
Nominal Power: 80 Watts
(fo: 500Hz, 12dB/oct)
Voice Coil Diameter: 75mm
Voice Coil Resistance: 7.2ohms
Moving Mass (incl. air): 3.6 grams
Weight: 0.65kg

P25 WOOFER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 25 - 3,000Hz
Free Air Resonance: 25Hz
Operating Power: 5 watts
Sensitivity (1W at 1m): 89dB
Nominal Power: 60 Watts
Music Power: 100 Watts
Voice Coil Diameter: 40mm
Voice Coil Resistance: 5.7ohms
Moving Mass (incl. air): 44 grams
Thiele/Small Parameters:
Qm: 3.15
Qe: 0.46
Qt: 0.40
Vas: 180:1
Weight: 1.95kg

Complete Kit Cat.K16030 **$1,095**
Speaker Kit Cat.K16031 ... **$879**
Cabinet Kit Cat.K16032 ... **$349**

VIFA/AEM 2 WAY SPEAKER KIT!

This exciting new speaker kit, designed by David Tillbrook (a name synonymous with brilliant design and performance) uses VIFA's high perfomance drivers from Denmark. You will save around $800 when you hear what you get from this system when compared to something you buy off the shelf with similar characteristics. Call in personally and compare for yourself!

The system comprises...
2 x P21 Polycone 8" woofers
2 x D25T Ferrofluid cooled dome tweeters with Polymer diaphrams
2 pre-built quality crossovers

The cabinet kit consists of 2 knock-down boxes in beautiful black grain look with silver baffles, speaker cloth, innerbond, grill clips, speaker terminals, screws and ports.

D25T SPEAKER SPECIFICATIONS
Nominal Impedance: 6 ohms
Frequency Range: 2 - 24kHz
Free Air Resonance: 1500Hz
Operating Power: 3.2 watts
Sensitivity (1W at 1m): 90dB
Nominal Power: 90 Watts
Voice Coil Diameter: 25mm
Air Gap Height: 2mm
Voice Coil Resistance: 4.7ohms
Moving Mass: 0.3 grams
Weight: 0.53kg

P21 WOOFER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 26 - 4,000Hz
Free Air Resonance: 33Hz
Operating Power: 2.5 watts
Sensitivity (1W at 1m): 92dB
Nominal Power: 60 Watts
Voice Coil Diameter: 40mm
Voice Coil Resistance: 5.8ohms
Moving Mass: 20 grams
Thiele/Small Parameters: Qm: 2.4
Qe: 0.41
Qt: 0.35
Vas: 80:1
Weight: 1.65kg

Complete Kit Cat.K16020 .... **$699**
Speaker Kit Cat.K16021 .. **$549**
Cabinet Kit Cat.K16022 ... **$209**

SUPERB NEW VIFA/EA 60 + 60 SPEAKER KIT!

The new Vifa/EA 60 + 60 loudspeaker kit has been designed to completely out perform any similarly priced speakers. This is a 2-way design incorporating drivers which give a deeper, more natural bass response and 19mm soft-dome ferro fluid cooled tweeters which provide clear, uncoloured sound reproduction.

These Vifa drivers are identical to the ones used in such fine speakers as Mission, Rogers, Bang & Olufsen, Monitor Audio and Haybrook just to name a few. Some of which cost well over $1,000 a pair!

The dividing network is of the highest quality and produce no inherent sound characteristics of their own; they simply act as passive devices which accurately distribute the frequency range between both drivers in each speaker.

The fully enclosed acoustic suspension cabinets are easily assembled. All you need are normal household tools and a couple of hours and you've built yourself the finest pair of speakers in their class!

D19 TWEETER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 2.5 - 20KHz
Free Air Resonance: 1,700Hz
Sensitivity 1W at 1m: 89dB
Nominal Power: 80 Watts
(fo: 5,000Hz, 12dB/oct)
Voice Coil Diameter: 19mm
Voice Coil Resistance: 6.2 ohms
Moving Mass: 0.2 grams
Weight: 0.28kg
Cat. C10301 .... $38

C20 WOOFER SPECIFICATIONS:
Nominal Impedance: 8 ohms
Frequency Range: 35 - 6,000Hz
Resonance Frequency: 39Hz
Sensitivity 1W at 1m: 90dB
Nominal Power: 50 Watts
(12dB/oct)
Voice Coil Diameter: 25mm
Voice Coil Resistance: 5.5 ohms
Moving Mass: 15 grams
Cat. C10322 .... $89

Cat. K86091 .... R.R.P. $499
SUPER SPECIAL, $349

FULL RANGE OF VIFA SPEAKERS AVAILABLE ON REQUEST!!

rie
Rod Irving Electronics
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Phone (03) 663 6151
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Phone (03) 489 8866
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P.O. Box 620, CLAYTON 3168
Telex: AA 151938

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(TOLL FREE)
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POSTAGE RATES:

$1 − $9.99	$2.00
$10 − $24.99	$3.00
$25 − $49.99	$4.00
$50 − $99.99	$5.00
$100 − $199	$7.50
$200 − $499	$10.00
$500 plus	$12.50

FREE POSTAGE FOR ORDERS OVER $75 & UNDER 3KG!!

The above postage rates are for basic postage only. Road Freight, bulky and fragile items will be charged at different rates.

Certified Post for orders over $100 included free!
Registered Post for orders over $200 incuded free!

All sales tax exempt orders and wholesale inquiries to:
RITRONICS WHOLESALE,
56 Renver Rd, Clayton.
Ph. (03) 543 2166 (3 lines)

Errors and omissions excepted

*Apple and IBM are registered trade names

MasterCard VISA

FREE POSTAGE FOR ALL ORDERS OVER $75 & UNDER 3KG!!

FREE POSTAGE FOR ALL ORDERS OVER $75 & UNDER 3KG!!

PROJECT INDEX

From page 100

KEY TO KIT SUPPLIERS
AEC All Electronic Components (03) 662-3506
Alt Altronics (09) 381-7233
App Applix (02) 758-2688
DSE Dick Smith Electronics (02) 888-3200
EC Energy Control (07) 288-2455
ED Electronic Discounters (08) 212-1799
FE Force Electronics (08) 212-2672
HIC Hi Com Unitronics (02) 524-7878
Jay Jaycar (02) 747-2022
LE Laser Electronics (075) 532-2066
RIE Rod Irving Electronics (03) 663-6580

No.	Name	Date	Suppliers
644	Modem	Oct 82, Nov 83, Feb 84	
645	Tasman Turtle robot	Apr/May/ June 82	
646	Turtle hand controller	Jul 82	
647	Turtle-talk voice synthesizer	Sep/Oct 82	
648	Micro-grasp robot arm	Apr/May 82	
649	Light pen for Microbee	Aug 83	AEC
650	Stac timer	Nov 78	AEC
651	Binary HEX trainer	Jun 79	AEC
652	System 80 joystick interface	Aug 82	
653	16-channel driver	Nov 82	
654	Apple II card	Mar 83	
658	RS232 breakout box	Dec 83	
659	Vic20 audio cassette interface	May 84	AEC
660	1802 learner's microcomputer	May/Jun/ Oct/Nov 81	
661	Chord tutor adaptor for 660	Nov 84	
662	6802 processor board	Apr 84	
664	Hobbybot robot	Nov/Dec 85	
665	Computing routing switch	Oct 85	
666	Printer switch	Feb 85	RIE
667	Printer sharer	Apr 85	
668	EPROM burner for Microbee	Feb 83	RIE, AEC
669	EPROM eraser	Jun 84	
670	ASCII keyboard	May 82	
671	'Bee parallel printer interface	Oct 83	RIE
672	'Bee teletype printer interface	Oct 83	RIE
673	'Bee multiprom board	Nov 83	
674	'Bee joystick controller	Dec 83	RIE
675	'Bee serial-parallel interface	Jan 84	RIE, AEC
676	'Bee RS232 adaptor	Feb 84	RIE, AEC
677	Chatterbox voice synthesizer	Jan 85	RIE
678	'Bee ROM reader	Apr 84	AEC
679	'Bee joystick adaptor	Jun 85	
680	Z80 cpu board	Nov 79	
681	Prog character generator	Jun 80	
682	S100 prom board	Mar 81	
683	Computer controller	Dec 84	AEC
684	Intelligent modem	Dec 85, Feb/Mar 86	HIC, Jay, ED
685	2650 100 computer	Dec 81	
686	PPI EPROM programmer	Oct 82	
687	VZ-200 update	Jul 86	
688	Bipolar PROM programmer	Jan 83	RIE, AEC
689	Bus sharing switch	Jan 86	
690	Little big board	Oct/Nov 83	
692	RS-232 to 20 mA current loop	Jan 85	
693	Tape auto search	Jun 85	
694	FORTH computer	May 85	EC
695	VZ-200 terminal	Aug 85	DSE
696	RSC-FORTH card extension	Dec 85	EC
697	FORTH controller board	Mar 86	EC
698	Auto-dialler for modem	Jul 85	
699	300 baud modem	May 85	RIE, AEC
1601	RS232 for Commodore	Jul 86	AEC, HIC, Jay, ED
1602	Commodore function switches	Aug 86	
1603	Commodore tape duplicator	Sep 86	HIC
1604	Twin joystick for 'Bee	Aug 86	
1605	FORTH A-D card	Sep 86	EC
1606	RIE 'Bee extender	Nov 86	
1607	Commodore talker	Feb 87	
1616	16-bit computer	Dec 86, Feb-Apr 87	App

RADIO FREQUENCY

No.	Name	Date	Suppliers
701	Masthead amp	Dec 74	
702	Radar alarm	May 75	AEC
703	Antenna matcher	Jun 75	AEC
704	Cross hatch generator	Aug 75	AEC
705	Three simple receivers	Dec 75	
706	Marker generator	Feb 76	
707	Converter for 28, 52 and 144 MHz	Feb 76	
708	Active antenna	Mar 76	AEC
709	Attentuator	Mar 76	
710	Power amp	Apr 76	
7112	Remote control switch	Jul/Aug/ Sep 76	AEC
712	CB power supply	Jun 77	AEC
713	Add-on FM tuner	Sep 77	
714	TV-FM antenna	Feb/Mar 78	
715	2 and 6 m power amp	Nov 77	
716	Power amp	Jan 78	
717	Cross hatch marker	May 78	AEC
718	SW receiver	Oct 78	AEC
719	Field strength meter	Nov 78	
720	2 m VFET power amp	Jan 79	
721	Aircraft band converter	Mar 79	AEC
722	Project 721 antenna	May 79	
723	Selective caller	Feb 82	
724	Microwave oven leak detector	Jul 79	RIE, DSE, AEC, Jay, ED
725	Polyphase SSB generator	Aug 79	
726	6 and 10 m power amp	Feb 79	
727	Antenna matcher	Jan 81	
728	UHF TV antenna	Mar 81	
729	UHF masthead amp	Apr 81	AEC
730	RTTY receiver converter	Aug 79	AEC
731	RTTY modulator board	Sep 79	AEC
733	Microbee RTTY	Apr 83	RIE, AEC
734	Phone patch line interface	May 83	
735	UHF TV converter	May 84	AEC
736	Picture plucher	Sep 83	
737	70 cm preamp	May 84	DSE
738	UHF booster amp	Jul 84	
739	AM stereo decoder	Oct 84	
740	FM tuner	Feb/Mar 76	
741	10-channel synth radio mic	Dec 84/ Jan 85	
742	Broadcast/coms speaker	Feb 85	
743	25 W UHF power amp	Jun 85	
744	UHF/VHF tuner	Apr 86	
750	6 m amp	Dec 83	
751	FM bug	Dec 85	Jay, ED
755	RTTY transceiver	Nov/Dec 84	RIE, AEC, Jay, ED
756	VZ200 RTTY transceiver	Nov/Dec 84	DSE
757	Cat RTTY/FAX	Nov/Dec 85	DSE
760	Video RF modulator	Oct 81	RIE, AEC
780	Novice tx	May/Jun 76	AEC

Amplifiers

TD300 $750.00
Slave Amp (150 watts per channel into 16 ohms) with stereo to mono switching.

ZPE SERIES II $2200.00
500 Mosfet Output Stages 250W into 8 ohms for bands that want power!

Disco Mixers

CITRONIC SM 350 $1070.00
6 Channel Input (2 Mikes + 4 aux)

ARISTA $450.00
6 Channel Input with Equalization.

Lamps
Carton Quantity Only
No Warranty on Breakages

DX60-ES, 240v, 60w
Discolux (soft glass) E.S., assorted Colours Box of 25 **$85.00**

G40BC, 240v, 40w
BC Lamps in Blue, Yellow, Orange Red, Green, Box of 100 **$85.00**

G25BC, 240v, 25w
Box of 100 **$75.00**

FLOURESCENT TUBES
White $3.50
Colours $6.50
Ultra Violet 4 ft. $45.00

Turntable

TECHNICS DIRECT DRIVE $290.00
Special Disco Suspension

TECHNICS SL1200
Top of the range Direct drive with pitch control **$850.00**

TECHNICS BELT DRIVE $190.00

TECHNICS CASSETTE DECK
Special while stocks last **$190.00**

Jumbo Strobe

JS 10 $195.00
White Flash Jumbo Strobe with Speed Control. Every performer should have one.

Helicopter

A GE 4515 lamp in housing can be swivelled and directed up or down spinning 360° in the one place.

RPS102 2 ARM SPINNER $275.00
RPS104 4 ARM SPINNER $495.00
RPS106 6 ARM SPINNER $550.00
UFO 324 UFO LIGHT (24XGE 4515) $2200.00

Scanner

S101 $160
Search Lighting effect

Scanner Bar

S104S $550
Light bar housing four GE 4515 lamps scanning with individual motors.

All housing complete with front cover and with provision for colour gel.

Micro phones

129B 33 cm Flexible Chrome Arm, goose-neck $5.90

186C Chrome Base Mount $3.40

518C Arista Mike $80

UD312 Primo Mike $120

102 Mike Stand, Adjustable $93.80

HL43U Flexible Arm Mike Holder — $2.90

SMOKE MACHINE, (Great for Special Effects!) $395.00
Fluid — 1 litre $15.00

Pinspot

PS 112S (Par 36 can) $55
(6v, 30w) Designed specifically for Mirror Ball Spotting. Used widely to achieve a bullet beam effect.

BONUS OFFER:
Bulk Buy 10 for $500.00 till sold out

PAR 56 $130
PINCHASER $700
Exclusively for Pinspots

Rope Lights

FOR BANDS DISCOS & CLUBS

PRL 803
Rope light, Tubes Red, Blue, Green, Orange, White.
$135.00(5m)

MULTI COLOURED:
White reinforced spiral tube with MC lamps: Tred-proof. **$135.00(5m)**

SRL 801 $180.00(10m)
Rope Controller
$195.00

Border Lights

BL104 — $195
FREE
Gel Filter Frame Mount Rkts

Halogen Beacons

WL 104 — $165
Warning lights are available in different colours.

ARTLITE

20th Century plastic in flat sheets (2 mm or 100 mm) or round tubing (8 mm) that glows under ultra violet lighting.
Available in 5 different colours.
Ideal for disco installations, bands and signwriters.
From **$5.65** per metre!!!

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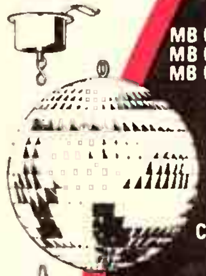
Victoria 3140
Telephone: (03) 735 0588

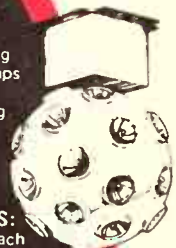
Mirror Balls



MB 005, 5" $27
MB 008, 8" $58
MB 012, 12" $88
MB 014, 14" $120
MB 018, 18" $160
MB 020, 20" $195
MB 012C Mirror Cylinder (12" length) 6" Dia. — $52
MB 008H Half Mirror Ball & Motor, 8" — $54.11
MB 012H

MIRROR BALL MOTORS:
A.C. 240V Heavy Duty — $100
Battery Motor $15.00
A.C. 240v — $39

Cosmos Light



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New 1/1000 s high speed shutter for VHS

At a quick glance, what clearly distinguishes National's new NV-M5A VHS Movie camera from earlier models is its new streamlined design and the fact that the battery pack is now inserted into the VHS Movie itself instead of being clipped on. This obvious change in outward appearance is indicative of several advances in video technology built into the new model.

The NV-M5A comes with a wide range of innovative features while reducing the weight by as much as 300 g compared with its predecessor model, the NV-M3A. Enhanced automatic functions ensure that even a first-time user can get excellent shooting results under virtually any shooting situation.

Major innovations in the NV-M5A include the new Piezo auto focus system and an exceptional high speed shutter.

The Piezo system is state-of-the-art in automatic focusing. This fully camera-internal measuring and adjusting system overcomes the shortcomings of conventional auto focus systems and achieves higher precision and faster response to any changes in the shooting distance. Even in 'difficult' shooting situations such as shooting through glass, etc, the makers promise sharply focused pictures. In addition, a two-step focus zone setting function allows the user to customize the measuring zone of the auto focus system to the subject of the shot.

The high speed shutter function is controlled by an on/off switch and can be activated when recording fast-moving scenes, such as tennis serves, golf swings, car races or amusement park rides. Then they can be played back in slow motion or still mode for detailed analysis.

The images have sharp edges, crisp details, and no blurring. Whereas the shutter speed for a conventional video picture is 1/50th of a second in the PAL recording system, the high speed shutter collects and records only 1/1000th of a second of video information for the same duration. Instead of recording all of the action occurring within the conventional 1/50th of a second, the new shutter speed records 1/1000 sec images — fast enough to freeze instantaneous action and reveal precise, movement-by-movement detail.

Just the thing for correcting that tennis serve or golf swing!

Anti-theft car CD

Everybody knows that Australia's crime rate sits at an alarming level, and that cars and the equipment they contain are prime targets for thieves. Pioneer has taken heed and incorporated an anti-theft system in its latest car CD come tuner, the Hideaway.

This new CD player and tuner has a built-in security code, which you set yourself, so that no-one else can use the the player. The company also provides a sticker for the car window which warns that breaking in is not worth the trouble.

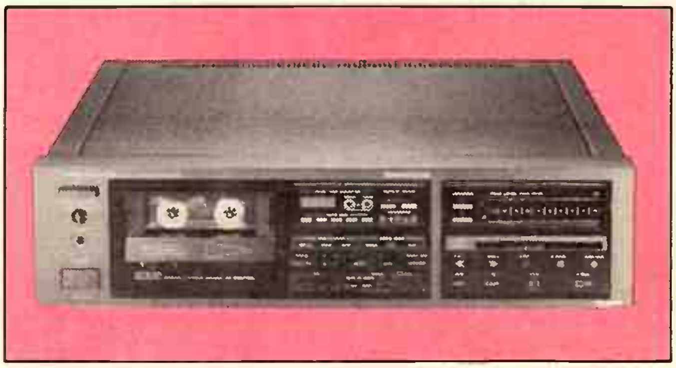
The AM/FM Hideaway tuner part lives up to its name. It can be installed almost anywhere, even hidden in the car boot leaving room on the dashboard for CD player or equalizer. When the tuner is hooked up to the CD player, all the normal tuner functions and displays work from the CD controls.

All controls are electronic, so volume, balance and tuning commands are operated by a soft touch of a button. A remote control is also available as an optional extra.

The Hideaway offers a quality of sound for cars that's as sophisticated as many home systems. It costs around $1300 RRP, so it's just as well the anti-theft security is included!

For further information contact **Pioneer's marketing manager Doug Bell** on **(03)580-9911.**

Onkyo launches new cassette deck



Onkyo Corporation of Japan has released its TA-2058 Integra cassette deck. This deck features the new HX-PRO noise reduction system as well as the Dolby B and C noise reduction systems.

Other features of the deck include a three-motor three-head configuration, full automatic accubias with five memory positions, four-digit real time tape counter, automatic music control system, and auto space function.

The three-motor system, with micro-computer control, achieves excellent stability and reliability in tape transport, and the three head configuration allows you to monitor the recorded signals during recording.

The automatic music control system scans the first 10 seconds of each track, allowing the listener to select the desired track quickly and easily. This feature operates in both rewind and fast forward modes.

The deck is finished in stylish matt black and sells for around $899 RRP.

For more information contact **Andrew Harrisson or Lynn Donovan, Hi-phon Distributors Pty Ltd, Unit 7, 56 Victoria St, North Sydney, NSW 2060. (02)923-2011.**

Smallest camera

JVC has released a new compact VHS camera-recorder onto the Japanese market.

Of the different VCR formats, VHS is by far the most popular. Accumulated total worldwide shipments of VHS machines exceed 110 million units.

With the introduction of the GR-C9 Mini VHS VideoMovie the format became remarkably portable. The GR-C9's size and weight, 750 grams, make it the smallest and lightest camcorder offered in any format, including 8 mm.

This camcorder offers up to one hour of recording on a compact VHS cassette, and uses a half inch field-storage CCD imager as its pickup element.

Midi VCR

Hagemeyer, the marketer of JVC products in Australia, has released five new video recorders.

Among the new offerings is the HR-D470E which has HQ circuitry, hi-fi stereo sound, two speed audio recording, one-year/eight-event timer that can be programmed from the remote control or from the deck itself and music scan of up to nine selections. Most interestingly it is MIDI controllable.

The budget model HR-D170EA has HQ picture improvement, pretuning to Australian channels (as with HR-D180EA, HR-D370EA and HR-D755EA), 14-day/four-event timer, remote control, microprocessor still and nine automatic functions.

The HR-D180EA is capable of two speed audio and video recording, microprocessor still, HQ picture improvement, one-year/eight-event timer, nine automatic functions, infrared remote control with timer programming and a go-to function.

Another version, the HR-D370EA, is designed for the audiophile who wants to take advantage of video recording. Features include hi-fi audio performance, up to eight hours in the LP mode, HQ picture improvement, one-year/eight-event timer, music scan (normal audio track) up to nine selections, infrared remote control with timer programming and go-to function. It has nine auto functions and is pre-tuned to all Australian channels.

The top of the line machine is the HR-D755EA, offering all these entries plus some others.

Its remote control has a built-in LCD panel which incorporates up to four sets of ▶

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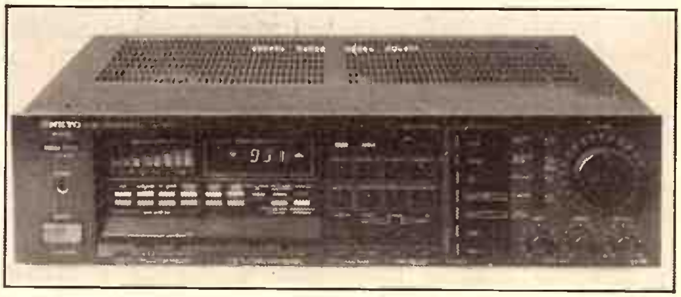
programmed data, clock and alarm functions, on-screen timer and mode check. It will allow the user to program up to eight events one year in advance. Other features include HQ technology, two speed audio and video recording, nine automatic functions, variable speed search, audio dubbing, insert editing, direct camera connection and a field still.

Recommended retail prices are: HR-D170EA $899; HR-D180EA $1199; HR-D370EA $1599; HR-D470EA $1799; and HR-D755EA $2499.



Another Onkyo

Onkyo has increased its range of receivers with the recent release of the TX-38 model.

Rated at 55 watts per channel, the TX-38 is equipped with seven program inputs: tuner, phono, CD player, two tape inputs, plus two video inputs which make video and audio dubbing simple as no extra connections or rewiring is required.

The TX-38 also boasts two exclusive Onkyo design features, the dynamic bass expander and the stereo image expander. The bass expander expands low range response in varying degrees depending on the level of the input signal, giving increased definition without the midbass and midrange colouration associated with conventional bass boost circuits. The stereo image expander creates a sensation of broadening the listening room to give you the impression of being in a much larger environment. The ambience on the sound tracks of video sources is improved considerably with this feature.

Another feature of the TX-38 is Onkyo's automatic precision reception system which optimizes the FM signal by automatically selecting the best reception mode. The selection chosen is indicated on the front panel.

This new model receiver sells for $999 RRP.

For further information contact **Andrew Harrisson or Lynn Donovan, Hi-phon Distributors Pty Ltd, Unit 7, 56 Victoria St, North Sydney, NSW 2060. (02)923-2011.**

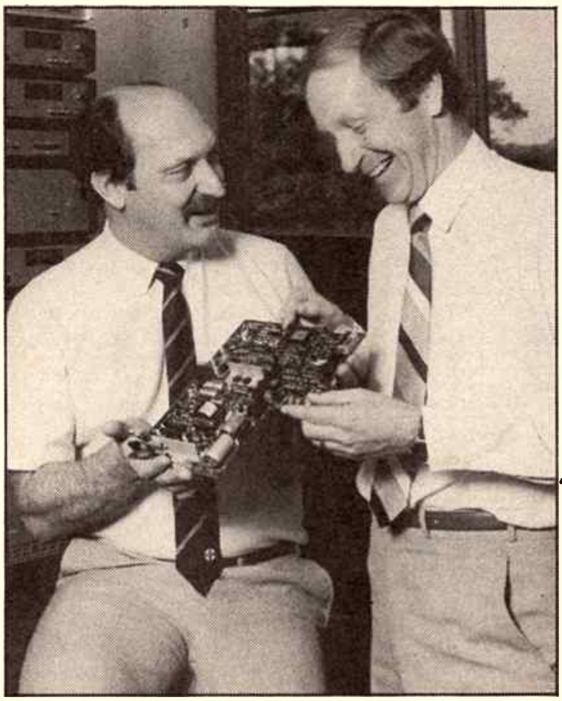
AWA wins prize

A new range of multi-channel digital microwave radios designed and built by AWA has won the 1986 engineering product excellence award from the Institution of Engineers, Australia.

The award was announced by Sir Eric Neal at the official opening of Professional Engineers Week in Sydney.

The new RMD Series digital radios were designed specifically to meet the challenges imposed by the harsh Australian conditions, including extremes of temperature as well as distance. Institution of Engineers assessors said that the engineering approach to the development of this product was of the highest order.

Telecom Australia was one of the first customers, placing orders in excess of $5 million after studying the prototype. ▶



Units have since been sold to the Western Australian police force and to the Reuters news agency.

The RMD digital radios will transmit any mix of voice and data traffic up to a capacity of 8 Mbits (equivalent to 120 voice channels, all operating simultaneously).

The radios are used to provide communications links in rural telephone networks, on oil rigs, pipeline projects and in support of major utilities such as power and rail authorities. Repeaters may be used to extend the links over virtually any distance.

Doug Roser, general manager of AWA's defence and transmission division, said that the new radios would be more suitable for the Australian environment than any similar systems designed overseas. They will, for example, operate over long semi-obstructed paths, minimizing the need for repeaters. Tests over semi-obstructed paths of more than 100 kilometres have given excellent results.

A typical example of usage is in a rail network. The radios can be used for PABX communication between terminals, to extend phone links to points along the track, to send electronic messages to the signalling equipment and to extend the mobile radio system throughout the network.

Mr Roser said that the radios would provide communications into areas very difficult to service because of remoteness and harsh conditions. They cope well with heat and cold, having an operational range over temperatures from 10° to 60°C. Also, they consume very little power, enabling them to be solar powered and to be located in simple shelters which results in large savings in infrastructure costs.

A major feature of the radio equipment is in its principle of operation, accepting streams of digital pulses and regenerating them without distortion at the receiving end. Voice signals can be converted to digital signals by pulse code modulation (PCM).

The export potential of the RMD radios has been supported by Telecom. The executive director of Telecom Australia, Ken Loughnan, said he was "enthusiastic about the product, and particularly about its export potential". He pointed out that the Chinese vice-minister of communications had seen the equipment at a Telecom-sponsored exhibition of Australian technology in August and showed significant interest.

Mr Loughnan said Australia showed particular technological strength in the field of rural communications. He said AWA's RMD radios were a strong part of this technology which could be marketed to developing countries with large rural populations, such as India, Thailand and China.

AWA has begun a strong export marketing drive. An agent company has already been appointed in England to spearhead the move into Europe. As well, the RMD digital radios were exhibited at the CommunicAsia exhibition in Singapore early last year and were included in an exhibition in the UK in November. They will also be on display at an exhibition in the Middle East and at the world's biggest telecommunications exhibition in Geneva in 1987.

For further information contact **Doug Roser at AWA, Cnr Lane Cove and Talavera Rds, North Ryde, NSW 2113. (02)887-7111.**

New Tannoy loudspeaker

The UK loudspeaker manufacturer Tannoy has released the Mercury II speaker which replaces its successful first Mercury model, launched in 1982.

The new model features some significant design improvements. A new ferrofluid-cooled polyamide soft dome tweeter gives a very smooth response and improved dispersion, and a taller cabinet has aesthetic advantages.

Finished in walnut or black ash, this loudspeaker sells for around $599 RRP.

For more information contact **Andrew Harrisson or Lynn Donovan, Hi-phon Distributors Pty Ltd, Unit 7, 56 Victoria St, North Sydney, NSW 2060. (02)923-2011.**

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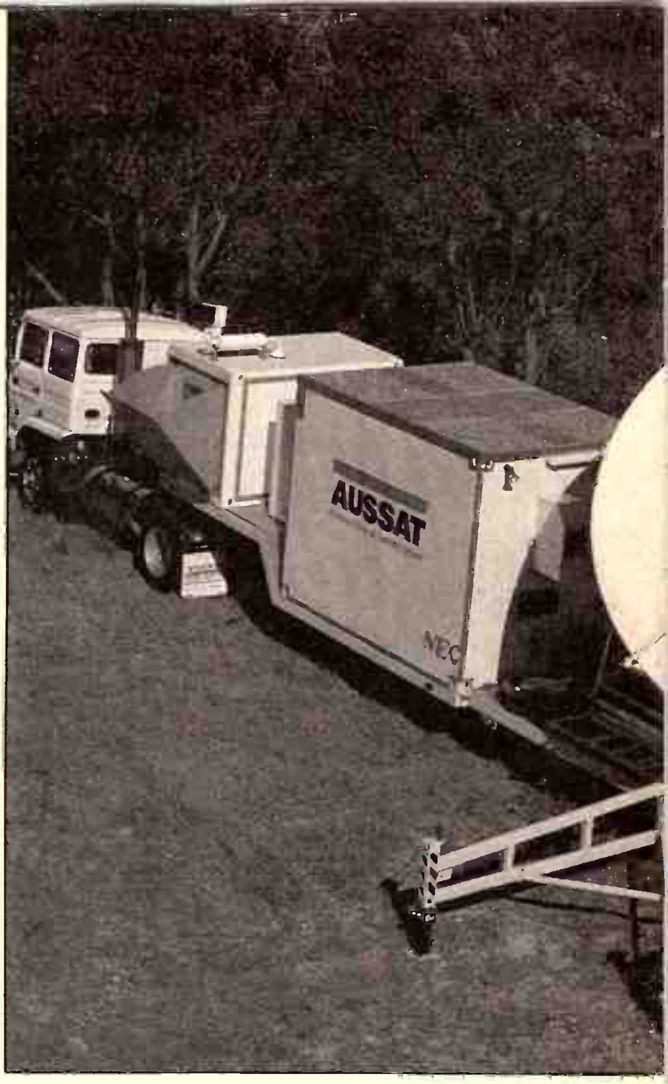
NEW HORIZONS IN TV NEWS AND CURRENT AFFAIRS



The latest advances in satellite communications enable instant pictures of world affairs to be brought into the lounge rooms of all Australians. And there's still plenty of space for future developments!

Pieter Wessels

Pieter Wessels is Facilities Director, ABC-TV News and Current Affairs.

The introduction of domestic satellites is dramatically changing the compilation and composition of news and current affairs programs on Australian television, and the effect of these changes will be a more knowledgeable and better informed public.

In looking at the history of newsgathering (or journalism) in Australia, the new developments are mind-boggling. At the beginning of white settlement in this country there were, of course, only newspapers and personal correspondence to find out what was going on in the world. Then in the 1930s radio began telling people what was happening; 'live' broadcasts enabled listeners to actually hear great events of the day. But the biggest change came in the mid-1950s when television opened a visual window on the world for most Australians and to some extent allowed them to make their own judgments of important events.

Since the introduction of television to Australia 30 years ago, newsgathering techniques for news and current affairs programs have gone through significant development phases.

First came the development of videotape which freed TV from the choice of only 'live' programs or film, with all the dangers and limitations of the former and the time-consuming and fragile nature of the latter. Next was the development of ENG (electronic news gathering). This freed TV newsgathering from the tyranny of film, which had to be processed and travel physically between points. And more recently we have the development of SNG (satellite news gathering) which has freed TV newsgathering from terrestrial landlines and their inherent limitations.

While these developments dealing with electronic gathering and networking of news material were going on, Telecom Australia was slowly expanding a network of terrestrial landlines throughout the country. These landlines never did and never will cover the whole continent. On long hauls, such as Darwin to Sydney or Perth to Adelaide, there was considerable loss of quality. Nevertheless, they were frequently in great demand by the competing television networks and much cut-throat activity took place, as well as some pooling when there was no alternative. The requirements of the four major Australian networks were simply too much for a land-based system, except on the busiest and most advanced routes like Sydney to Melbourne.

As electronic recording and electronic interchange between cities developed, the TV industry was also building up its ability to get material from point-to-point on 'links' — microwave facilities that could be small, portable and throw a television signal short distances, or big and cumbersome and throw signals long distances.

Slowly, newsgathering became manageable electronically. It was recorded electronically, linked electronically, relayed electronically and put to air electronically. All that was needed was the ability to get the signal from anywhere to anywhere without having to rely on landlines.

The Telecom landlines did provide what are known as 'plug-in points' in major switching areas scattered throughout the country. News crews could wheel up, plug in their cameras or recorders and relay their pictures back to base. And if the cameras were at a conference 20 kilometres from the plug-in point, microwave transmitters could be used to get the signal back. But there were many patches and plugs along the signal path, any of which could go wrong.

More recently there has been the development of the 'mini-link' transmitter and 'omni-directional' receivers which give most television stations the ability to cover breaking news in their city.

But the latest development in the news

scene is satellite news gathering, or SNG for short. And it is SNG that has opened up a new horizon in newsgathering.

Wide satellite coverage

With SNG it is possible for news and current affairs programs to get live coverage or videotape replays from anywhere in the country, without restriction. So for the first time it is possible to cover any event in Australia and to show that event to every person in Australia.

The first broadcast of this type was undertaken in October 1986 when the ABC news and current affairs department took a transportable Aussat ground station to the Defence Forces Operation, Kangaroo 86, near Rockhampton in Queensland, and beamed out reports on one of the ABC's transponders.

This exercise also showed what could be achieved by satellite news gathering in the event of a real conflict.

With the introduction of Aussat, television stations lucky enough to have transponders and ground stations, such as the ABC, found that exchanging of news and current affairs material between State capitals became a breeze. An expensive breeze but one that works well, with tremendously high quality and none of the logistics problems of terrestrial lines.

With Aussat, the ABC can gather material from all its newsrooms — Sydney, Melbourne, Brisbane, Adelaide, Perth and Hobart, plus Canberra and Darwin. This operation has led to a blossoming of news from the far corners of the country. Reports from Perth and Darwin are frequent in the Eastern States. Western Australia gets reports from the Eastern States with equal ease. In fact ABC news departments in all States have every story available to them. Programs have changed and more national news is seen in every state.

This flowering became possible largely because the facility was available at a fixed cost, which was built in to the programs each year. Newsmakers could send as much as they wanted without having to make fine decisions of cost versus news value. Bang! Stories are sent off to everyone and each State makes its own decision.

So, in newsgathering the main benefits of the Aussat transponders are that they enable point-to-multipoint relay, give excellent quality, are available at a fixed price, and distance is no longer a concern. And in programming terms, live feeds are easy, live crosses are more reliable, quality is compatible, logistic problems are minimal and audio is on the same signal.

US experience

In the United States — which in so many ways sets the scene for trends in Australia — satellite news gathering has expanded greatly, with companies set up just to supply the demand for portable earth stations and transponder time. The trend in America has been for each TV station to get its own earth station and to cover lots of local news by means of it.

One dramatic example occured in August 1985 when Hurricane Danny struck the Louisiana coast. Viewers of WBRZ in Baton Rouge watched the eye of the hurricane move ashore over Vermillion Parish. Through live satellite transmission from the very centre of the storm, they saw debris tumbling before 140-kilometre-an-hour winds and trees bent over parallel to the sand. Then suddenly the trees snapped upright and the blowing rubble settled. The rain stopped. The sky cleared to vivid blue as the eye of the storm passed over. WBRZ reporter Jay Young, who had fought for footing in the force of the gale, remarked on the eerie stillness and pointed out birds returning to the air. Twenty minutes later the winds struck again.

For viewers in Baton Rouge the live coverage offered a frightening preview of the powerful storm that seemed headed

> 66
> ***With the introduction of Aussat, television stations lucky enough to have transponders and ground stations, such as the ABC, found that the exchanging of news and current affairs material between State capitals became a breeze.***
> 99

their way. For those in Houston, New Orleans and Miami it provided a glimpse into the hurricane phenomenon that threatens their cities almost every summer. For television journalists it was news as news ought to be — a triumph in reporting made possible by technology.

Indeed, coverage of the hurricane was a major breakthrough in local television news. WBRZ and three other stations (in Houston, New Orleans and Miami) cooperated in a comprehensive reporting effort that outclassed the national networks. Using truck mounted satellite stations, they were able to tell a story of vital concern to their audience from a uniquely local perspective.

It is not hard to go from this American example to the Australian situation. Cover of our great natural disasters — fires, floods, cyclones — is of vital concern to the whole community. Frequently lives depend on people appreciating the danger and knowing of its approach. But so often Australian news organizations can't cover because terrestrial bearers are burned or flooded, or links towers are blown down.

Viewer's expectations

Then there is the viewer's changing perception of what television can do. Anyone who watched the MTV awards with their live crosses to people all over the world, and the Live Aid concert with its earth girdling network, can have no doubt about what Australia's young viewers expect today. And these young viewers expect no less of news programs than of rock shows.

Older viewers have seen the change in overseas news coverage in this country, from the film flown in from overseas within my working life to the live satellite footage of murder and mayhem and terror that is so much part of our lives today. ▶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34,800uF
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Pack/Post:- $3 plus 5% of order value; extra for heavy items
WANTED: Electronic parts, computers, test equipment, CASH paid.

Repeatedly, surveys have shown that people place more trust in television news than in other media. They feel they can look at the picture of an event, or watch it live, and then make their own judgment.

For the makers of television news and current affairs programs, pictures are the be-all and end-all. We must have the ability to cover any story anywhere in Australia and show it to everyone in the country who wants to watch. And there are more and more people wanting to watch.

Anyone in Australia can now see ABC-TV news and current affairs programs, provided they are within range of a transmitter or have a dish. And soon at least one commercial channel will be available via satellite too. We must therefore program for the whole country, not just the big cities.

Network requirements

To program on a truly national basis the Australian television networks must develop satellite news gathering similar to that of the United States. We must be able to take a ground station to anywhere in the country with speed and ease; get it operating there and get pictures onto transponders in a very short time.

Two things are needed. Firstly, portable (not simply transportable) earth stations and, secondly, access to transponders at a moment's notice. To be truly portable the earth station should be sufficiently small to be easily carried on a scheduled passenger aircraft, light enough to be carried in a station wagon, and able to be readily handled by a two-man crew.

Such a system would be a 'first reaction' hardware, to be moved to the site of a breaking news story and followed up later by a transportable earth station.

The transportable earth station would be fully self-contained and capable of being moved around and set up in a new location quickly. This type of earth station would be needed for covering bushfires, sieges, floods, cyclones, etc, and it would need to be sturdy enough to stand up to the roughest conditions.

Access to transponders is another difficulty. In Australia the networks have usually taken slabs of time on Telecom bearers or Aussat transponders. But this locks out the smaller stations and their individual requirements. They cannot afford to buy slabs of time which they might or might not use. With breaking news it is usually too late if you order only when the need is apparent!

In the United States the smaller, local television stations are becoming the main users of transponder times. There the trend has been for companies, some of them co-operative, to buy transponder time in slabs for their affiliates to use as required. Conus and other such suppliers seem to be doing very good business so perhaps the same will be allowed to happen here.

Future advances

Miniature ground stations and instantly accessible transponders will take care of the present. But what of the future?

The next step appears to be pictures of Earth from space.

In the recent Chernobyl disaster in the Soviet Union, newsgatherers in the Western World were unable to get any pictures at all. The Soviet Union wasn't releasing any.

So the major American networks turned to space. They arranged for two satellites operated by private companies (one from the United States and one from France) to fly over Chernobyl and to take photographs. These photographs cost only a few hundred US dollars each and gave a startling amount of detail. From them the networks were able to deduce the size, cause and effects of the disaster.

It is my guess that this type of 'space journalism' will grow, eventually to include moving pictures and perhaps even sound.

Governments will attempt to stop it, mainly by setting up government monopolies in space work. But in Europe and Asia there are already private firms established in space. For the Western media at least, even if their own governments won't allow them into space, they can buy from the pirates. And that may be fair enough if they're the only source available.

Finally there is the biggest challenge of all — pictures of space news from space.

I look forward to the day that Richard Carleton or Jane Singleton is asked to anchor a show from the Moon, with the coverage coming back to Earth via an Aussat transponder! ●

“ *They arranged for two satellites operated by private companies (one from the US and one from France) to fly over Chernobyl and to take photographs. These photographs cost only a few hundred US dollars and gave a startling amount of detail.* ”

COMPACT BATTERIES OF THE FUTURE

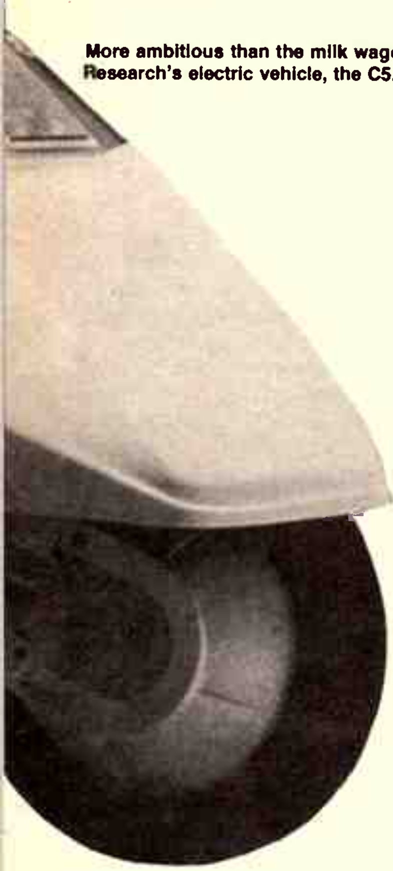
Engineers designing electrical and electronics equipment have long been frustrated by the weight and size of the batteries that have to be carried. Now British and Danish scientists are collaborating to develop all-solid-state rechargeable lithium batteries that will bring pollution-free driving a great deal nearer and may trigger many exciting new ideas for battery-powered equipment.

Dr Alan Hooper

Materials Development Division, Harwell, UK

Battery-powered electric vehicles (EVs) are already in use in many countries. One example, in the UK, is the humble milk-delivery wagon, or 'milk float'. It is successful because its job necessitates work over only a short range and at low speeds. In built-up areas, it has the added advantage over the internal combustion engine of not causing pollution. It is efficient and convenient for continual stop-start operation and a commercial fleet of such vehicles is easy to maintain.

On the other hand, its restricted perform-



More ambitious than the milk wagon is Sinclair Research's electric vehicle, the C5.

ance causes considerable frustration to motorists who meet it on the open road for it cannot travel at the speed of the rest of the traffic. Golf-carts would hardly be welcomed on the freeway! So the view of the general public is that electric vehicles have poor performance but are acceptable for specialist duties.

It is the source of power, the battery, which lies at the heart of the electric vehicle problem. To put it simply, traction batteries are too heavy and too large for the amount of energy they store or the power they can provide: a large fraction of the energy stored in a typical traction battery is needed just to propel the battery itself.

Aqueous electrolytes

For practical purposes, the present choice of batteries for EV traction is between two systems, each employing an aqueous electrolyte, which is either lead-acid or nickel-iron. This situation has remained essentially unchanged since the beginning of the 20th century despite many attempts, especially over the last 25 years, to develop new systems. Over that period, competition has led to significant improvements in the performance of existing systems and of vehicles with good short-range, traffic-compatible capabilities. Most of the vehicles now available are urban delivery vans but one of the latest is a version of the popular Peugeot 205 car, powered by a nickel-iron battery.

There are certain practical drawbacks specific to individual systems, but the main, general problem is still that of limited range. EVs are, in general, economically uncompetitive with their internal combustion engined counterparts.

The performance offered by the enormous energy density of petroleum, with more than 10,000 Wh/kg (watt hours per kilogram) compared with 20-40 Wh/kg for lead-acid traction batteries and a high-rate recharge capability (two minutes at the pump in contrast to a battery charge of several hours), will never be matched by that of any battery system, in spite of an on-board energy conversion efficiency that is five times better. However, if a battery were available with high energy density (100 to 200 Wh/kg) it would significantly affect the practical value of EVs in a wide variety of applications from wheelchairs and bicycles to commuter cars, taxis and delivery vehicles.

Not only would longer ranges and greater load-carrying capabilities be realized, but the improvements in gravimetric energy density would open up considerable scope for innovative engineering in vehicle design, using lighter and cheaper materials. It is this, rather than cheaper batteries, which would lead to a cost-competitive electric vehicle.

Portable electronics

Similar problems are to be found in other technologically important areas. The vast demand for portable electronics equipment in the computing and communications fields brings with it a need for small, lightweight, rechargeable power sources. Both the business executive and the infantryman in the field would benefit from a lighter load to carry.

In the case of the hand-held cellular radio telephone or the 'wrist watch' device the problem is not only that of suitcase sized batteries. They must be suitably shaped too. Furthermore, a flat-screen television ideally requires a flat battery pack.

There are also growing markets in telecommunications and other industries for standby power sources. Here, too, there is a trend towards smaller electronics packages and correspondingly small power sources.

Nicad batteries have been used traditionally in these markets and, more recently, NiH_2 batteries too, in space applications such as power sources for satellites where cycle life and reliability are also of prime importance. But the low energy densities so far achieved have restricted the electrical load capabilities of missions. Space stations and deep space probes will require power sources with higher energy densities.

Much better energy densities are theoretically available from alkali-metal couples, but materials problems have restricted their use mainly to primary battery systems and to secondary batteries operating at high temperature. Of the latter, the sodium-sulphur battery is the best developed. It uses an Na^+ ion conducting solid, sodium-beta-alumina as a solid electrolyte and has to be operated at 350°C. Predicted energy densities are more than 100 Wh/kg; more prototype traction batteries have been made and vehicle demonstrations carried out in several countries.

However, sodium-sulphur batteries are still not commercially available, even after some 17 years of research and development by large teams of scientists around the world. Remaining problems include the reproducibility of manufacture and reliability in the use of beta-alumina ceramic tubes, and the thermal control and safety of large batteries. High temperature systems of this kind will, even if successful, be useful only where large batteries are needed.

A small, room-temperature, rechargeable lithium battery with a liquid organic electrolyte has recently become commercially available in Canada. Its cathode material (MoS_2) leads to a low open-circuit voltage and moderate energy density. A useful life of more than 100 charge/discharge cycles is quoted but little information is yet available from field trials. Applications under consideration include photographic flashguns and electric wheelchairs.

Radical departure

Rechargeable all-solid-state lithium batter- ▶

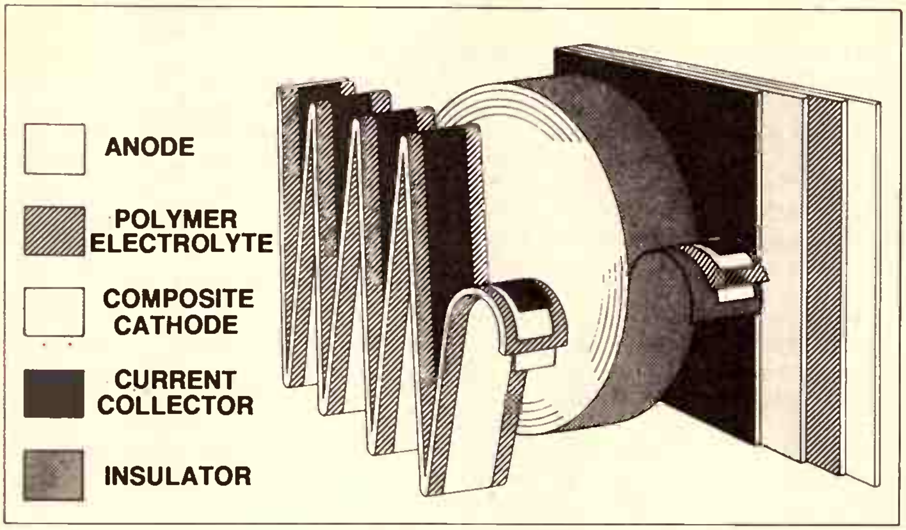


Figure 1. Three ways of constructing all-solid-state cells with large surface contact areas.

ies now being developed at Harwell constitute what is perhaps the most radical new departure in battery technology for decades. They also promise very exciting commercial prospects. Based on thick-film polymer technology, with no liquid components, they offer very high energy density, mechanical flexibility and variable geometry as well as being robust and safe.

This work has evolved from a program begun here in 1978 to investigate materials for advanced alkali-metal rechargeable batteries. It was shared between Harwell, universities in the UK, and research and development establishments in Denmark. The Anglo-Danish Battery Program as it became known was jointly sponsored at Harwell by the UK Department of Trade and Industry (DTI) and the European Community.

The aim of the program was to examine the properties and behaviour of several promising solid electrolytes and electrode materials described in the literature, to obtain a sound idea of their properties. This would define the problems with their use in batteries and enable assessment of their compatibility with other materials in cells. Such work would enable the researchers to find out reliably which materials might be technologically useful for electric vehicle batteries in the future. It was hoped to obtain a fairly hard-headed assessment of whether alkali-metal batteries could be developed that would achieve their potential energy density advantages and to identify which materials could best be chosen for future cell development studies. A working temperature range of 100°C to 200°C was considered acceptable for a first-generation EV battery.

All-solid-state

Because of persisting difficulties with organic liquid electrolyte batteries, all-solid-state cells were seen as the only practical way forward for operation at ambient and moderate temperatures. The cells developed in the program have lithium anodes and a so-called intercalation or insertion compound as reversible cathodes. Examples are V_6O_{13} and TiS_2.

Although the early stages of the program studied in depth the very interesting crystalline inorganic lithium-ion-conducting electrolytes Li_3N and $LiI(Al_2O_3)$, the choice of this type of cell was made more realistic by the discovery of polymer-based solid electrolytes by Michel Armand and fellow workers in France. Certain polar organic materials such as poly(ethylene oxide) will dissolve alkali-metals salts and manifest

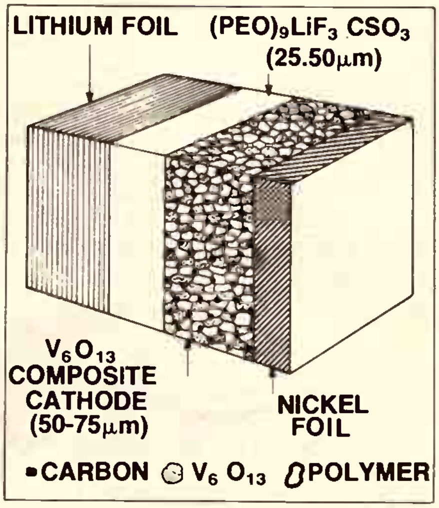


Figure 2. Basic arrangement of the elements of an all-solid-state cell. The notation PEO stands for poly(ethylene oxide).

rapid alkali-ion conductivity.

The absolute conductivities of such polymer-based materials are not in general as high as those of crystalline solid electrolytes but they may be made into thin, pinhole-free plastic sheets with good enough conductance for use in cells and batteries. Equally important is that the plasticity of the polymers overcomes the other big problem of solid-state battery systems, namely how to maintain good contact between faces.

Harwell staff have concentrated over the last four years on developing the technology for making the polymer-electrolyte plastic battery, and have built and tested cells. Techniques for continuous production of the electrolyte and cathode components in the form of thin films have been developed and their dimensions can be scaled-up when required. The thickness of a complete cell is only one or two hundredths of an inch (one-quarter to one-half of a millimetre) and there are prospects of making even thinner cells. There are close similarities between the structure and fabrication technology of the battery and many products outside the traditional battery industry, including printed and packaging materials and photographic film.

It has been shown that in laboratory-scale cells, operating at around 120°C, there is a high utilization of the active cell materials at discharge rates of a few hours and with lives of over 100 deep discharge cycles. Larger cells, of up to 500 cm^2 area, and series-connected multi-cell stacks have also been successfully made and tested. From these results we predict usable-energy densities for solid-state traction batteries that would make them one-fifth of the weight and one-third of the size of lead-acid batteries now in service.

Temperature range

At present the cells, which are poly(ethylene oxide)-based, operate most effectively at 100°C or just above, so they are quite suitable in that respect for vehicle traction service and for use in satellites. Earliest specialist applications may also be found where the environment is hostile with temperatures of up to 150°C, a region where most conventional batteries fail. They may include down-hole instrumentation in the solid industry and certain standby power sources. Furthermore, lower-temperature performances can be achieved with existing materials and cells when the power requirements are low, as for many microelectronic jobs.

One attractive possibility in this field is the integration of the battery with the circuit it powers: the thin-film planar technology is compatible with conventional printed circuit board and hybrid electronic circuitry. For example, the technology lends itself to the development of a self-powered intelligent credit card incorporating a microprocessor.

But for many other prospective uses, operation at room temperature and below is required. At high power levels, this will mean developing new cell materials, especially new polymer electrolytes. Work is now going on in many countries and a research and development program here is being sponsored by an industrial group or 'club' of battery users, manufacturers and materials specialists. Supported by the DTI, Harwell's Solid-State Battery Working Party aims to provide the basic technology to make all-solid-state lithium batteries based on polymeric electrolytes, for as many applications as possible. Studies will concentrate at first on developing better electrolytes but expand as membership of the group grows.

Success in this area will open up many new uses in the military, industrial and domestic sectors. It might well lead to 'cordless' vacuum cleaners, lawnmowers and power tools, to new flashlights, toys and electronics equipment.

The idea of batteries based on an all-solid-state polymer electrolyte perhaps using various materials and construction technologies for different applications, holds out one of the most versatile and exciting prospects for battery development this century. ●

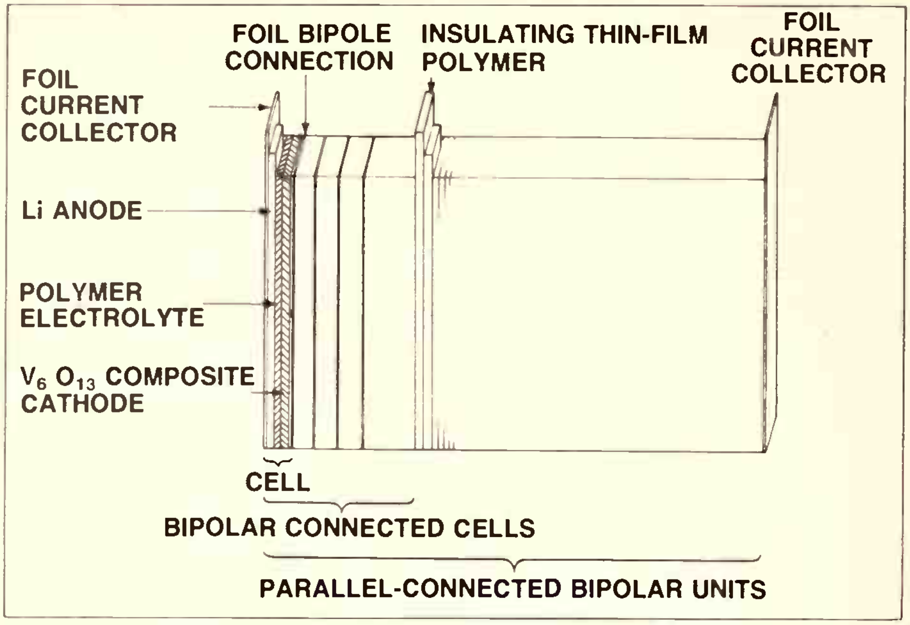
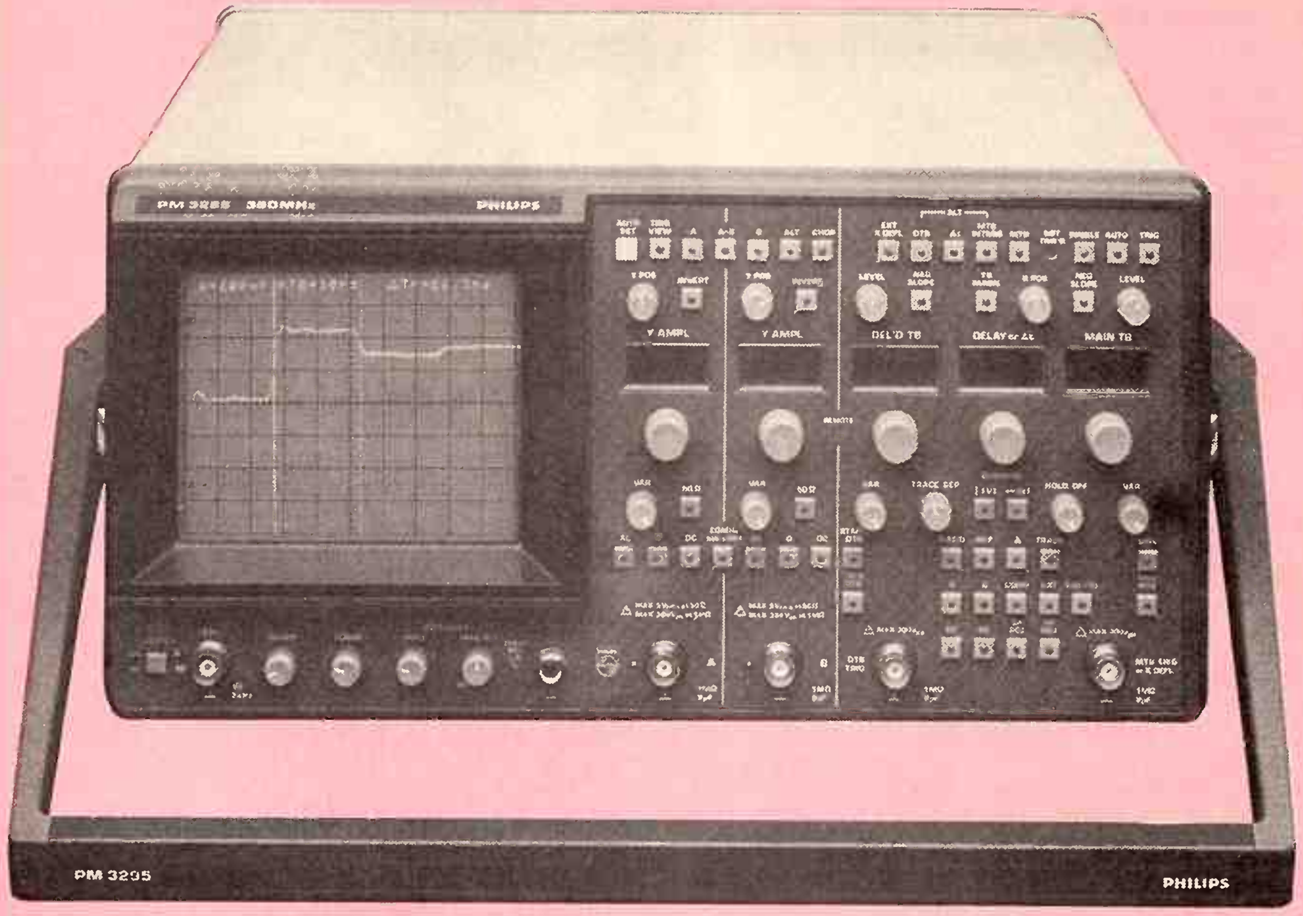


Figure 3. Basic assembly units of series-connected units to form a traction battery module.



Philip's 350 MHz PM3295.

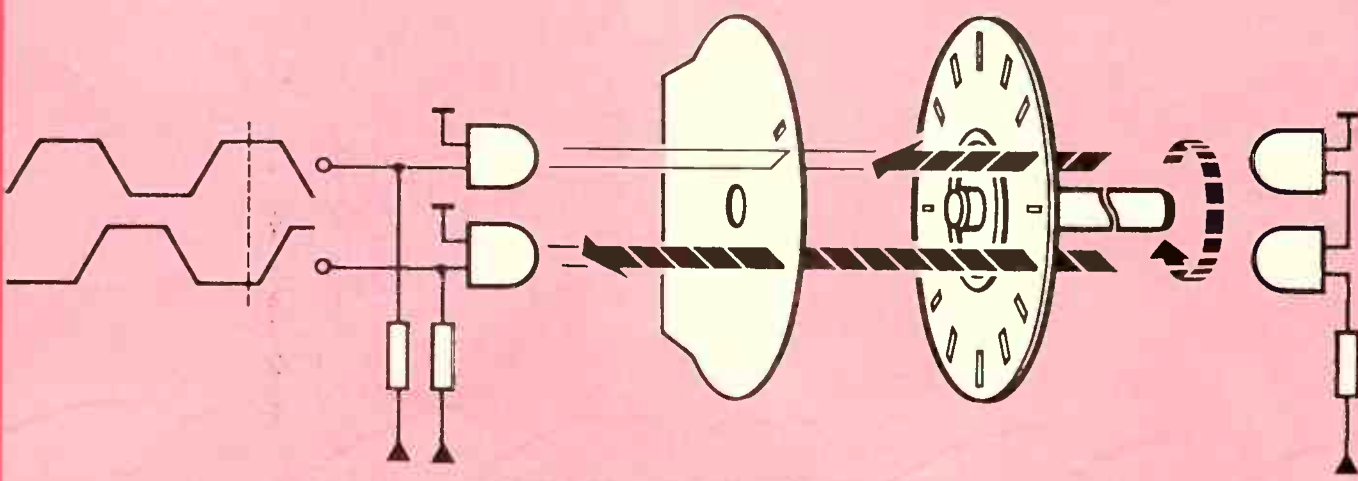


Figure 1. Schematic of rotary switch circuitry.

HIGH FREQUENCY OSCILLOSCOPE DESIGN: EVOLUTION OR REVOLUTION?

The demand for ever higher frequencies and the growing use of test instruments in automatic and semi-automatic test set-ups has led to a striking change in oscilloscope design. While the increasing degree of circuit integration has led to the evolution of the modern compact high frequency oscilloscope, a revolution has taken place in methods of operation, control and display.

Gerard Imbens

Gerard Imbens is with Philips Test & Measurement, Eindhoven, The Netherlands.

A VHF oscilloscope — one operating over 350 MHz — is by its very nature an exceedingly complex animal. It has been up to the instrument maker to ensure that its sophistication is not a barrier to easy and fast signal measurement.

The sometimes conflicting requirements of manual and systems operation require careful attention to ensure that the user remains in full control of the instrument at all times, and is not left in the dark about settings when switching between local and remote control.

New approaches to measurement

The microprocessor has become almost an established part of modern instrument design. But the use of microprocessors to simplify control is a drawback in increasing instrument speed.

However, the microprocessor is ideal for simplifying front panel control. Combined with pushbutton switches, digitized commands from rotary controls and LCD or LED displays enables front panel design to be kept very simple while providing the maximum of information to the user.

Taking measurement simplification one step further, provision of on-screen information — such as timebase settings and attenuation factors — allows the operator to take in signal information at a glance.

The increasing use of cursors for voltage and time provides a new approach to oscilloscope measurement. Preferably cursor operation should be as simple as possible. Direct digital display of time and voltage differences can now be provided on the CRT display, using the microprocessor to calculate readings by combining control settings with cursor positions.

Voltage and time reference measurements are also no longer restricted to set positions on the oscilloscope screen — either to fixed markers or to preset numbers of divisions. Freely selectable cursors can be set to any part of a signal and this measurement used as a base for calculating the relative sizes of other signal details.

Another area of front panel control where the microprocessor can play an important role is in providing an autoset facility. As most if not all front panel controls in the oscilloscope are now digitized, it is relatively simple to provide optimum settings whenever required.

Such a procedure would start by determining the correct vertical sensitivity to adapt the signal to the screen size, then select a suitable triggerable signal and set the timebase to give a couple of periods of the signal on the screen. Other controls could also be set to make the signal clearer; for example, selecting chopped mode if the timebase is 500 µs/div or lower.

The result of such an autoset operation is not necessarily perfection, but it can be good enough to put the user within a step or two of the desired result.

Integrating test systems

There is an increasing demand for the full integration of oscilloscopes into semi-automatic testing systems. Many test situations now rely on central control and remote analysis of the resulting data.

Automatic and semi-automatic test systems offer many advantages, not least the possibility of more thorough testing. Remote analysis of results allows a very much more complete examination of circuit or machine performance than is possible with conventional manual methods.

At first sight, the analogue oscilloscope does not appear to fit comfortably into this type of situation. Many oscilloscope measurements need a combination of knob 'twiddling' and operator discrimination. It is difficult to imagine a remote computer 'reading' a signal to locate overshoot or an unexpected glitch. It is therefore necessary to combine local and remote operation in the same oscilloscope. The computer ▶

would, for example, select the basic instrument settings, stimulate the device under test and then switch to local control to allow the instrument operator to use discrimination in carrying out the measurements.

Once all the final settings are made, the user would make an SRQ — service request — to the central computer which would switch back to remote control and read the settings and measured information directly for subsequent analysis.

Building on bus control

The IEEE instrument bus offers a useful standardized method of interfacing such instruments. However, for an oscilloscope to obtain the maximum benefit from such operation, it should be designed fully around the IEEE bus. The major requirement is to keep the local user fully informed on instrument settings so that when switching back to local controls the settings have a real meaning.

To achieve this again means taking maximum advantage of microprocessor control.

Use of LEDs for the indication of all pushbutton selections is a first step. Reducing the number of rotary switches for timebase setting and attenuation also helps. The most important step, however, is to make the mechanical position of knobs and switches independent of their electrical position.

The real complication comes from the rotary potentiometers used for level settings. Here it is necessary to provide some form of digitization circuitry which can be read remotely (see Figure 1). One solution is to have a series of track-and-hold circuits, one for each potentiometer.

Improving signal handling

Of course, work with VHF signals not only requires new approaches to measurement and operation but also to signal handling. A first step is to keep 'hot' high frequency signals away from front panel controls, developing extensive applications of cold switching with the incoming signal staying on the relevant pc board.

Not that VHF problems are trivial even then. Extensive use of multilayer boards offers one way of dealing with such problems. By incorporating earth planes in the pc board structure itself, it is relatively simple to provide matched 50-ohm striplines. And by having several layers in the pcb, it is even possible to cross over VHF signals on the same board while keeping the 50-ohm stripline approach. This is necessary on the trigger selection boards, for example, where either input channel should be available for triggering.

Signal paths also have to be kept to a minimum for VHF signals. This can be handled using integrated circuits. Ideally, for economic reasons, standard ICs should be used where possible: custom ICs are expensive — and can take a long time, relatively speaking, to be developed.

One method of combining standard ICs and other components in the smallest possible space compatible with VHF signal handling is by the use of thin film circuits with SMDs. Surface mounted devices are rapidly gaining an important share of the high frequency circuit market because of the very short circuit connections possible.

Mounting SMDs in thin film circuits makes it relatively simple to combine ICs with discrete components such as capacitors and laser trimmed resistors. The resulting parts can be developed in much less time than a custom IC, offer good VHF signal handling properties and can be made to tight tolerances.

Displaying bright signals

However good the circuitry, it is the CRT which provides the most striking measure of the VHF oscilloscope's performance. To obtain the maximum from a tube requires a new approach to design to overcome the limitations of conventional CRTs due to the power requirements of normal deflection systems.

An economic solution to the problem is provided by the travelling wave deflection tube. Not only are power requirements of this approach less than with conventional post-deflection acceleration tubes — so reducing the dissipation in the final amplifier — but it also provides a very much brighter image.

Some compromise is inevitable in tube design between light output and sensitivity. For a VHF oscilloscope, it is the maximum writing speed which is important; increasing final amplifier power will compensate for any loss in sensitivity.

The travelling wave deflection system makes it possible to match the signal speed with that of the electron through the structure. If this was not done the signal could change while the displaying electron was still passing, leading to distortion on the screen.

If there is a 3 kV acceleration voltage between the gun and the deflection system, the electron beam is travelling at only 10 per cent of the signal speed. Therefore the deflection signal path has to be increased to 10 times that of the electron.

A couple of methods exist for this: the meander line and the helical structure. While the latter is more difficult to make, it offers a much higher impedance and so is easier to drive. And by making a balanced structure, impedance can be increased even further — the higher the impedance, the better the performance of the structure. ●

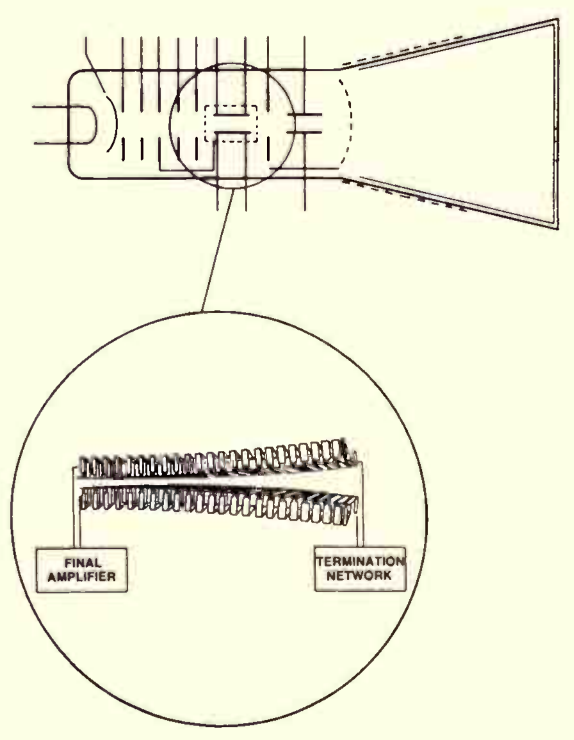


Figure 2. Diagram of travelling wave tube with deflection section.

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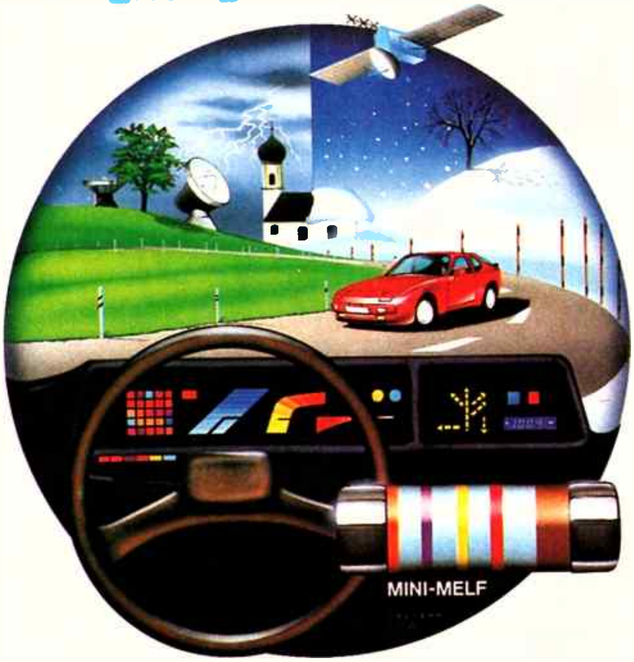

BEYSCHLAG Metal Film Resistors »Harmonic Series«

Version	Temperature Coefficient	Tolerance
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PRECISION	TC 25 – 15	0,25 % – 0,1 %
Style	**Rated Dissipation P70**	**Resistance Range**
MBA 0204 - BX	0,4 Watts	0,22 Ω – 10 MΩ
MBB 0207 - BX	0,6 Watts	0,22 Ω – 10 MΩ
MBE 0414 - BX	1 Watt	0,22 Ω – 22 MΩ

IEC Series

E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192	E 24	E 96	E 192
10	100	100		147	147		215	215		316	316		464	464	68	681	681
		101			149			218			320	47		470			690
	102	102	15	150	150	22	221	221		324	324		475	475		698	698
		104			152			223	33		328			481			706
	105	105		154	154		226	226		332	332		487	487		715	715
		106			156			229			336			493			723
	107	107		158	158		232	232		340	340		499	499		732	732
		109	16		160			234			344			505			741
11	110	110		162	162		237	237		348	348	51	511	511	75	750	750
		111			164	24		240			352			517			759
	113	113		165	165		243	243		357	357		523	523		768	768
		114			167			246	36		361			530			777
	115	115		169	169		249	249		365	365		536	536		787	787
		117			172			252			370			542			796
	118	118		174	174		255	255		374	374		549	549		806	806
12		120			176			258			379			556	82		816
	121	121		178	178		261	261		383	383	56	562	562		825	825
		123	18		180			264	39		388			569			835
	124	124		182	182		267	267		392	392		576	576		845	845
		126			184	27		271			397			583			856
	127	127		187	187		274	274		402	402		590	590		866	866
		129			189			277			407			597			876
13	130	130		191	191		280	280		412	412		604	604		887	887
		132			193			284			417			612			898
	133	133		196	196		287	287		422	422	62	619	619	91	909	909
		135			198			291			427			626			920
	137	137	20	200	200		294	294	43	432	432		634	634		931	931
		138			203			298			437			642			942
	140	140		205	205	30	301	301		442	442		649	649		953	953
		142			208			305			448			657			965
	143	143		210	210		309	309		453	453		665	665		976	976
		145			213			312			459			673			988

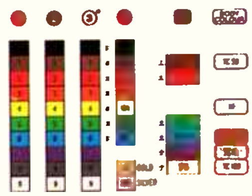
RANGE OF VALUES 0 OHM – 10 MOHMS TEMPERATURE COEFFICIENTS TC 15 – TC 100 TOLERANCES 0.1% – 5%

Colour coding for Beyschlag Mini-Melf – as is usual for resistors with leads – with 4 or 5 colour bands for resistance value and tolerance

* is not used for 4 band coding

EXAMPLE 37.4 KOHM ± 1% TC 50

BEYSCHLAG GmbH P.O. Box 1220 D-2240 Heide
Telephone 481-950 Telex 28801 Telefax 481-95209



Metal Film Resistors »Harmonic Series« STANDARD	light green
Metal Film Resistors »Harmonic Series« PROFESSIONAL	light blue
Metal Film Resistors »Harmonic Series« PRECISION	light blue
Carbon Film Resistors STANDARD	ruby-red

Colour coding according to IEC Publication 62 and DIN 41 429

band 1	band 2	band 3	band 4
0	0	x 1	
1	1	x 10	
2	2	x 100	± 2 %
3	3	x 1 k	
4	4	x 10 k	
5	5	x 100 k	
6	6	x 1 M	
7	7		
8	8	: 10	± 5 %
9	9	: 100	

Example:

red - violet - orange - gold = 27 k Ω ± 5 % TC 100

band 1	band 2	band 3	band 4	band 5	colour dot
0	0	0	x 1		
1	1	1	x 10	± 1 %	
2	2	2	x 100	± 2 %	
3	3	3	x 1 k		TC 15
4	4	4	x 10 k		TC 25
5	5	5	x 100 k	± 0,5 %	
6	6	6	x 1 M	± 0,25 %	
7	7	7		± 0,1 %	
8	8	8	: 10		
9	9	9	: 100		

Example:

red - violet - yellow - red - brown = 27,4 k Ω ± 1 % TC 50

A cut out and keep Resistor colour coding chart from Crusader Electronics

CRUSADER ELECTRONIC COMPONENTS PTY. LTD.

81 Princes Highway, St Peters NSW 2044. Phone (02) 519 5030, 516 3855, 519 6685. Telex AA23993 Code: CRUSAD Distributors: **Sydney** George Brown & Co. Pty. Ltd. Phone 519 5855; Geoff Wood Electronics Pty Ltd 810 6845. **Wollongong** Macelec Pty. Ltd. Phone 29 1455. **Canberra** George Brown & Co. Pty. Ltd. Phone 80 4355. **Newcastle** D.G.E. Systems Pty. Ltd. Phone 69 1625. **Melbourne** R.P.G. Agencies Pty. Ltd. Phone 439 5834; Jesec Components Pty. Ltd. Phone 598 2333; Rosnik Distributors Pty. Ltd. 720 3370. George Brown & Co Pty. Ltd. Phone 419 3355. **Brisbane** L. E. Boughen & Co. Phone 369 1277; Colourview Wholesale Pty. Ltd. Phone 275 3188. **Adelaide** Protronics Pty. Ltd. Phone 212 3111; D. C. Electroics Pty. Ltd. Phone 223 6946. **Perth** Simon Holman & Co. Pty. Ltd. Phone 381 4155; Protronics Pty. Ltd. Phone 362 1044.

REDESIGNING THOUGHT

Human limitations of memory, reasoning and communication place restrictions on the accuracy of our thinking. An answer of the future is to supplement our thought processes with artificial intelligence.

Harry Tennant

Harry Tennant works on AI at the Computer Sciences Laboratory of Texas Instruments in Austin, Texas.

Artificial intelligence (AI) is the task of engineering a technology of thought. Our first inclination is to emulate human thought. We can observe people thinking and the results of their thinking. We can theorize on the actual process of thought, implement the theories on computers and thereby hope to build computers that think. Although the understanding of human thought can be useful, the goal of AI is to build a useful technology of thought (or a collection of technologies), regardless of the similarity it has with human thought.

The design of passenger jets, helicopters, and hang gliders resulted from an inspiration for duplicating the flight of birds. It was useful to understand how lift, drag, weight reduction and propulsion worked for birds, but the technology of flight we use today has diverged considerably from nature's solutions. The artificial solutions can carry more cargo at greater speeds over longer distances than nature's fliers can. Starting from the example of birds, we have redesigned flight into a technology that better suits our needs and better utilizes our existing technologies.

Work on artificial intelligence has started from examples of human thought. The discipline is just beginning to show tangible results, but we can see the process of the redesign of thought already in progress.

Although they fall far short of human capability in generality, we see knowledge-based systems that exceed the performance of human experts within limited domains. We can also see many opportunities to improve on nature's design of intelligence. We will consider three: memory, reasoning, and communication.

An important aspect of human intelligence is memory. Reflection on memory reveals plenty of room for redesign. Our memory, while prodigious and impressive in many ways, has some major design problems. Why is it that when I go to the grocery store with more than two or three things to buy, I inevitably forget some of them? Why is the capacity so low? Why not two or three thousand items instead? Psychologists have suggested that forgetting is important so that our minds are not cluttered with the irrelevant. My grocery store distress is just an unfortunate by-product of a necessary function. But forgetting is not necessary for effective thought — all those memories need to be properly organized but they don't need to be forgotten. Forgetting is only necessary if memory capacity is full.

> ***"A technology of thought stands a much better chance of being based on correct knowledge than human thought."***

Jack Meyers, the physician whose knowledge of internal medicine has been captured in the Caduceus expert system, has reported that Caduceus knows all that he has known about internal medicine over a five-year development period. The difference is that Meyers learned it when it was needed and forgot it when it wasn't. Caduceus ended that period with an accumulation of all the knowledge.

There seems to be a scheme for memory compression which we use that is something like "don't remember what you can infer". If it worked reliably it would be a fine scheme. The problem is that it seems to work so poorly. Of course, the only time we are aware of its existence is when it fails, but that seems uncomfortably often. I visited Trafalgar Square recently. I was excited about seeing again what I had seen 16 years before. I had a vivid memory of it, but despite its vividness, it only corresponded roughly to the reality of Trafalgar Square. This memory was entirely unreliable — not only was it wrong, but its vividness (evidently a fabrication) convinced me of its accuracy.

One of the reasons that writing, libraries, photographs, movies and audio tapes are so useful to us is that they help to get around this serious bug in our mind design — flaky memory. One of the reasons that AI systems will be useful in the future is that they will be able to remember more in quantity and greater quality for specific applications than human memory does. One of the reasons that the character of Sherlock Holmes was able to solve crimes better than others was that he could better remember facts the significance of which were evident only well after they were discovered. We can expect computer-based deduction to share Holmes' advantage because it will be designed to do so.

Paper is a marvellously reliable form of external memory. When I file an article in a ▶

filing cabinet, I am certain to get it back unchanged when I retrieve it. When I file 10 papers, I can get back exactly those 10 papers.

When I read a paper, I don't recall the whole thing, only a few ideas from it. But when I read 10 papers on related subjects, I can get back more. The mind draws associations, inferences and can link concepts from one to examples from another. One paper can present a new point of view which allows one to interpret the material in all the others. This is valuable, but would be a lot more useful if it could be combined with recall of the specific facts, numbers, statements and chains of inference that have led to new conclusions and new insights.

At the present state of AI technology, the redesign of thought, we are not particularly good at drawing associations and linking concepts automatically. This capability is critical for supporting human thought and for knowledge-based systems in domains where the knowledge changes rapidly. There is a useful technology of inference, however, that reveals what knowledge and facts were used to come to a conclusion. Rule-based expert systems provide audit trails of inference chains through pieces of knowledge back to the facts on which a decision was based. This makes the conclusions more convincing and helps to make disagreement more specific.

> *One of the reasons that AI systems will be useful in the future is that they will be able to remember more in quantity and greater quality for specific applications than human memory does.*

Just as we have limitations on our short-term memory, we also are limited by the number of facts that can be brought to bear on a decision. The Prospector expert system for locating mineral deposits found a very valuable deposit that had been repeatedly overlooked by the human experts. The reason — the program was able to methodically examine more possibilities.

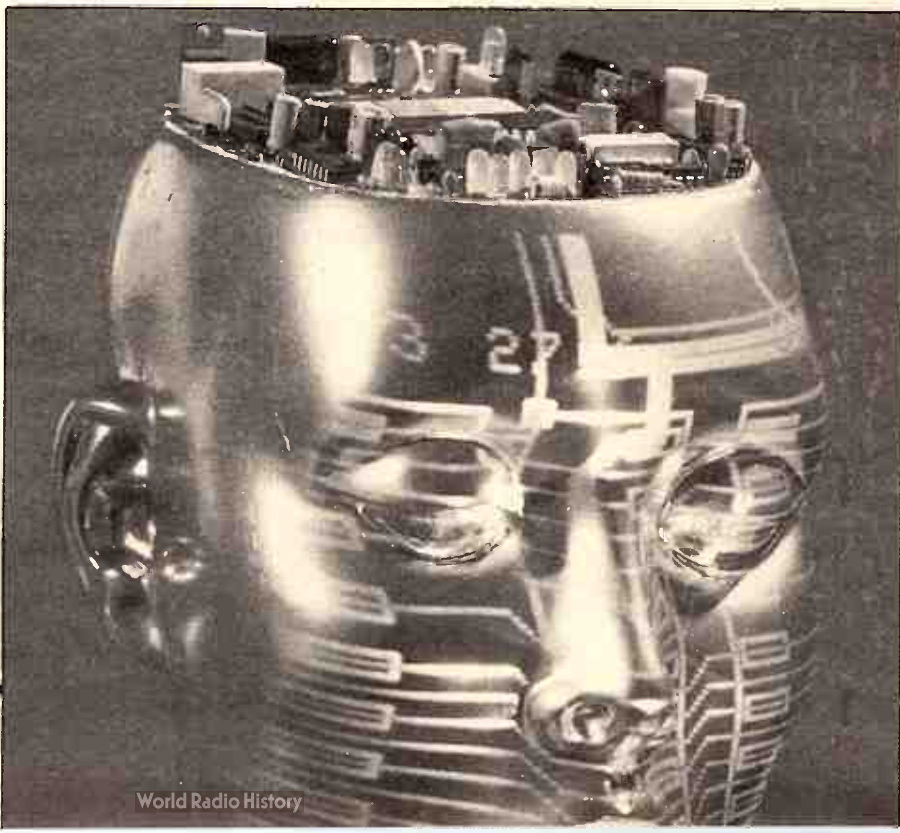
We humans sometimes have difficulty in applying our knowledge. We can get bored or distracted from the task. We say our minds wander; we do not continue a thought task through to completion. As we redesign thought in AI technology, we will no doubt eliminate the possibility of distraction from an important thought task. We humans tend to have several things on our minds. We think about our professional problems but also what we will have for dinner, how we will pay for our children's orthodontia or how to deal with an upset spouse. We will engineer such distractions out of our thought technology.

An expert system developed by Southwestern Bell for checking telephone cables for problems can analyze vast amounts of data describing phone system operation far more quickly than could a human counterpart. The biggest difference between the diagnostic process for a person or a machine is that the oppressive monotony of the task is not a factor for the machine.

Another problem that our natural intelligence has when applying knowledge is that we readily get confused and befuddled. We don't seem to be able to step through very long chains of reasoning or consider very many alternatives before the task overwhelms us. In gathering the knowledge for expert systems, one rarely finds inference chains of more than about five links. A highly knowledgeable expert can construct a large number of these short chains of reasoning but does not construct longer chains. In our redesign of thought, there seems to be no inherent reason why chains of inference need to be short. Our current knowledge-based system technology can construct inference chains of arbitrary length without any signs of befuddlement if given the knowledge to do so.

Reasoning, the process of thought, is the application of knowledge. If the knowledge is incorrect or insufficient, the resulting decisions and judgments will be flawed. This is true of any thought, natural or artificial.

A technology of thought stands a much better chance of being based on correct knowledge than human thought, it seems to me. When we humans add to our knowledge, it is generally through a slow, laborious, repetitive process. The process is characterized by acquiring some knowledge, forgetting some of it, getting some of it wrong, acquiring it again, correcting misconceptions and so on. We call the process 'learning'. A far more efficient method of knowledge acquisition is programming — directly installing knowledge. Any programmer who has children will recognize the advantages of programming over learning. When my children misbehave, I often wish that I could get into their heads to manipulate the knowledge directly, both to see clearly what is causing the 'bug' and to repair the knowledge, if necessary. But alas, they must acquire knowledge like "don't pinch your brother while we're in the car", "be aware of thoughtful gestures and say



thank you", "sharp sticks could spoke someone's eye out" and "if you tip your glass while drinking from a straw, it will spill all over you"; they acquire this knowledge by 'learning' it, requiring trial after trial after trial after . . .

On the other hand, human minds have the advantage that they don't 'crash' if a teacher makes an error when giving new knowledge. It is very attractive to duplicate that sort of robustness in the redesign of thought — but certainly not at the cost of the plodding inefficiency that characterizes much of human learning.

> *Another problem that our natural intelligence has when applying knowledge is that we readily get confused and befuddled. We don't seem to be able to step through very long chains of reasoning or consider very many alternatives before the task overwhelms us.*

The opportunity to program computers exists because we have direct access to the knowledge they use. That is not the case with humans. Direct access to knowledge in the redesign of thought means that communication can be handled differently, more effectively. If disagreements or misunderstandings occur, it may be possible to examine the knowledge of the two (assuming they are both artificial) directly to identify with precision where concepts, priorities, or goals differ. We are bound to be able to redesign thought in such a way as to make this more effective than the way humans communicate and miscommunicate. Human communication is often inarticulate and laden with reactions to feelings of social position, etc, which may have no direct relevance to the message.

I mention programming but do not mean to imply that programming will be unchanged. Computer programs that think are quite different from what we have programmed in the past. Our programming tools will be quite different, and we are already seeing this. The programming tools on LISP machines, widely used for AI programming, are oriented towards flexible manipulation of detailed and extensible data structures. They are oriented towards exploration and incremental development. They will continue to evolve, perhaps in the direction (among others) of robust systems, ensuring that incremental development will not cause catastrophic 'crashes'.

It is these programming tools and a new understanding of techniques of programming that has enabled the AI systems we have seen emerge to date. New tools and deeper understanding of the programming problem will drive future advances.

From the emerging technology of AI, our redesign of thought, we can expect to see a number of benefits. We extol the benefits of applying knowledge when we require good educations for our children and recognize the need to keep abreast of the developments in one's field. A technology of thought will amplify an individual's effectiveness by making expertise available to him that he would not otherwise have. But the same benefits of increased effectiveness can be had without AI — for centuries we have improved our individual effectiveness by relying on the knowledge and expertise of others. If this were the sole benefit of AI, then the argument would be one of economics: is it more cost-effective to use AI systems than human counterparts? It seems clear that with the low and falling price of computation and with the inexpensive distribution of software either electronically or on magnetic and optical media, economics is on the side of AI systems.

More important than the economic considerations are the opportunities for improvement in the redesign of thought. AI will bring us knowledge-based applications that humans simply cannot duplicate due to limitations of memory, reasoning and communication. We can expect reasoning in technical domains that is to our current knowledge-workers as current payroll and accounting programs are to the Cratchet-like clerks of the past. We can expect the redesign of thought to result in a variety of systems as different as the power of a jumbo jet is from the sleek speed and manoeuverability of a jet fighter, which are both very different from the silent elegance of a hang glider and the improbable utility of a helicopter. We can expect a lot from the redesign of thought and we are beginning to see it today. ●

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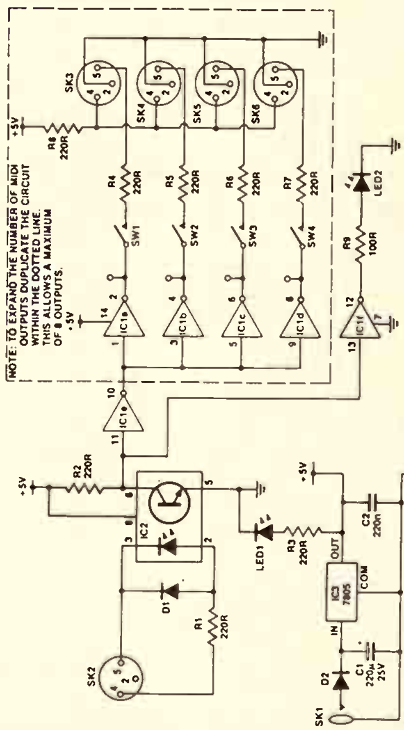

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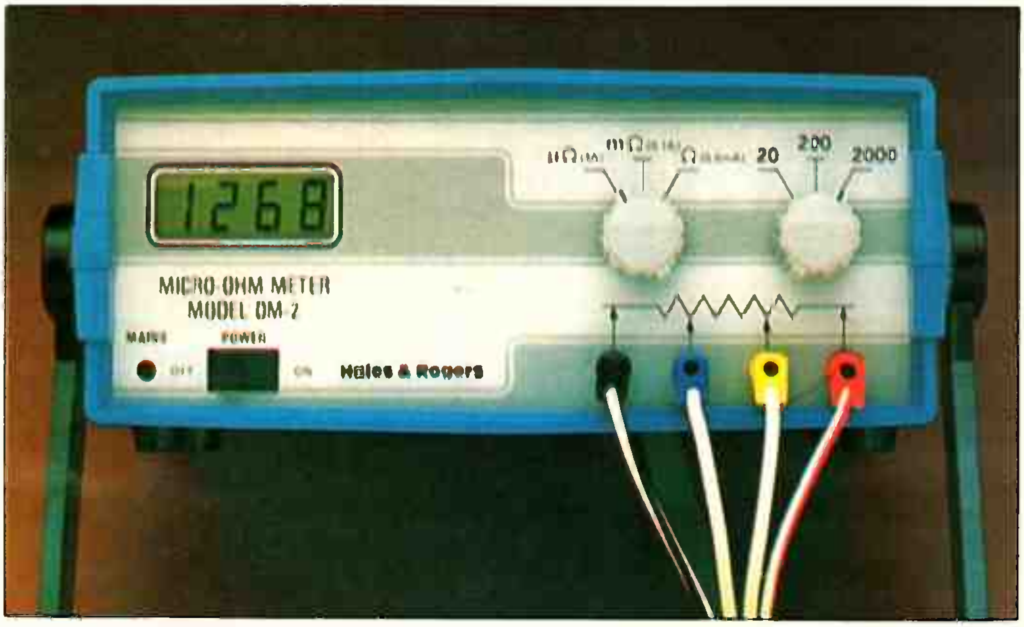
Local DMM

Sydney-based Hales and Rogers is claiming export success for its DM2 micro-ohmmeter. This follows acceptance of the DM2 by the US Navy and extensive use within NASA.

The DM2 offers 3.5 digit resolution with a range of 199.9 micro-ohms to 1999 ohms full scale. It's claimed to be ideal for measuring earthing system resistance in medical equipment, switch and circuit breaker contact resistance, for quality control and non-destructive testing of fuse links and many other vital applictions.

The DM2 is available for $1795 including test leads.

For further information contact **Robert Russell** on **(02)858-5322.**



TV testing

Over 70 different patterns are available for comprehensive testing of monochrome and colour televisions, video recorders and monitors in two new economic, compact and easy-to-use test pattern generators: the PM5514 and PM5514V from Philips Test & Measurement. A front panel keyboard speeds pattern selection on both instruments. LEDs next to each key show the pattern or combination selected.

The PM5514 provides basic rf facilities for checking and alignment of consumer receiver and recording equipment. Simple coarse/fine tuning with a 16-point analogue bar graph indicator allows selection of VHF or UHF signals from 175 to 275 MHz or from 525 to 810 MHz. And there is also a separate video output. Internal 1 kHz or external sound modulation is switch-selectable.

The PM5514V meets the specific needs of video testing such as for computer and CCTV monitors, providing a variable 0 to 1.5 V or fixed 1 V composite video output signal. An RGB option providing red, green and blue signals with separate sync and subcarrier allows servicing of those monitors which will not accept composite video signals.

A choice of models in the PM5514 is available to meet PAL television standards B, G, H, I or D. The PM5514V is supplied in versions meeting these or NTSC M standards. Chroma subcarrier, line and field frequency in the PM5514V match the TV standard chosen.

Waveform analysis from Tektronix

A new range of oscilloscopes from Tektronix features bandwidths up to 1 GHz, 10-14 bit resolution, and up to 12 input channels. It also includes a user interface that simplifies oscilloscope operation and waveform analysis with touch screen control, interactive menus and intelligent functions.

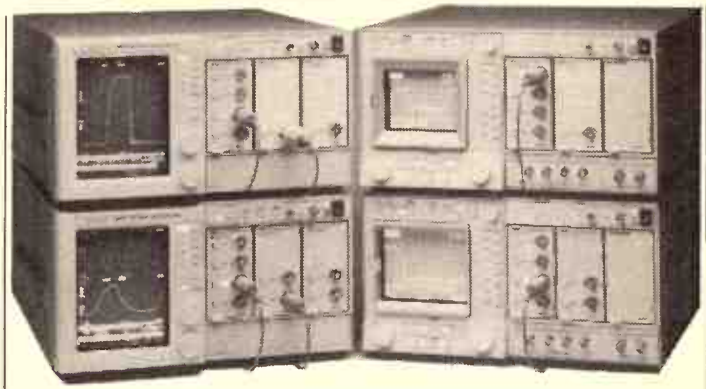
The new user interface is incorporated into the 11000 series product line, comprizing two new digitizing and two analogue oscilloscopes. They are the 1 GHz 11402 digitizing scope, the 500 MHz 11401 digitizing scope, both with 10-14 bit resolution; the 500 MHz 11302 programmable analogue scope with micro-channel plate CRT; and the 400 MHz 11301 programmable analogue scope. These latter two are both with built-in full function counter-timers.

In addition, five new interchangeable plug-in modules have been released, allowing the engineer to configure the required measurement system by using any of the modules, with any of the mainframes.

The modules are the 11A32 dual channel vertical amplifier with switchable 50Ω/1MΩ impedance, 11A52 dual channel amplifier with 50 Ω impedance and the 11A71 1 GHz single channel amplifier.

Controls on the 11000 series are grouped on or near the infrared touch-screen, allowing engineers to focus their attention on the display.

Users are guided into the touch-screen controls system via major menu keys beside the screen. The major menus include waveform, trigger, measure, store/recall and utility. Once inside a menu, operators carry out measurement functions with screen control and user-assignable knobs. Functions for the knobs include settings, sweep rate, vertical sensitivity, trace



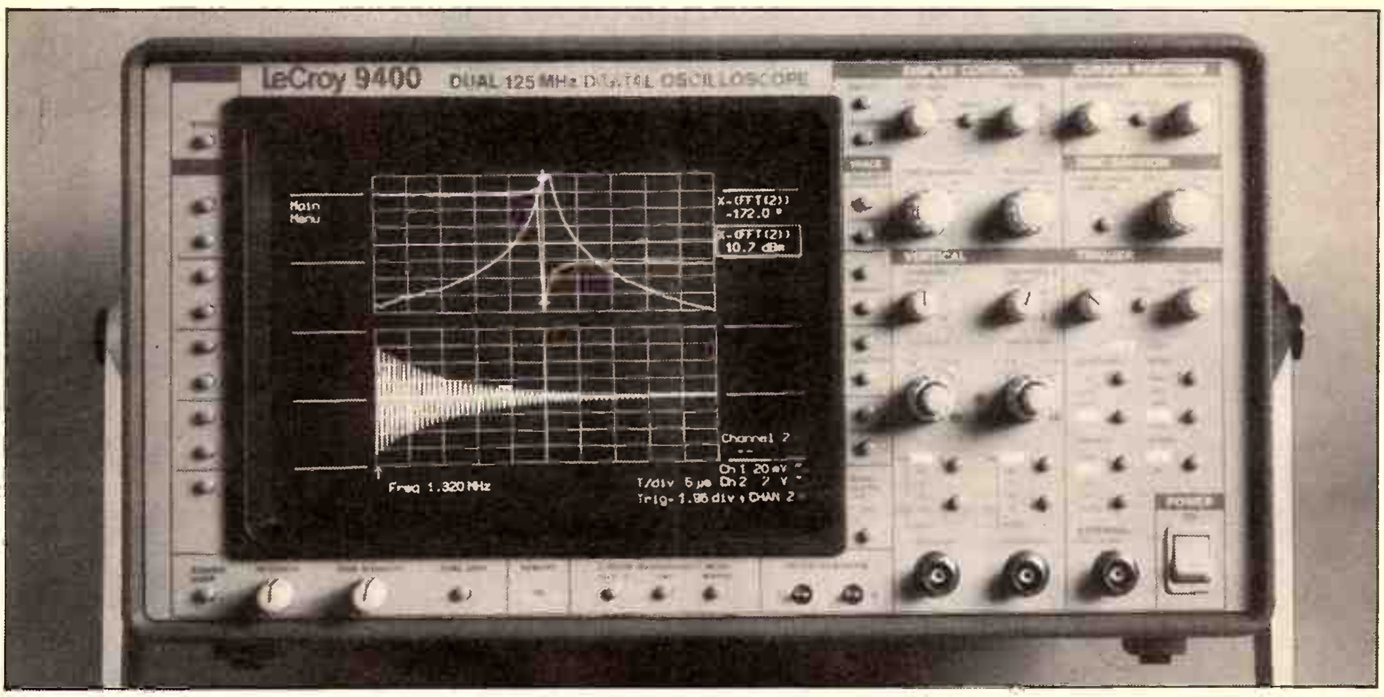
positions and offset, and triggering level.

The 11300 series programmable analogue oscilloscopes are equipped with a built-in 500 MHz counter-timer that greatly simplifies difficult measurements. The counter-view trace allows the engineer to see exactly what portion of the waveform is being measured by the counter-timer.

Waveforms are automatically displayed on the new 11000 series oscilloscopes by applying the probe to the signal source and pressing the autoset button. The displayed signal is then easily adjusted for the proper measurement.

Both digitizing and analogue oscilloscopes can display up to eight traces simultaneously. This is particularly of interest to digital designers who need to compare many channels of data at once.

For further information contact **Tektronix, 80 Waterloo Rd, North Sydney, NSW 2113. (02)888-7066.**



ETP Oxford has just released an FFT spectrum analysis package for the LeCroy 9400 digital oscilloscope. The screen shows a logarithmic amplitude against phase transform of the bottom trace, a 50 µs damped sine wave.

Gauss/Tesla meter

Elmeasco has released the FW Bell model 4048 handheld digital Gauss/Tesla meter.

The unit measures magnetic field from 0.1 G (10 mT) to 20 kG (2 T) in three ranges, using a Hall-effect probe as the sensor. A special custom-formatted LCD provides a large readout of field strength, plus all other information relative to the reading and to instrument function and battery condition.

The 4048 features auto or manual range switching, instant one-button probe zeroing, dc and true rms ac response to 12 kHz, peak hold and scale suppression.

Accuracy is quoted as ±2% of reading on dc, including probe and ±2½% on ac up to 100 Hz.

Applications include relay and solenoid testing, education, pipe weld inspection, loudspeaker magnet checking, dc and ac motor testing, and, of course, classifying and sorting of magnets.

Digitizers

Two new digitizers from GTCO Corporation are claimed to set new performance/size standards by providing the most powerful operation combined with the smallest footprints available in the current electromagnetic digitizer market.

Marketed in Australia by the TCG group, the new Digi-Pad 1111A and 1117A incorporate a new controller, new grids, and new enclosures.

They are designed for use with a wide range of accessories, including stylus, pressure pen, 4D input, and 1-, 4-, 5- and 16-button cursors.

Both have a dual RS232C interface plus current loop, serial TTL and optional GPIB interfaces. They can digitize through non-metallic material up to 1 inch in thickness with 0.001 inch resolution (11,000 x 11,000, or 11,000 x 17,000 points).

The new models are said to have the world's most complete diagnostics. Virtually every component right down to individual grid lines is automatically tested on power-up. Self-tests are performed with an internal four-tone alarm which eliminates the need for user-supplied test equipment. They are compatible with most software and hardware from AutoCAD to VAX.

For more information, contact **Mike Barraclough** at **TCG** on **(02)699-8300.**

B&K stereo imaging

Brüel & Kjær's new stereo microphone sets 3529 and 3530 consist of two matched pairs of omni microphones for 'spaced apart' (A-B) stereo recording.

The stereo image which is gained by this recording method depends on close matching of the individual microphones for sensitivity, time and frequency response.

B&K claims the best possible stereo image has been ensured by matching the microphones to within 1 dB in amplitude response over the entire frequency range 20 Hz to 20 kHz and within 10° in phase over the range 50 Hz to 20 kHz.

The method of powering the microphones differs. Type 3529 is intended for use with B&K's own power supply Type 2812 (included with the set), which gives a transformerless high level output. Type 3530 utilizes standard P48 Phantom systems.

In addition to standard accessories such as cable clips, windscreens, and a sonically designed mounting boom, the 3529/30 sets include two additional types of protection grid which allow the frequency response of the microphone to be tailored to individual recording needs.

New CV meter

Keithley Instruments has introduced in the Model 595 quasistatic CV meter, an instrument that uses a new method for making quasistatic capacitance versus voltage (CV) measurements in semiconductors.

It's the first of a new line of CV meters to be introduced by Keithley's instrument division. According to the makers, it uses the new technique to provide more complete data than instruments using a ramp voltage. It can distinguish between displacement and leakage (or resistive) currents, and it can determine the timing parameters needed to assure equilibrium more quickly by taking measurements at a single bias voltage point.

The 595 uses a new 'feedback charge method' that applies a stepped voltage across an unknown capacitor, causing a change in charge. The change is measured by a feedback charge circuit, consisting of a sensitive amplifier and a precision feedback capacitor. This is said to have several advantages. Firstly, ramp measurement methods lose sensitivity at slower ramp rates. But slower rates are becoming more important as semiconductor production processes improve, increasing minority carrier lifetime. The feedback charge method eliminates this weakness, since its signal-to-noise ratio is not dependent on the rate of voltage change.

Secondly, the 595's feedback charge method can determine whether the current observed is a capacitive current, a leakage current due to resistance across the unknown capacitor, or a spuriously generated dc current. This differentiation is very difficult when using existing instruments.

The feedback charge technique reduces the time needed to assure quasistatic equilibrium, since it allows

tests to be made at a single bias voltage point with various timing parameters, rather than having to wait for an entire ramp at each various speed to assure equilibrium.

For more information phone **Scientific Devices** on **(03)579-3622.**

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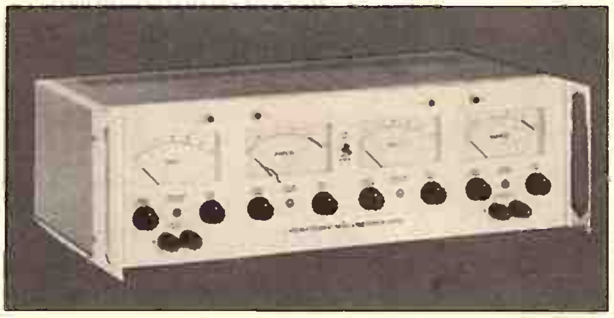

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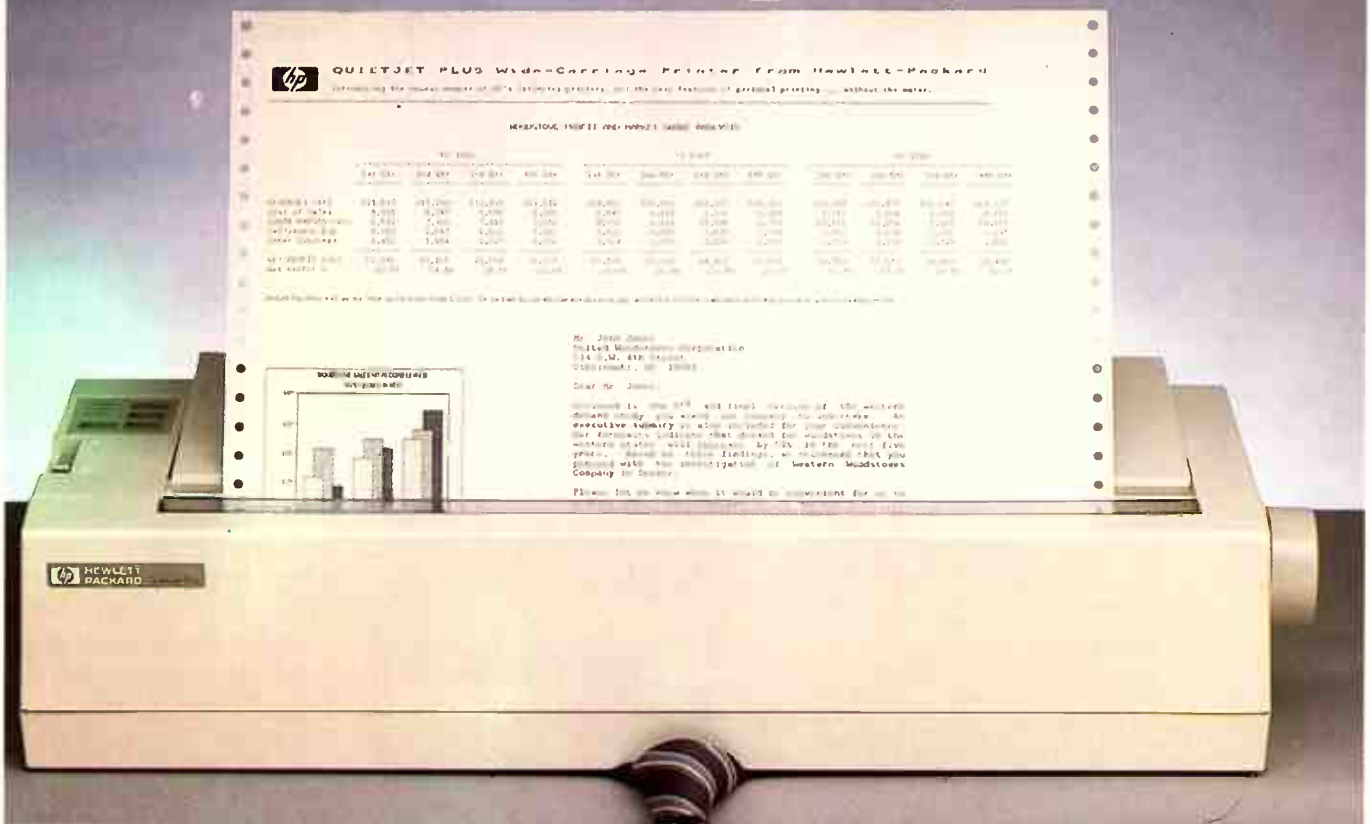

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