Electronics & Technology Today

The New Electronics Today!

Canada's Magazine for High-tech Discovery

October 1987

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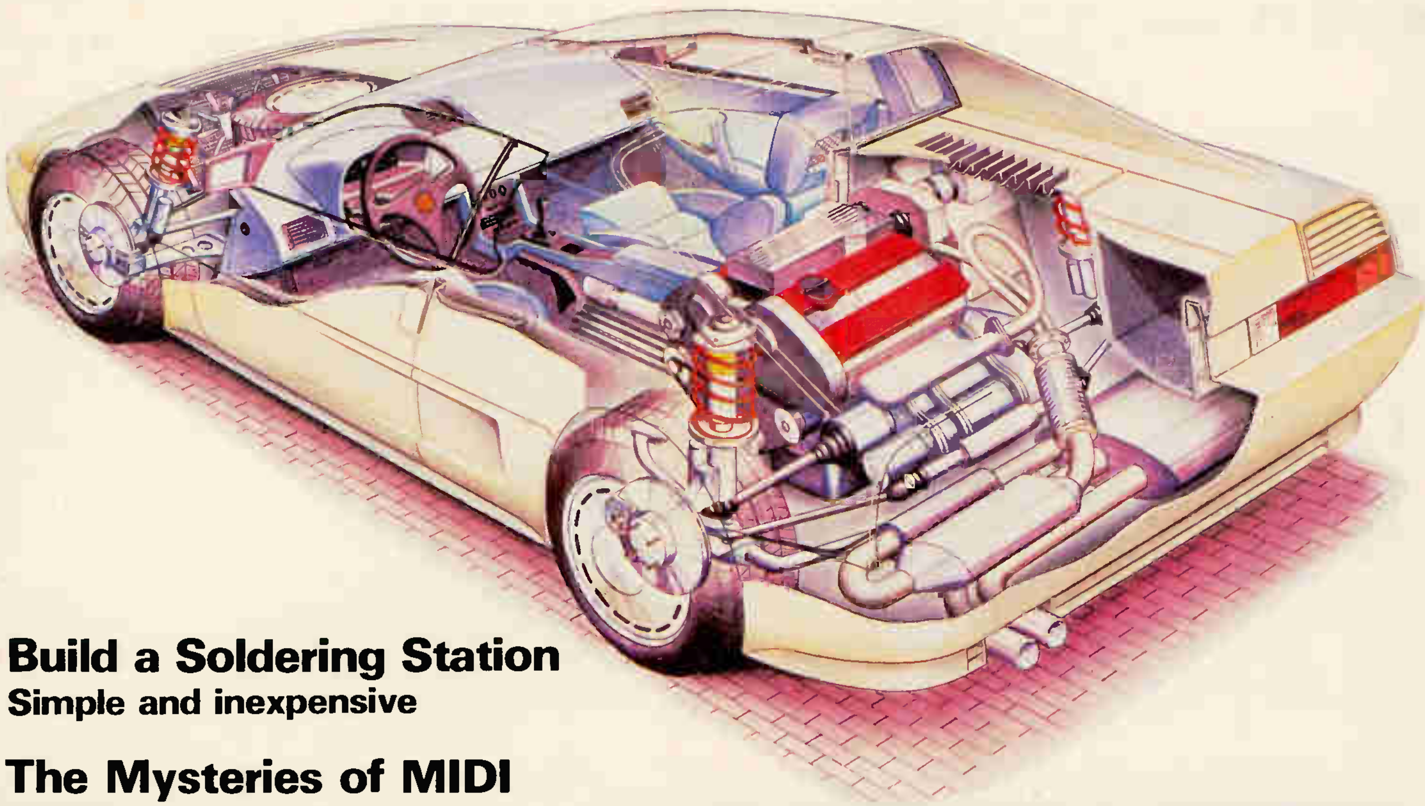
What you might be driving in 10 years



Build a Soldering Station

Simple and inexpensive

The Mysteries of MIDI

Explaining the computer music controller

Build an audio mixer!

Microlasers!

First Look at Luxman's Digital Tape Deck

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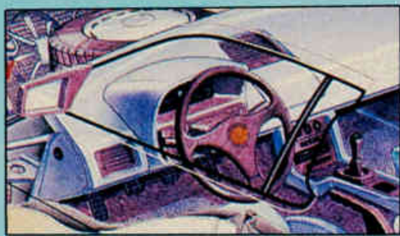

The main cover photo is courtesy of Nissan Motors; the Luxman DAT photo is courtesy of Alpine/Luxman Electronics.

Electronics & Technology Today is Published 12 times a year by:
Moorshead Publications Ltd.
1300 Don Mills Road,
North York, Toronto, Ont. M3B 3M8
(416) 445-5600

Editor: **William Markwick**
Assistant Editor: **Edward Zapletal**
Director of Production: **Erik Blomkwist**
Production Manager: **Dolph Loeb**
Circulation Manager: **Sharon Cernecca**
Advertising Manager: **David Stone**

Publisher: H.W. Moorshead; **Executive Vice-President:** V.K. Marskell; **Vice-President - Sales:** A. Wheeler; **Vice President-Finance:** B. Shankman; **General Manager:** S. Harrison; **Production:** Kevan Buss; Naznin Sunderji; **Accounts:** P. Dunphy; **Reader Services:** N. Jones, K. Parkinson, R. Cree, K. Barkwell; **Advertising Services:** R. Ferrara.

Newsstand Distribution:
Master Media, Oakville, Ontario

Subscriptions:
$22.95 (one year), $37.95 (two years). Please specify if subscription is new or a renewal.

Outside Canada (US Dollars) U.S.A. add $3.00 per year. Other countries add $5.00 per year.

Postal Information:
Second Class Mail Registration No. 3955. Mailing address for subscription orders, undeliverable copies and change of address notice is:
Electronics Today, 1300 Don Mills Rd., Toronto, Ontario, M3B 3M8

Printed by Heritage Press Ltd., Mississauga
ISSN 07038984.

Moorshead Publications also publishes Pets Magazine, Computing Now!, Computers in Education, and Government Purchasing Guide.

Circulation Independently Audited by MURPHY & MURPHY Chartered Accountants.

Electronics & Technology Today

Canada's Magazine for High-tech Discovery

Volume 11, Number 10 *October, 1987*

Features

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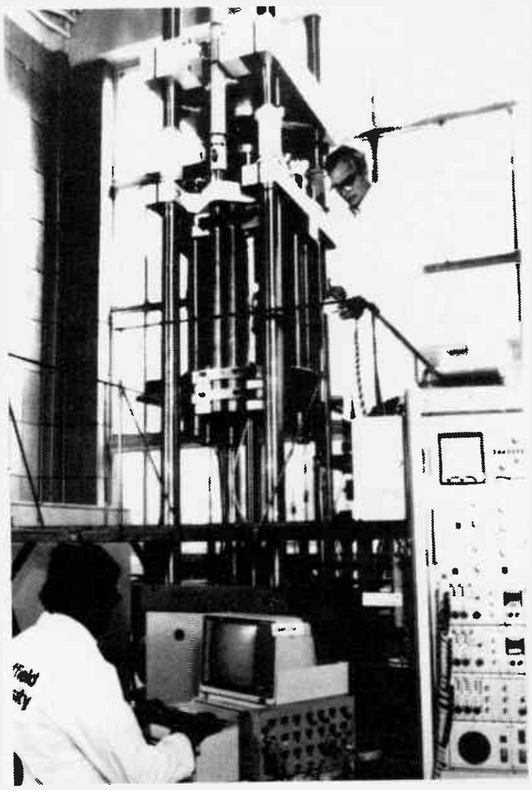
INFORMATION

Fatigue Testing of Metals
By M.W. Brown, Univ. of Sheffield



Testing of engineering materials to destruction is a well established procedure, providing fundamental information to the designer and the fracture analyst. Tests may be either under a steadily increasing load or, in the case of fatigue testing, subject to frequently repeated loads.

Fatigue failure is particularly hazardous because it can occur without clear warning symptoms after several years. The majority of engineering components experience repeated stress in service, and may exhibit a complicated history of random loading with two or more superimposed loads.

A good example of this is the driving axle of a tractor, which transmits a torque from the engine to the wheels. The torsional stress changes with the power demanded by the driver, each depression of accelerator pedal giving one fatigue cycle.

However, further stresses arise in the axle as it bends when the tractor traverses a rough surface, every bump in the ground producing a sudden load. This complex or multiaxial loading forms fatigue cracks which grow until eventually one is large enough to produce a failure.

Predicting Crack Fatigue

Multiaxial fatigue can also be found, among others, in aircraft structures, aero engines, railways lines, power plant, pressure vessels, nuclear structures and offshore oil platforms. It is therefore essential to be able to predict not only when a fatigue crack will form, but also the path taken by the crack and the expected service life of the particular component if costly failures and unnecessary accidents are to be avoided.

The majority of fatigue tests conducted in the past have been uniaxial in nature, that is, a rod subjected to tension-compression cycles, or a bar under repeated bending. However, because real components suffer complex loads, a range of tests must be performed under multiaxial fields of stress to understand correctly the physical processes of failure.

To date, multiaxial tests have concentrated on combined tension and torsion, and have provided valuable information. It is from such data that some modern failure theories used in design have been derived.

Nevertheless, many fractures in service do not fall within the tension-torsion category, and so there is a need for more versatile test facilities, first to simulate actual loading histories and stress patterns, and secondly to study the new high performance materials available to the designer.

Choosing Strength Direction

With the advent of composite materials and metals with inherent directional properties, such as those used in airframes, strength can be optimized in a chosen direction, where it is required. Consequently modes of crack growth and the nature of damage that accrues during fatigue can be different to those observed in a traditional uniaxial test on the same material.

Two biaxial stress fatigue test rigs, built by W.H. Mayes and Son in collaboration with the University of Sheffield, show crack extension under a variety of load patterns. These are elevated temperature machines, capable of conducting tests where creep interactions accelerate the propagation of fatigue cracks.

Furthermore, the effect of mechanical stress raisers or notches on fatigue cracks can be observed. Automatic monitoring of the crack growth is achieved by using a dc potential drop technique, in conjunction with a data logging system.

Test Procedure

In these cruciform test rigs, a square specimen is loaded along each of the four edges using servo-hydraulic actuators, and an initial defect machined in the centre of the specimen is observed as it extends, with a travelling microscope. The rate of propagation and the preferred crack growth path are readily obtained. The specimen design gives a uniform stress field, so that fracture mechanics assessments are not difficult to perform, the specimen being a centre-cracked panel experiencing cyclic tension-compression. However, such cracks are inevitably large, from 4mm up to 70mm.

To study the formation and growth of small cracks under a multiaxial stress, a more complex fatigue test facility has been designed at the University of Sheffield. This not only generates the biaxial stress fields obtained in the above test rigs, but allows the operator to specify the direction in which stresses are applied.

The new system can produce every conceivable biaxial stress field experienced in practice. It also allows the researcher to conduct experiments under conditions hitherto unobtainable in the laboratory, providing the fracture group at Sheffield with the chance to assess critically current design procedures and to test the validity of more recent theories of metal failure. At present, design codes are based on uniaxial fatigue data alone, and the method generally recommended for prediction of three- dimensional stress/strain behaviour is known to be incorrect.

Four Modes

The specimen chosen is a tube with a 20mm outer diameter and a 16mm bore, in which fatigue cracks are observed. It is loaded in four modes:

Stretched or contracted along the tube's axis.

Twisted clockwise or counter-clockwise.

Pressurized in the bore.

Pressurized externally, since the specimen is contained within a substantial pressure vessel.

With these four loading modes, the direction, magnitude and biaxiality of stress can be selected as necessary, and the stresses may be either positive or negative to allow fully reversed cycling. A microcomputer monitors the actual load conditions and ensures that the correct relationship between stresses is maintained.

To obtain the high stress level for fracture of ductile steels, oil pressures of up to 165Mpa are required, so high pressure engineering techniques are used in the design of oil seals, pipework, intensifiers, and so on and strict safety standards are observed. Failure of the specimen is readily detected by a decrease in the applied load, or by an inability to maintain a pressure difference between the inside and outside of the tube once the specimen wall has been penetrated by a fatigue crack.

A pair of hydraulic actuators produces the tensile load and torque, and two intensifiers supply the high pressure fluid to the specimen itself, the loads being controlled by servo hydraulic valves. The axial thrust and torque applied to the specimen and measured with a load cell and also in each case with an independent pressure gauge.

Complete Strain Analysis

However, in low life fatigue it is important to measure the strains, or distortions to which a material is subjected, since these govern the growth of cracks. To this end, a multiaxial extensometer has been designed to operate inside the pressure vessel, where it can monitor the axial extension or compression, the angular twist, and change in external diameter of the specimen's working section.

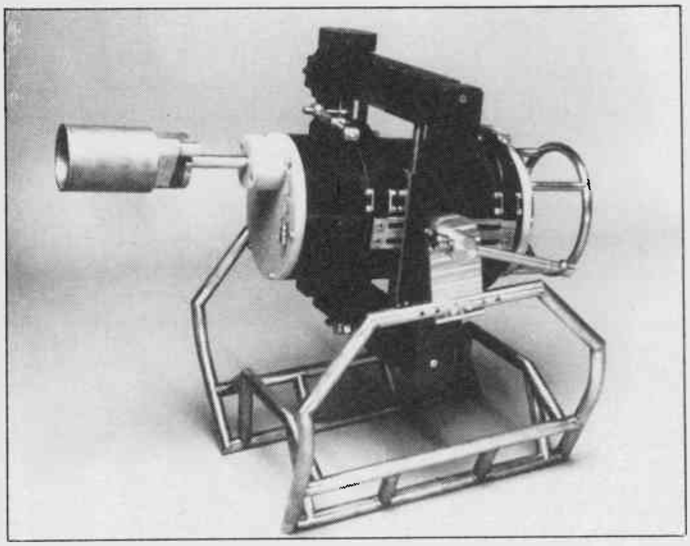
From these three strain readings, a complete strain analysis of the tube can be made. In low cycle fatigue, it is conventional to control the applied strains, to ensure that they follow a specified cyclic history.

A microcomputer monitors and records the three strains and four loads during a test, giving a description of how the strength of a material changes under cyclic stress.

It is intended that future work on the multiaxial test rig should involve industry, by considering technologically relevant problems and by selecting materials of industrial significance. ■

Electrolysis Drills Underwater

By Arthur Fryatt



The electrolytic head of the OIS cutting system mounted on its stabilizing frame, which allows very accurate subsea location

The corrosive effect of naturally occurring electrolysis when dissimilar metals are positioned near one another on a subsea structure is well known and carefully avoided by design engineers. Such electrolytic action can cause severe wear problems to underwater components of oil rigs, ship's propellers, and so on. To give protection against this, sacrificial anodes are usually employed.

The effect of passing an electric current through a conductive solution was first quantitatively studied by Faraday, who originated most of the terminology used in describing the phenomenon. A conducting solution is known as the electrolyte and the chemical changes that take place when passing an electric current through this solution is termed electrolysis. This refers to the electrochemical decomposition of the subjected metal under controlled conditions.

Faraday's laws of electrolysis state that the mass of any substance liberated in electrolysis is proportional to the quantity of electrical charge that liberated it. Furthermore, the masses of different substances liberated by electrolysis through application of the same quantity of electrical charge are proportional to the ratio of the relative atomic mass to the valency, or combining power, of the elements involved.

In quantitative terms, for every amp of current applied approximately one gram per hour can be dissolved.

Research Project

In 1982, a research team at Oilfield Inspection Services (OIS) began work on harnessing controlled electrolytic action in subsea conditions for accurately cutting holes in metal structures. In conjunction with the British Government's Department of Energy, the OIS research team perfected a compact, portable, robust and economic electrolytic cutting system as an alternative to conventional mechanical land hydraulic drilling techniques.

The principle of electrolysis was harnessed for efficient removal of metal by passing low voltage electric current through a conductive electrolyte (in this case seawater) from a hollow electrode.

The electrolyte-filled gap between the anode and the cathode is maintained in the system by non-conductive diamond particles embedded into the electrode, thus dissolving an annular groove and leaving a central core for retrieval and examination.

Equipment is designed to operate in depths up to 300m and to cut holes up to 75mm diameter; at a penetration rate of 90mm/s in steel without inducing heat or stress into the parent material. The system is equally effective producing angular holes or holes over an irregular surface.

Compact and Accurate

The system can also be used for onshore applications by employing a closed circuit flow of electrolyte through the cutting electrode.

The electrolytic head is a nylon and anodized aluminum pressure compensation housing filled with a high grade de-watering fluid. The unit contains two 12VDC pancake motors, one coupled to a gearbox to activate and oscillate the chuck and electrode assembly and the other coupled to a pump continually transporting fresh electrolyte to the electrode tip.

A subsea stabilizing frame and X-Y positioning quadrant are provided for the accurate location of the electrolytic head within a predetermined area. The stabilising frame can be secured either by circumferential ratchet straps or electromagnets. Fine adjustment is made through an X-Y screw-adjustable positioner. The electrolytic head has a diameter of 175 mm and is 460 mm long, including the electrode. It weighs 21 kg in air (10 kg under seawater).

Power Supply

The pressure compensating and oil-filled subsea power supply unit is constructed from nylon and anodized aluminum. It contains a 5.8 kVA transformer supplying a maximum continuous cutting current of 200A, a 250A bridge rectifier assembly and a 12V power supply for pump and crank motors.

It also houses a cutting current sensing unit comprising a calibrated current sensing element, stable linearized monitor amplifier and signal encoder, and coaxial driver. The power supply is linked to the surface control module by a four core, steel wire-armoured power and telemetry umbilical.

The first such subsea electrolytic cutting system developed by OIS was a diver-deployed unit and its cutting capacity of up to 75mm diameter was particularly useful in drilling holes to stop the spread of cracks in structures and the removal of cores for analysis. This unit could be deployed by a single diver who need not stand by during operation, as the system is completely controlled from the sea surface.

The strategic placing of a small hole at each end of a structural crack makes it possible to prevent crack propagation by replacing high and uncertain stress concentrations my much lower and safer values. The use of electrolysis for such an application reduces the concentration of stresses around a hole periphery even more than mechanical drilling.

Remotely Deployed System

Towards the end of 1984, development moved further with the design of a remotely deployed system for producing large diameter holes within a conductor casing, when the Texaco oil company approached OIS with a problem to convert two 660mm outside diameter existing conductor columns by producing two 405mm diameter holes in each at specified distances and within a given circumference.

The subsea cutting unit also had to support freely 29.2m of 465mm diameter casing which acted as the reference locator within the mudline suspension ring for the initial vertical positioning. By the spring of 1985, the system had been designed, built and installed on the rig ready for use.

In operation, the equipment was lowered into the conductor to a predetermined depth on the drill pipe. When the correct vertical and circumferential position was achieved, the latter by gyrocompass, two sets of hydraulically operated rams firmly locked the tool in position, simultaneously completing the anode return path through the workpiece. The cathodic electrode was then driven to the pipe wall in readiness for cutting.

Precise control of the parameters, such as hydraulic pressure, current, voltage, penetration rate, and so on was accomplished by a telemetry link between the subsea microprocessor and the surface operators. The control system was designed to monitor and control the remote instrumentation, ensuring tight bond between the host and the remote units to eliminate the possibility of false commands.

First Major Application

The work performed on this project represented the first major application of underwater electrolytic grinding. Surface deployment, remote control and short set-up time, combined with the lack of weather dependence resulted in substantial cost savings compared with alternative diver supported operations.

In all, four 405mm diameter holes were produced at depths of 116m and 148m in an average time of 24 hours per hole.

Continuing research related to the fundamental principles of electrochemical machining is now being evaluated with the aim of developing a range of practical tools for surface application as well as subsea use.

Experimental work has already proved the viability of producing much larger holes, and not necessarily circular.

Arthur Fryatt is with Oilfield Inspection Services, UK.

Simulator Postscript

Sharp-eyed pilots looking at the cover of our flight simulator issue last month may have wondered whether we had come up with some new kind of airplane cockpit. In fact, the printing negatives were reversed somewhere in the printing process, and because cockpits are basically symmetrical, nobody noticed until the magazine was out.

In our coverage of Microsoft/Sublogic simulators for micros, we neglected to mention one remarkable feature because we didn't have the hardware, and that was the ability to hook two Ataris or Amigas together for dual flying. We finally patched an Atari ST into an Amiga 500 via the RS232 ports and a 3-wire cable, and selected the Multi-player option. This is one of the absolute best bits of software we've encountered. You can take off, fly formation and land with the other person's plane beside you. In addition, you can do this via modems so armchair pilots can do aerobatics together over the phone. Amazing.

Digital Thermometer

Duncan Instruments Canada Ltd, introduces their new microprocessor-based digital thermometer with J,K, and T capability, the Model 2000JKT. A feature of the Duncan 2000JKT of interest to Canadians is the pushbutton C/F temperature conversion. At the touch of the button, the Duncan 2000JKT converts Celsius to Fahrenheit and vice-versa. The Duncan 2000JKT has a large 4-digit LCD display and can measure - 190 to + 1000 C using a J-type thermocouple. The Duncan 2000JKT has an accuracy and resolution of 0.1%. There is a differential mode for various temperature measurements using a reference point other than O degrees, a memory storage/recall and a hold feature. Accuracy in standard mode is ±0.1% and in differential mode ±0.3°C over a 100°C span. Contact Duncan Instruments, 121 Milvan Drive, Toronto, Ontario M9L 1Z8, (416) 742-4448.

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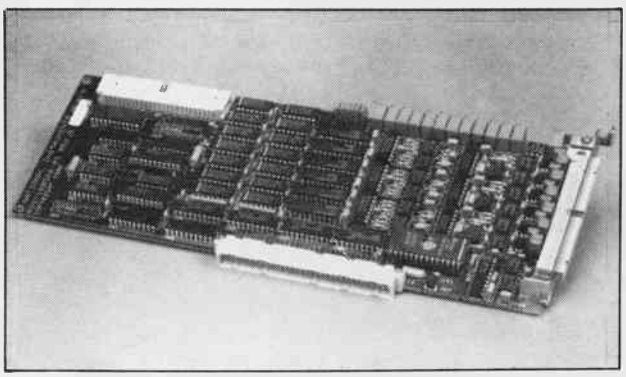
Analog Board For Mac II



National Instruments announces a NuBus Analog Output Board for the MacIntosh II Computer. The NB-AO-6 features six 12-bit digital-to-analog converters with accurate voltage outputs that can be used to provide test signals and generate waveforms for automated test equipment. Each converter also provides current outputs of 4-20mA that can be used in industrial control systems.

Each analog output channel provides fast and accurate voltage and current outputs. Recalibration is seldom necessary because of the low time and temperature coefficients implemented by the use of flying-capacitor and chopper-stabilizing technique.

The NB-AE-6 features a high performance Real-Time System Integration (RTSI) bus interface that allows synchronization with processes on other NB series boards. The converter outputs can be updated by a RTSI bus signal, and external signal, or software control. In addition, DMA capability is provided over the RTSI bus allowing the NB-AO-6 to generate six different waveforms simultaneously. Waveforms can be generated with sample rates up to 380 ksamples/second.

The new board allows reference voltages to be supplied between - 10V and + 10V, thus providing the capability for four-quadrant multiplication. This capability enables gain control of of audio signals and linear modulation.

The NB-AO--6 is supported by the National Instruments LabVIEW software system. The board is available for the price of $ 1,296 (Cdn., FST extra) exclusively from Allan Crawford Associates, 5835 Coopers Avenue, Mississauga, Ontario L4Z 1Y2, (416) 890-2010.

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For Your Information

The Underground Simulator

The London underground, or tube, has introduced this videodisk based simulator that will enable its drivers to experience and cope with more situations in a few hours than they are likely to meet in several months driving beneath the Capital's streets. Operating on a laser-vision system controlled by a BBC master computer, the simulator will enable a trainee driver to start, drive and stop a train in normal and emergency situations and to test reactions to a wide variety of line and signal conditions. Developed by the National Computing Centre in north-west Britain, the simulator is believed to be the first using videodisk. Although simulators have been used for many years, especially in the Aircraft industry, the underground version has been designed as a low-cost system that replaces conventional methods of teaching while also being cost effective. The London underground has 680 miles (1094km) of track, 273 stations, 457 trains and carries about 2,400,000 passengers daily.

Holographic Head-Up Display For Pilots

What is claimed to be the world's first holographic head-up display (HUD) for pilots is now being commercially produced by GEC Avionics of Rochester, southern England. The company had recently received a $US72m production order from General Dynamics Corporation of the United States to equip F-16C Fighting Falcons with new wide angle raster HUDs. The system uses diffractive (holographic) optics to provide the pilot with a wide field of view suitable for both day and night operations. It is driven by an advanced computer to form symbols which are projected into the pilot's forward view, enabling him to fly the aircraft without visual reference to the instruments.

Continued on page 36

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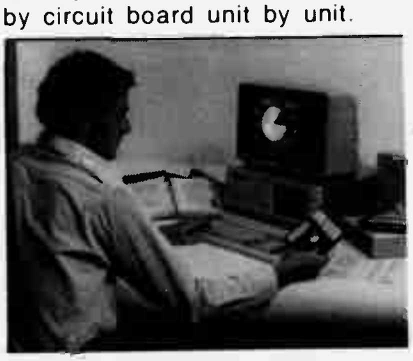

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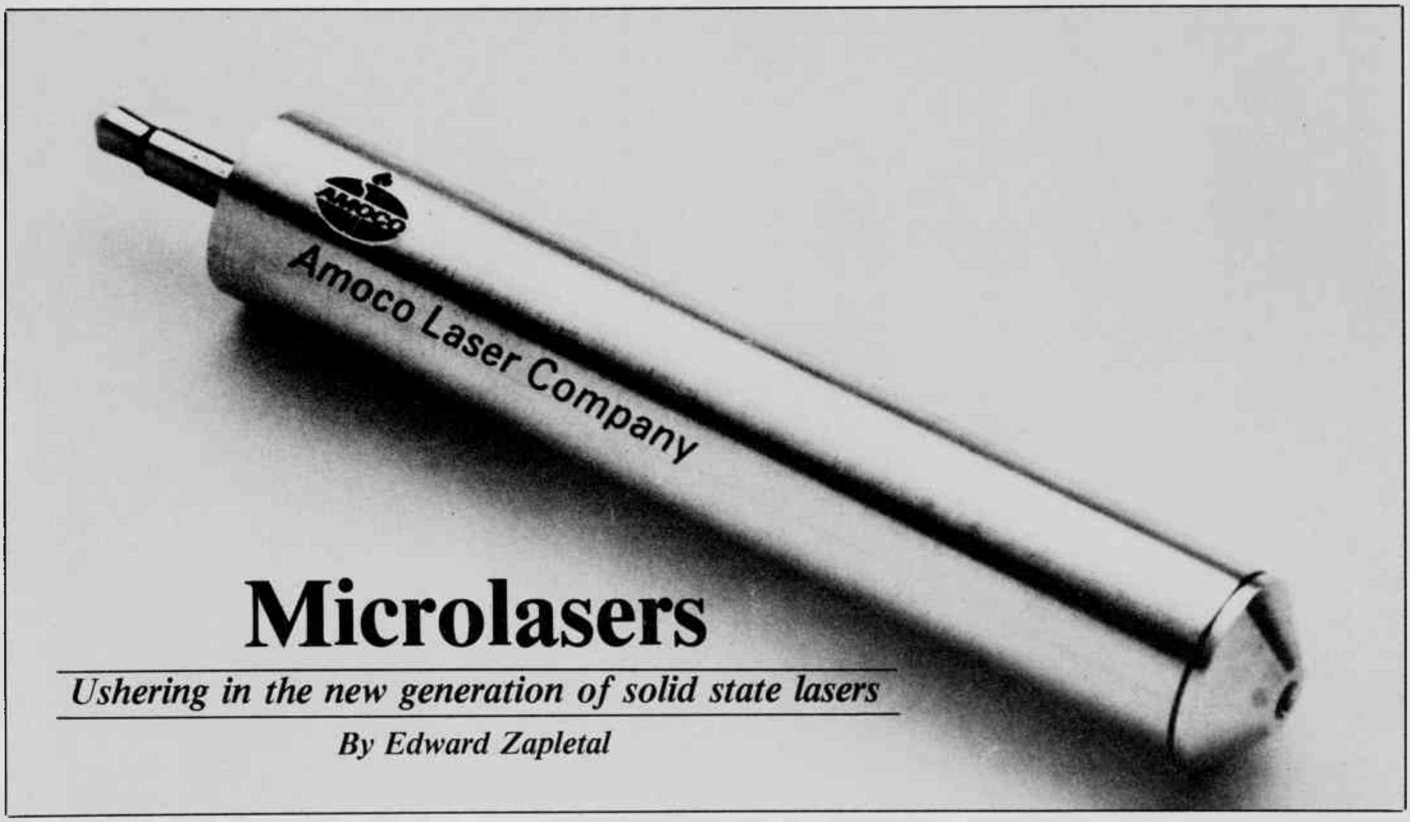

Microlasers

Ushering in the new generation of solid state lasers

By Edward Zapletal

Just as computers have evolved from the room-sized behemoths of yesteryear into the tiny handheld units of today, lasers, too, have crossed over into the world of miniaturization.

With the introduction of microlaser technology, a whole new vista of product development is on our doorstep. Telecommunications, fiber optics, computer technology and a wide variety of other industries all stand to benefit from the advances made in microlaser technology. There are over two hundred North American companies actively involved in laser technology research and manufacturing including Amoco Laser, Canon, Eastman Kodak, 3M Canada, and Litton, just to name a few.

Differences

All current lasers, except laser diodes, whether they contain a glass gas discharge-tube, a glass flashlamp, or a metal-ceramic tube, are based on vacuum tube technology. These conventional lasers are pumped by a gas discharge through a glass tube, are handmade, and as a result, are expensive, fragile and inefficient. The power supplies for these units are the size of a refrigerator, and require upwards of two kilowatts of power to operate.

The key feature of microlaser technology is that microlasers are optically pumped by laser diodes (semiconductors), which are far more inexpensive to produce in large quantities than the components necessary for the conventional laser. The power supplies necessary for these components can be contained within a handheld package consuming only about 2 watts of electrical power (Table 1). With this in mind, the potential to apply the technology right down at the consumer level is very attractive.

Applications

The introduction of the green light microlaser will be providing high utility for the increasingly complicated machinery of today's industry as well as in the consumer market. Areas such as holography, direct write film systems, projection television, photographic scanners, and color printers will benefit greatly from the new compact laser technology.

Microlasers are also well suited to applications where the analysis of complicated mechanical components require tolerances down to the microinch.

Farther into the future, but not by much, the green light laser will be employed in such safety oriented equipment such as collision avoidance for aircraft and automobiles.

In the construction industry, the low-power and compactness of the microlaser will enhance precision alignment and levelling for construction and surveying. In building construction, microlasers improve precision alignment in such areas as ceiling hanging. The small size and high efficiency of microlasers make them particularly well suited for these field applications.

Laser Printers

With desktop publishing and affordable computers at hand, it is now possible to turn out professional looking newsletters etc, without having to shell out enormous sums for phototypesetting. The pivotal component in all of this is the laser printer. It provides almost phototypeset quality at 300 dots per inch resolution which, to the untrained eye, is near perfect.

There are three basic elements necessary for the laser printer to perform its job: laser light, electrical charges, and toner (similar to that found in photocopiers).

After having commanded the computer system to print a particular page or document, this information is sent to the printer in the form a bit image. This bit image is then transferred to the light-sensitive rotating drum by passing it through a semiconductor laser focused through a series of lenses. The drum holds a negative charge as it's rotating and as the light from the laser hits this it becomes neutralized in those places where the final type will be. The surrounding areas remain negatively charged.

Once the entire bit image is charged onto the drum, the drum rotates through a cartridge of negatively charged toner. Because like charges repel, the toner is attracted only to those areas which were neutralized by the laser. The image is then transferred onto paper using the same electrostatic technique as that which was used for the toner. As the paper is fed into the rollers, it is given a positive charge. Because opposite charges are attracted to each other, the toner is transferred to the paper.

To make the image more durable, the paper is then passed through two rollers heated to approximately 200 degrees Celsius. This combination of heat and pressure fixes the toner to the paper preventing any smudging. (Photocopiers should work so well.)

The prognosis for the future of laser printers is a good one. With laser technology rapidly progressing, we are likely to see 600 dot per inch printers on the market within months. Beyond that, it is difficult to say, but there has been talk of 1200 DPI laser printers which would offer a quality of type rivalling that of the phototypesetter.

Bar Code Scanners

Industrial inventory control, supermarket and department store checkouts have become extremely efficient in recent years thanks to the semiconductor lasers used in handheld inventory communications devices. Virtually every product sold or handled in bulk quantities has bar code markings which allow for automatic inventory update at the point of sale.

Medicine

Although the consumer and industrial markets are large, they are only but a few of the areas in which the microlaser has the potential to make itself known. In medicine for example, microlasers will be instrumental in applications ranging from the delicate procedures required for eye surgery to the not-so-delicate procedures of more conventional surgery. Because the entire laser surgical instrument system and power supply can be handheld, surgeons will have much greater flexibility.

In addition to its surgical uses, the semiconductor laser has found a place in high resolution imaging systems for diagnostic purposes. A new system from 3M Canada, utilizing a high speed infrared laser diode, claims 20 times better resolution than existing CRT technology on diagnostic-quality film, directly from the output of digital electronic examination equipment (Fig. 2).

The unit is compatible with diagnostic systems such as computed tomography (CT), magnetic resonance (MR), ultrasound, digital angiography and digital subtraction (DS). The system provides direct film imaging from digital

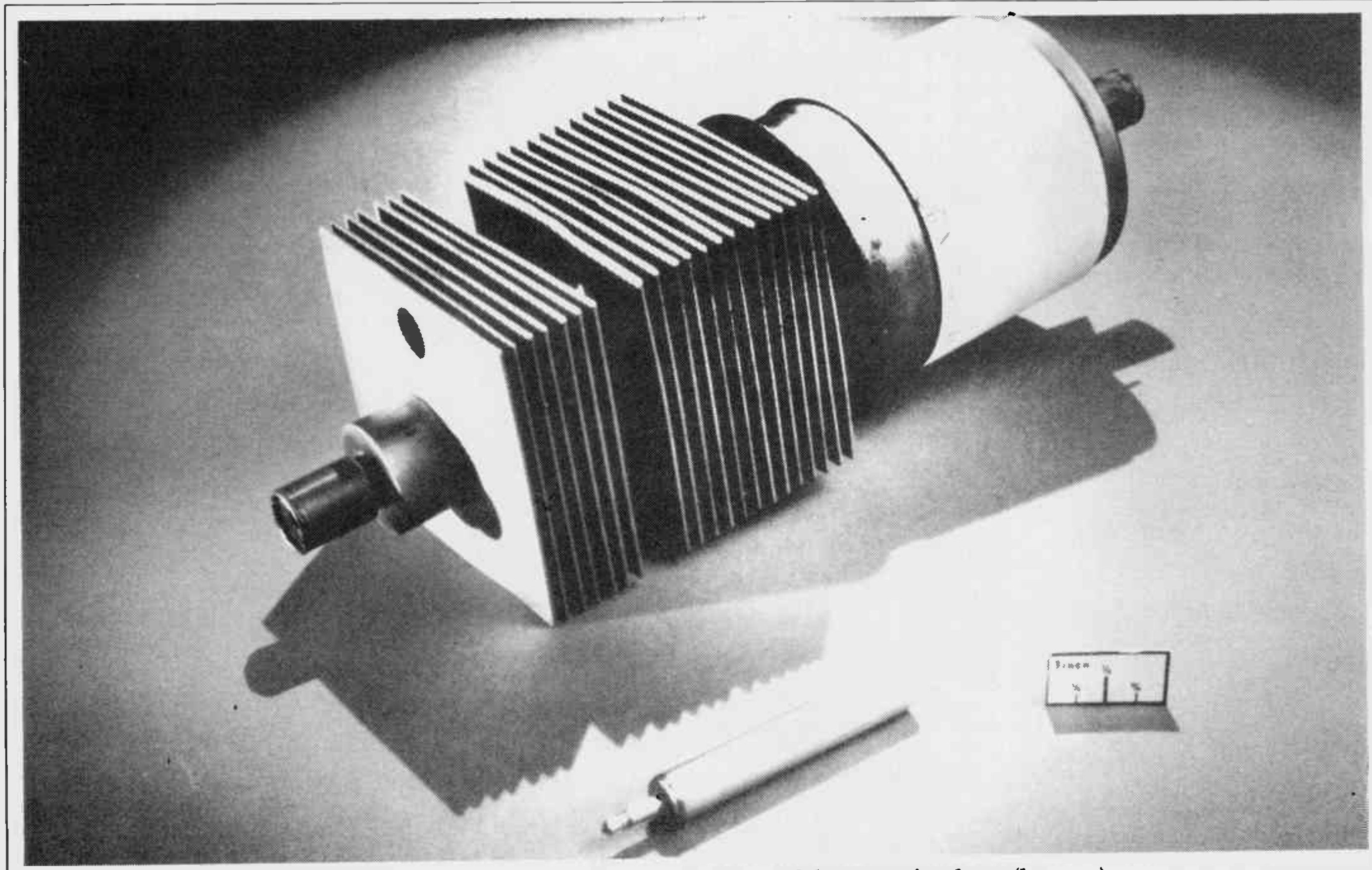

Fig 1. A comparison between the old-style air-cooled Argon-Ion lasers and the new microlaser (bottom).

data without the inherent image degradation of conventional technology, which requires an intermediate CRT display.

Conventional CRT imaging techniques allow single image resolution of 512 x 512 pixels, with an upper limit of 1024 x 1024 pixels with the most sophisticated equipment generally available. With these limitations, the maximum image is comprised of an area of 1,048,576 pixels.

The new 3M system allows single-image resolution of nearly 4000 x 5000 pixels for a 35 x 43cm (14 x 17in.) film sheet, or almost 20 million pixels, each with 256 discrete levels of grey scale. According to 3M, diagnostic value of films imaged by the new 3M technology is greater with this expanded resolution, yielding greater detail for discerning subtle diagnostic features.

A special 3M laser imaging silver halide film has been developed as well. The 7-mil polyester base, blue-tinted film gives optimum contrast and dynamic range and can be processed in standard 90-second processing systems.

Table 1 - Specifications for the Amoco Infrared Laser (1064nm wavelength)

Power:	50mW
Stability:	± 2% RMS in 8 hours. This stability specification will be satisfied as long as the ambient temperature changes by no more than 1 degree centigrade per hour. The laser will be less than ± 10% RMS over its entire temperature range.
Noise:	± 0.2% RMS measured at frequencies between 10Hz and 8GHz.
Collateral Radiation:	1 microwatt @ 810nm.
Output:	Continuous Wave (CW)
Lifetime:	10,000 hours
Op. Temp. Range	50°F to 100°F when mounted on a suitable heatsink. Maximum operating temperatures can be increased if a fan is employed.
Pointing Stability:	30 Microradians/degree centigrade

The Future

As with any burgeoning technology, the laser is destined to find more uses in the everyday items which we have come to rely on. Look for more widespread applications in the automotive industry, specifically in the areas of safety. Laser holography for entertainment systems, projection television, audio and video systems will also become popular as we search for more exciting ways to while away our leisure time.

As Dr. Tom Wolfram of Amoco Laser put it: "This is a very exciting technology because it has the potential to open large new markets in the same way that the transistor replaced vacuum tubes in existing products. In short, they will usher in a new era." As well he adds "they represent a quantum leap from hand built vacuum tube lasers to an efficient, all solid state tool for the 21st century."

We would like to thank the Amoco Laser Company, Apple Canada, and 3M Canada for their kind assistance with this article. ■

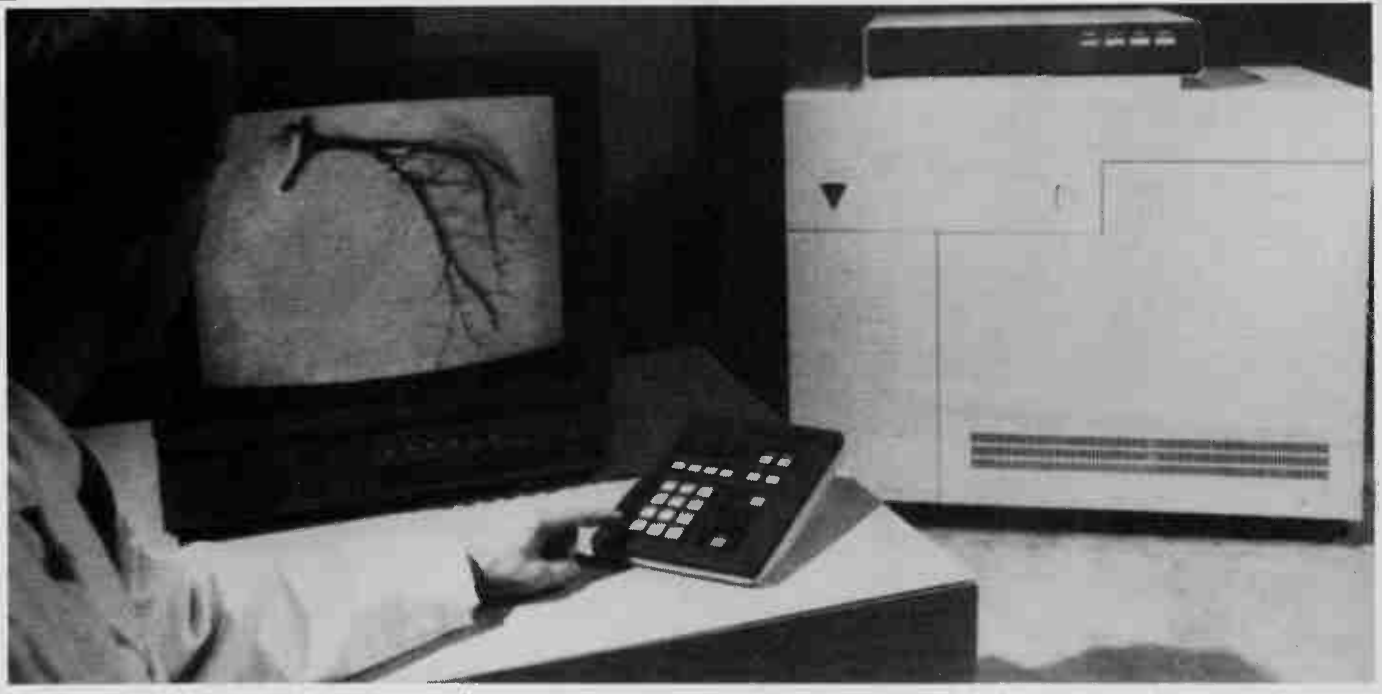

Fig. 2 The 3M Laser Imager used for medical diagnostic purposes.

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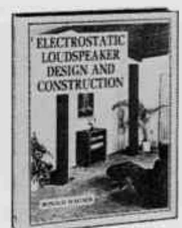

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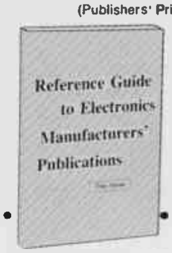

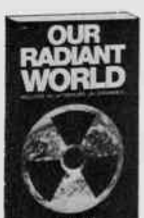

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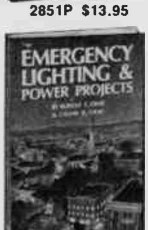

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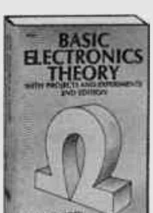

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Soldering Iron Temperature Controller

Keep your iron at the right temperature with this simple circuit.

By Mark Waluk

If you do a lot of soldering you will know the frustration of having too much or too little heat for the connection you are trying to make. One way of solving this would be to have more than one soldering iron, but this is too impractical. Or you could buy one of the commercially available controllers (some of these come complete with temperature sensors and vacuum desolderers), but these devices can be fairly expensive.

For under $40 you can build a surprisingly simple temperature controller that will work with any soldering iron using a resistive heating element. Using the temperature controller you can turn a normal soldering iron into a versatile tool with a wide range of temperatures, and prolong the life of your soldering iron as well.

How it Works

The temperature of a soldering iron can be controlled by the voltage supplied to it, thereby regulating the amount of power it uses. We could build a circuit to do this, but it is unnecessary since there is already such a device available for a low price: the light dimmer.

A light dimmer is a triac with a triggering circuit synchronized to the line frequency. As the dimmer is turned up, the trigger pulses go from late in the half cycle to earlier. This has the effect of increasing the average amount of current from a small amount, when the pulses are late in the half cycle, to the full amount available when the triac is triggered near the beginning of the half cycle. We will be using the light dimmer to control the current in a soldering iron, thus controlling the power used by it and the amount of heat it generates. It should be kept in mind that the power used is proportional to the square of the voltage and that every time the voltage is increased by 1.4 times, the power is doubled.

Fig. 1 shows the schematic of the controller, and as you can see there are very few parts. The light dimmer we will be using is the type with "rotary on" and is continuously adjustable. Also, be sure that the dimmer you buy has RFI suppression.

Fig. 2 shows the layout of the components; this may be changed if you use a different box than that of the one which is specified. If the dimmer is in the way of the LED you can either cut a notch in the mounting plate of the dimmer or move the LED to a new position. Be sure that the box is metal, or at least sturdy enough to take the stress of plugging and unplugging the soldering iron. And, when you are wiring the circuit be sure to ground the box and receptacle. The size of fuse you use will depend on the size of wire used; for 18 gauge use a 5 amp fuse. This will protect the dimmer as well

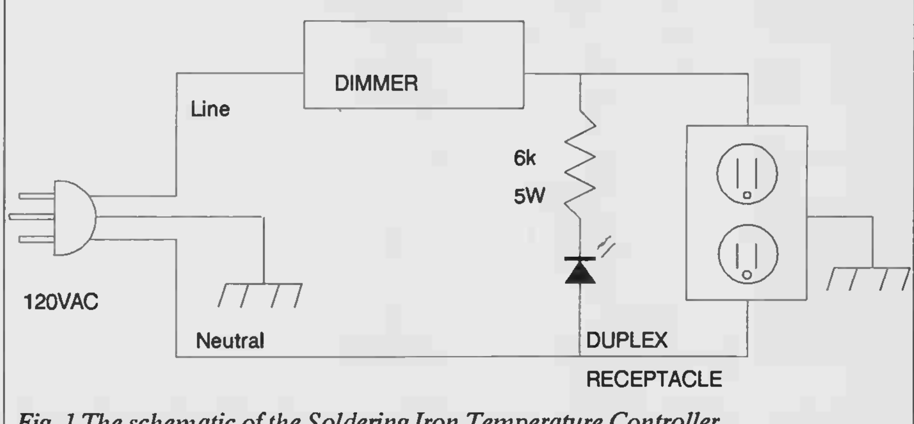


Fig. 1 The schematic of the Soldering Iron Temperature Controller.

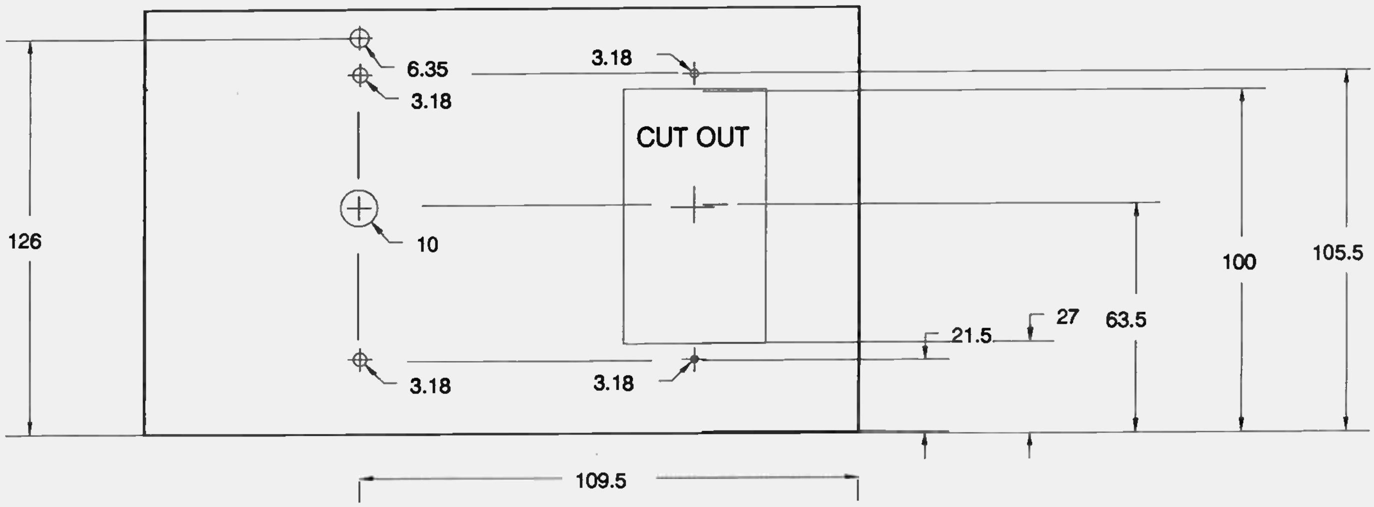


Fig. 2 Details of the box layout for the Soldering Iron Temperature Controller. Note: all dimensions are in millimetres.

as the wiring. A receptacle cover is used as an escutcheon plate to cover the hole cut in box for the receptacle, and you can use the knob that comes with the dimmer if you don't want to buy a new one. I preferred a different knob because it makes the project look a little more professional.

Calibration And Use

Once you've wired the controller and checked the wiring, plug your soldering iron into it, plug the controller in and turn it on. If everything is working properly the LED should come on when the knob is turned slightly.

To calibrate, connect the AC voltmeter across the receptacle and turn the controller on. Turn the controller fully on and mark this as the high setting. Turn the controller down until the voltmeter reads 85 volts. At this voltage a 120 volt soldering iron will be receiving half power. Next turn the controller down until the voltmeter reads 30 volts; this is the low setting.

In order to have the advantage of a wide variety of temperature settings, a high wattage (45 or 50 watts) soldering iron should be used. The light dimmer can handle a resistive load up to 500 watts (check the rating on the dimmer you purchase), but it cannot handle inductive loads at all so don't try the controller with a soldering gun.

To solder lugs and other heavy work set the controller to high. For soldering components and other delicate work set the controller to medium. If you put your soldering iron down for a few minutes turn the controller to low, this will keep the iron warm, allowing it to heat up quickly when you need it again. Turing it to the low setting also helps to prevent oxidation and pitting of the tip as well as burn out of the heating element.

To clean a badly oxidized soldering iron turn the controller fully on and allow the soldering iron to heat up. Dip the soldering iron in a can of solder flux, then wipe it off with a damp sponge.

Mark Waluk is a freelance writer from Edmonton, Alberta. ■

Mysteries of MIDI

An explanation of the use of the Musical Instrument Digital Interface

By Sam Withey

Advances in modern technology enable a single musician to play several instruments simultaneously, or a group of musicians to perform together with precision timing, an essential element in the enjoyment of playing or listening to music. These functions became possible because of the development of the sequencer and the MIDI interface. The sequencer is a microprocessor controlled module which is similar in use to the multi-track recorder, but which stores information regarding pitch, timbre, amplitude, timing and control signals in digital form. This data, when transferred to a digital, polyphonic synthesizer, causes the synthesizer to play automatically, together with any other digital keyboards and drum machines linked by MIDI interface.

All modern digital electronic instruments are microprocessor controlled and the MIDI interface ensures that the processor locks are synchronized in order that they will all perform functions at the precise times. The term MIDI is derived from the initials of Musical Instrument Digital Interface and is an internationally agreed standard of communication between microprocessor systems used in music applications. It enables the chaining of two or more instruments, equipped with the interface, by means of a single cable between each. The interface was designed and developed through the co-operation of major musical instrument manufacturers to overcome the problem of linking together instruments produced by different companies.

MIDI laid down rules by which digitized musical information could be transmitted and received in a standard from. Both the software and hardware specifications are formally documented and have been accepted by most leading electronic musical instrument manufacturers since its development in 1982. While MIDI implementation charts and transmit/receive data bit patterns are supplied with instruments, unfortunately, instruction manuals supplied with the instruments offer very little useful information about the operation of MIDI and some instructions deviate from the standard. It is hoped here to put some clear meaning into the standard instruction set, to help non-technical reader/instrumentalists get a little more out of their instruments.

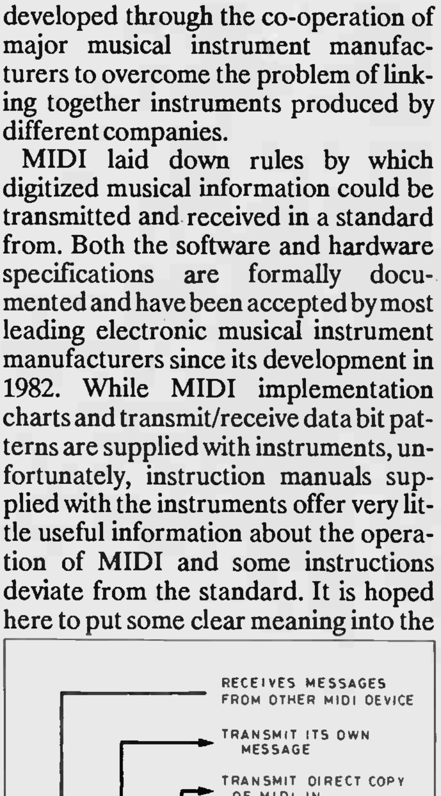


Fig. 1 MIDI THRU is a copy of MIDI IN.

What Is It?

MIDI is a bidirectional asynchronous serial interface similar to the familiar RS232 serial interface, but with a much higher baud rate of 31,250, which is arrived at by subdividing 1MHz. Unlike the RS232, which has signal voltage levels of +3V to +12V and -3V to -12V, the MIDI interface only requires 0V to 5V logic signal levels. The inputs are opto-isolated to ensure the absence of ground loops which prove so troublesome with many items of audio equipment. Connections are via standard five pin, 180 deg. DIN sockets and provision is made for MIDI-IN, MIDI-OUT and with some instruments, MIDI-THRU, this being a buffered direct copy of the MIDI IN signal; Fig. 1.

Format

The format of the MIDI interface was chosen as a compromise between speed and low cost. The transmission speed is high enough for all but the most sophisticated applications and is cheap enough to be included in even the least expensive units. Although information is in serial form, the microprocessor speed is sufficient to give the impression that sound is instantaneous. The

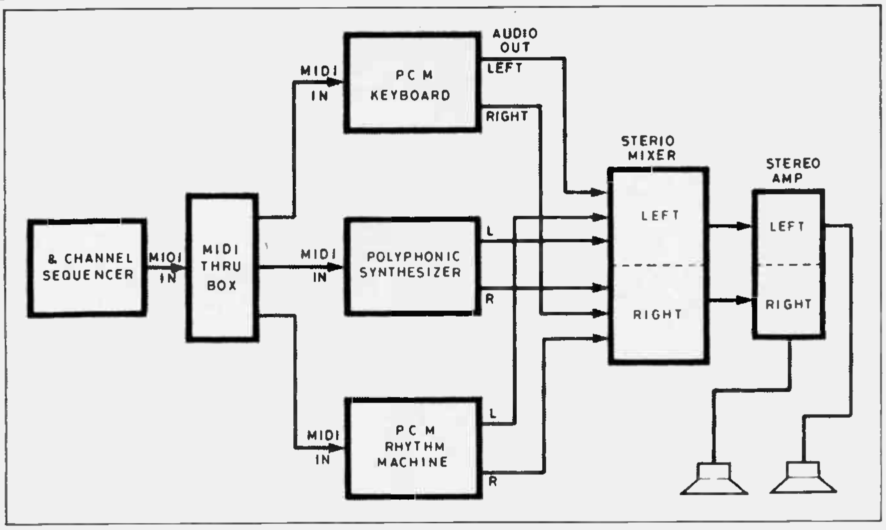


Fig. 2 Example of connections using the MIDI THRU.

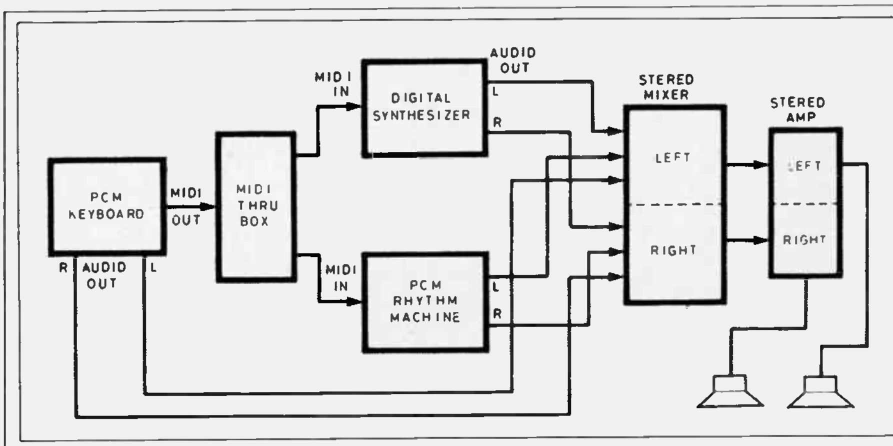


Fig. 3 Keyboard driving synthesizer and rhythm machine

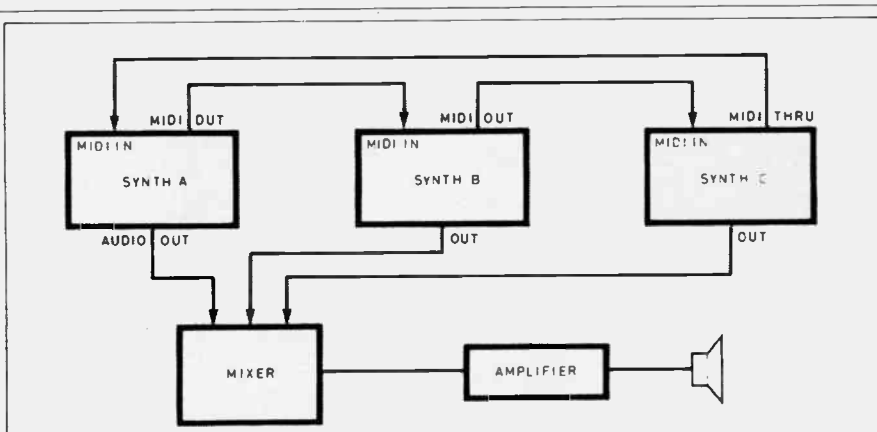


Fig. 4 Synth A, B, and C will sound if B is played.

microprocessor in each machine is able, through a specialized software language, to translate the digital coding received from the Master source; digital data being identical whether transmitted, or received.

The Master unit can be any unit in a group that can include keyboards, synthesizers, drum machines, sequencers and computers. Normally the choice depends on whether pre-programmed music is being played, or whether one or more keyboards are being played in real time, with backing from other instruments or sequencers. Ultimately the choice will always fall on the instrument which offers the simplest instruction set, or the most suitable unit for a specific application. As an example, the author uses a sequencer as Master when tracks have been programmed into it. The eight-track sequencer then controls the start and stop of a programmable keyboard, and programmable drum machine, together with the timbre, pitch, time values and effects on eight independent tracks of a synthesizer. In addition to this, the keyboard and synthesizer can be split and played in real time if required. As an alternative, the author, when playing in real time, uses the keyboard as Master, with MIDI controlled, pre- programmed rhythms stored in the drum machine and MIDI selected tones from the synthesizer that play simultaneously with the Master keyboard.

Examples

To illustrate the examples above, in the first instant the MIDI OUT of the sequencer is plugged into the Master or IN socket of the MIDI THRU box. The outputs from the box are then connected to the MIDI IN sockets of the synthesizer, keyboard and drum machine with standard five pin DIN leads and in any order, Fig. 2.

In the second example the MIDI OUT of the keyboard is plugged into the Master socket of the MIDI THRU box and two of the outputs connected to the synthesizer and drum machine, Fig. 3.

In the situation shown in Fig. 4 synthesizers A and C have MIDI THRU sockets which make the following functions possible. If A is played, the performance data of A will be sent through its MIDI OUT to B, which will sound. C will not sound as it is connected to the MIDI OUT of B. This is because the data fed into the MIDI IN of B is not outputted through the MIDI OUT. Therefore when A is played only A and B will sound.

If B is played, B's data will be sent from its MIDI OUT to the MIDI IN of C, making C sound. At the same time, a direct copy of the signal will be sent from C's MIDI THRU socket to the MIDI IN of A causing A to sound. Therefore playing B causes A, B and C to sound. In theory many MIDI devices can be connected by using MIDI THRU's, but as these are buffered outputs there will be a time when delays are noticeable. This makes the MIDI THRU box the more efficient method of distribution, or channelizing as this is known.

Some machines that do not have MIDI THRU sockets send the data fed to it at its MIDI IN direct to its MIDI OUT socket, while others have a single socket with selectable MIDI OUT, MIDI THRU. Yet again some have only a single MIDI IN socket because the others are considered unnecessary.

As modern instruments produce a stereo output these effects should be maintained by using a mixer with left and right input channels.

Channelizing

A single MIDI cable can be used to transmit several messages to different instruments at the same time through one of the sixteen channels, Fig. 5. Each message, carrying information of pitch, tone, modulation etc. is sent on a different channel and the receiving instruments are tuned in to the channels carrying the information you wish them to respond to. Although every instrument has 16 channels at its disposal, the number of channels that can be used at any time depends on the number of functions of the instrument and what its associated modules are each capable of. For instance, an instrument that is limited to rhythm, bass, accompaniment, poly and solo can utilize five different channels to transmit data to modules assigned to receive the messages.

The setup illustrated in Fig. 5 shows a typical method of distribution. Any channel number can be chosen for each function, providing the receiving module is capable of "tuning in" to a particular channel. some modules are only equipped with a single channel and have to be allocated to that channel exclusively. In the example it is assumed that the Bass Line is only capable of receiving on Channel 16.

The concept of channelizing is similar to that when television stations broadcast by transmitting wireless signals (each comprised of sound, vision, teletext, synchronization signals etc.) through different channels respectively. A TV set receives all the information from one antenna, but can select any desired broadcast by switching the channel selector.

The chart lists the codes of Channel and System messages. The first byte of Channel messages have a note triggering code and channel number.

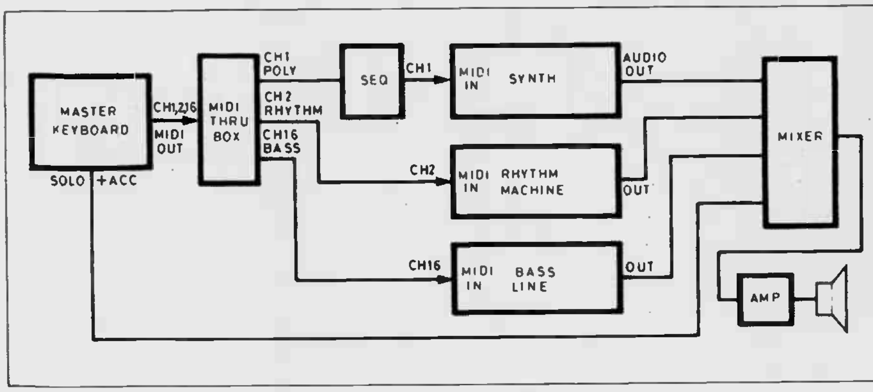


Fig. 5 An Example of channelizing.

Table 1 - Transmitted and Recognized Data

STATUS 1st Byte	DATA 2nd Byte	DATA 3rd Byte		Description
1000nnnn	0kkkkkkk	0vvvvvvv	Note Off	Receive only function n = channel number 0–15 (Channels 1–16) k = key value 0–127 (limited by keyboard) v = note velocity 0–127 (key off velocity) ignored
1001nnnn	0kkkkkkk	0vvvvvvv	Note On/Off	n = channel number 0–15 k = key 0–127 v = note velocity 0–127 (0 = Note Off 64 = Note On)
1011nnnn	0ccccccc	0vvvvvvv	Control Change and Mode Messages	n = channel number 0–15 c = control number 0–127 c = 1 modulation wheel c = 5 Portamento time c = 6 master time c = 64 sustain c = 65 portamento off c = 92 tremolo c = 93 chorus c = 94 celeste c = 123 all notes Off v=0 c = 124 OMNI Mode Off v=0 c = 125 Omni Mode On v=0 c = 126 Mono Mode On v=0 c = 127 Poly Mode On v=0 (123–127 All Notes Off) v = note volume 0–127 (0 = Note Off 127 = Note On)
1100nnnn	0ppppppp		Program Change	n = channel number 0–15 p = program 0–127 (tone or rhythm pattern storage —typically 32 ROM, 32 RAM)
11110011	0sssssss		Song Select	s = song 0–127 (song or rhythm sequence typically 8 ROM 8 RAM)
11111000			Clock	Transmitted when internal clock is selected
11111010			Start	
11111100			Stop	

Modes

The 16 channels can be used in four different modes compiled from OMNI ON/OFF, POLY and MONO (see Table 3) and these cause the most confusion. In OMNI ON mode a receiver will recognize the messages on all channels without discrimination, which

Table 2 - Midi Implementation Chart

Function		Transmitted	Recognised	Remarks
Basic Channel	Default Changed	1–16 1–16	1–16 1–16	Memorised
Mode	Default Messages Altered	Mode 3 X ••••••••••	Mode 3 POLY/MONO Mode 1–3, 2–4	OMNI ON/OFF ignored
Note Number	Range	36–96 ••••••••••	0–127 36–96	0–11, 12–23, 24–35=36–47 97–108, 109–120, 121–127=85–96 ●
Velocity	Note On Note Off	X X 9n v=0	X X 9n v=XX	XX=ignored
After Touch	Keys Channel	X X	X X	
Pitch	Bender	O	O	8 bits effective 0–12 half tones
Control	1 6 64 93	O X O •OX	O O O O	Vibrato Master Tune Sustain Pedal Chorus
Program Change	Range	O 0–63 ••••••••••	O 0–63 0–31, 32–63	0–31 preset 32–63 memory
Exclusive		O	O	Timbre, sequencer data and others
Common	Song Pos Song Sel Tune	X •OX 0–16 X	X X X	
Real Time	:Clock :Commands	O O	O (Midi mode) O	
Aux: Local ON/OFF Mes: All Notes OFF sag: Active Sense es: Reset		X O X X	O O X X	
Notes		•OX Whether or not the data for these items can be transmitted can be set. ● Numbers change when transpose switch used.		

Mode 1: OMNI ON, POLY Mode 2: OMNI ON, MONO O: YES
Mode 3: OMNI OFF, POLY Mode 4: OMNI OFF,MONO X: No

Table 3 - Mode Types

MODE 1 - OMNI ON, POLY
Voice messages are recognized in all voice channels and assigned to voices polyphonically.

MODE 2 - OMNI ON, MONO
Voice messages are recognized in all channels and control only one voice monophonically. Only one sound is emitted.

MODE 3 - OMNI OFF, POLY
Voice messages are recognized in the channel selected by the receiver and are assigned to sound polyphonically.

MODE 4 - OMNI OFF, MONO
Voice messages are recognized in the channel selected by the receiver and are assigned to sound monophonically, and with a sequencer enables the assignment of different voices to individual channels, according to the capacity of the sequencer. This mode is useful if a polyphonic synthesizer is used to control monophonic synthesizers

could sound quite chaotic. In OMNI OFF mode a receiver will accept information exclusively on a selected channel. POLY means that more than one note can sound at the same time. The number of notes is dependent on the number of DCOs, or Digitally Controlled Oscillators, the instrument, or synthesizer has and how they are employed.

Eight note chords are playable for one oscillator, and double this for two oscillators, but a tone produced by using both oscillators can only make eight notes sound. MONO means only one note will sound on each channel. Other notes, in a different voice, can sound from other channels. Typically one channel could play bass line, another could play the solo line, a third could play first harmony, etc. One point to note here is that MIDI cannot turn a monophonic synthesizer into a polyphonic instrument.

Normally, when power is first applied to a MIDI device it defaults to Mode 3. Most keyboards transmit and receive, or recognize only in Mode 3, while synthesizers are also able to utilize Mode 4. The latter are normally capable of altering messages received in Mode 1 to Mode 3 and those received in Mode 2 to Mode 4. Rhythm machines normally default to Mode 3 to transmit, but also recognize Mode 1.

There are two kinds of MIDI messages: Channel messages and System messages. Channel messages contain channel numbers, Voice messages and Mode messages. The most basic of these are Note On and Note Off. The Note On message includes what key and how hard it is pressed. The Note off indicates what key is released. Key numbers can be assigned to the drum voices of a rhythm machine. Control keys such as vibrato and sustain are communicated as Control Change messages.

A MIDI Master device can deliver Mode messages to slave devices. Program Change messages are associated with tone colours or rhythm patterns stored in memory and vary with each instrument. Only by comparison can tones by matched. System messages can be set without setting a MIDI channel. These include Song Select, which are arrangements utilizing the tones, or patterns stored in Program Change; Clock, which is set for Internal on the Master and MIDI on slave devices and the Start/Stop functions. Exclusive messages are used in the tone colour data of synthesizers or for communication of sequencer data. It is original for each manufacturer with its own ID number.

Table 2 is a typical MIDI Implementation Chart usually supplied as a standard form with all MIDI instruments. This should be studied in conjunction with the channel message table. ■

The Car

Ideas from automakers on wh-

By Bil

In this article, you'll find various estimations, guesses and prognostications from automobile manufacturers on the subject of future engineering developments. Some of the technology, such as 4-wheel steering, is a reality now, and the discussion is really one of marketing projections. Sometimes what seems like a good idea just doesn't sell (see *Edsel* in the encyclopedia).

Sometimes the predictors just can't foresee some remarkable new development. The computer-on-a-chip surprised everybody. Occasionally, they go in the other direction; the pop-sci magazines of the 1940s and 50s had us all flying to work in helicopters and living on vitamin pills.

And lastly, there's always the problem that car makers are not going to tip their hands and reveal any new technique that they're saving as a sales stimulator.

I realize that I've prefaced this article with more clauses and disclaimers than an insurance policy, but trying to predict the future puts you way up there in the egg-on-the-face big leagues.

A lot of the information from the automakers doesn't seem to be all that futuristic, but you have to remember that the big auto companies are fairly conservative and rather slow to adapt new technologies. The gadgetry you see in their show-car designs may appear in showrooms five to ten years from now.

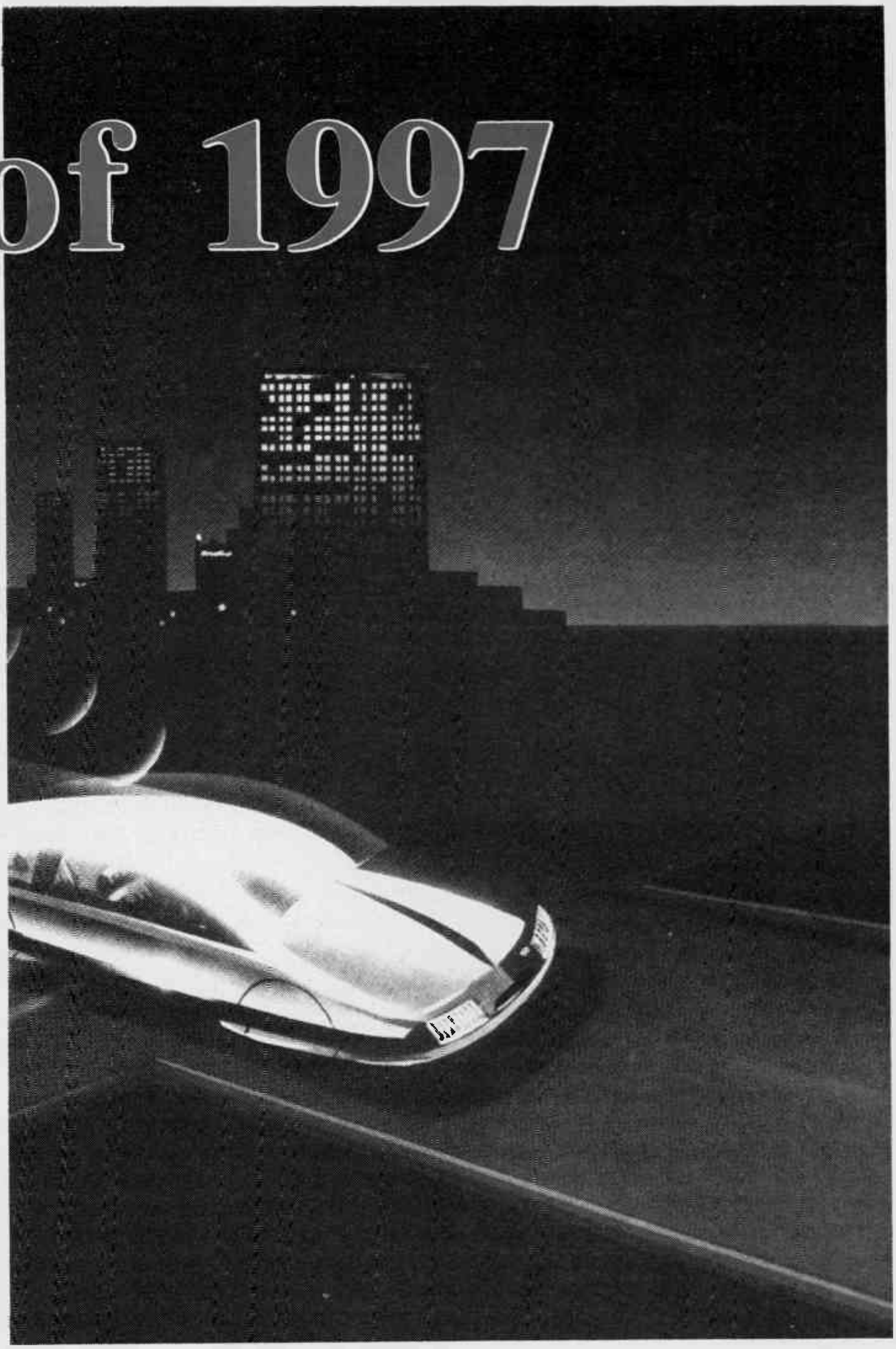
Nissan's Cue-X

The Nissan Cue-X is an actual prototype, used to test hi-tech innovations. You can't buy one, nor are you likely to be able to, because it functions as a testbed for futuristic ideas. It has all the options that can be fit into it, and would naturally be in the luxury personal car range if it were on the market. However, that's not to say that some of the features won't appear in regular models at some point.

The aerodynamic styling is based on the sleeker cars of today, as are most of the "cars of the future" we've seen. You can only do so much with a four-wheeled rectangle. Still, the aerodynamic drag is very low at 0.240, allowing the 300HP engine to give a top speed of 250km/h. This top speed is said to be for strain- free cruising with the expected higher speed limits of the future. To provide high-speed stability, the front and rear spoilers are driven by motors to project and reduce the moment of yaw (rotation of the car around its centre as seen from above). In the rain, the spoilers project at 50km/h to increase downward forces and prevent aquaplaning. In heavy braking, the rear spoiler is raised to act as an air brake, increasing the drag coefficient from 0.240 to 0.302. How well these aerodynamic spoilers will work in general remains to be seen.

In all the future projections, cars are powered by reciprocating piston engines. The fantastic new engine-of-the-month that you see on newsstands have so far remained as laboratory novelties, with the possible exception of the Wankel rotary; it never lived up to its promise, but it at least worked. The Nissan Cue-X is based on a conventional 2,960cc single-overhead-cam V6. You

# of 1997



you'll be driving in the future.

Markwick

can't beat tried-and-true technology.

Where the engine is unusual is in the refinements of the auxiliary equipment. This equipment seems standard if you look under the hood: turbocharger, computer control, fuel injection, etc. It's the engineering approach that takes them out of the ordinary.

The **turbocharger**, for instance, has two ceramic turbines in parallel, minimizing the time required to spin up and reducing the turbo lag. An electronically controlled flap on the air inlet is used to tune the airflow to the engine's requirements; this impedance-matching system provides higher torque at low speeds and higher horsepower at high speeds. Since compressing the incoming air heats it and thus reduces its density, an intercooler is fitted to reduce inlet air temperature. While this feature is fitted on today's cars, Nissan has cut the size in half by using a liquid refrigerant as a coolant instead of air. The unwanted heat energy is expended in terms of the latent heat required to vaporize the liquid, which is then condensed in an air-cooled heat exchanger.

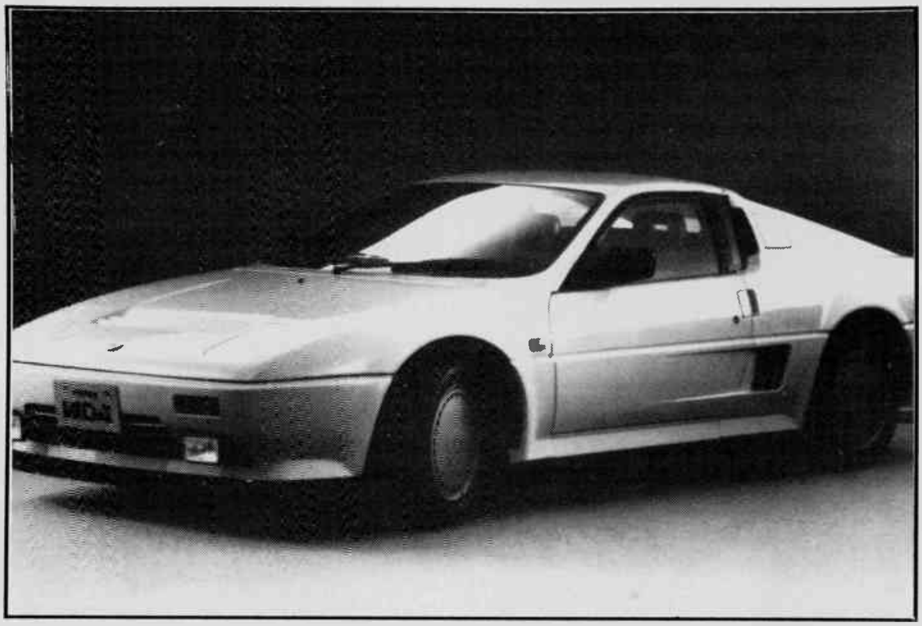
In the **ignition system**, the spark plugs are fired by piezoelectric elements mounted on each plug and fired by a low-voltage control signal. This eliminates the usual distributor and high-tension wiring. Spark plugs also contain a piezoelectric transducer which monitors combustion chamber pressures. Should detonation ("knocking") occur, the control computer can retard the spark; each cylinder can have its own timing adjusted individually.

The **cooling system** is unusual in that variable temperatures can be obtained, high for fuel economy at low speed, low for power in highway driving. Electronically controlled valves direct the coolant flow for uniform engine wall temperature. The coolant is actually allowed to boil; the use of the latent heat of vaporization gives enhanced cooling without increasing system size.

The **drive train** is four-wheel drive, electronically controlled to send the proper amount of torque to each wheel. A wet multi-plate clutch is hydraulically controlled to allow a variable torque split of 0% front/100% rear to 60% front/40% rear. Four-wheel steering for 7% of low-speed rear wheel control and electronically-controlled air suspension, plus anti-skid braking provide the optimum conditions for vehicle control.

The **instrument panel** is digitally generated and displayed on two cathode-ray tubes and a liquid-crystal-display. Five different modes are available from the controlling software, giving the driver digital readouts, analog bargraphs, engine performance readouts and more. A pressure sensor in each tire broadcasts to a pickup in the wheel hub; readings are displayed to warn the driver of low pressures, or even of a blowout, since the tires have a limited ability to run even when deflated.

For **driver information** systems, a Global Positioning System receives information from satellites and gives the driver navigational information on a 9-inch CRT; it's said to be precise enough to guide the driver through city streets. A laser radar system detects cars in front of the Cue-X within 120 metres, and can



Nissan's Mid4, a car which shares many technical features with the Cue-X, and has similar styling.

either display them or activate a collision-avoidance braking system.

There's an innovation called the "Drive-By-Wire" system, a name adapted from aerospace terminology. Stepping on the accelerator sends an electronic signal to the computer, which takes a look at the vehicle speed, transmission gear, and engine speed, and then activates the throttle through a servo. The idea is to provide fine control of throttle settings at lower speeds and large throttle openings for acceleration, etc. I think we'd all reserve judgement on that one.

Lastly, as mentioned before, there's nothing on the Cue-X that hasn't been at least tried already; it's the way that the Nissan engineers have optimized and implemented the features that make this car such an attractive design. Most of the features are practical, sensible applications rather than hi-tech sparklers to stimulate sales. Missing from their documentation is any mention of pricing, or whether they've solved the problem of poorly- designed emission controls that plague today's cars. Nor do they mention fuel problems — at some point we really do have to wean ourselves from petroleum; presumably the engine would use propane or natural gas.

Ford's T-2008

Ford has gone out on a limb and described what the car of the year 2008 will be like, hedging their bets with an opening sentence that says no one knows for sure. While that's true enough, the T-2008 is based on reasonable projections.

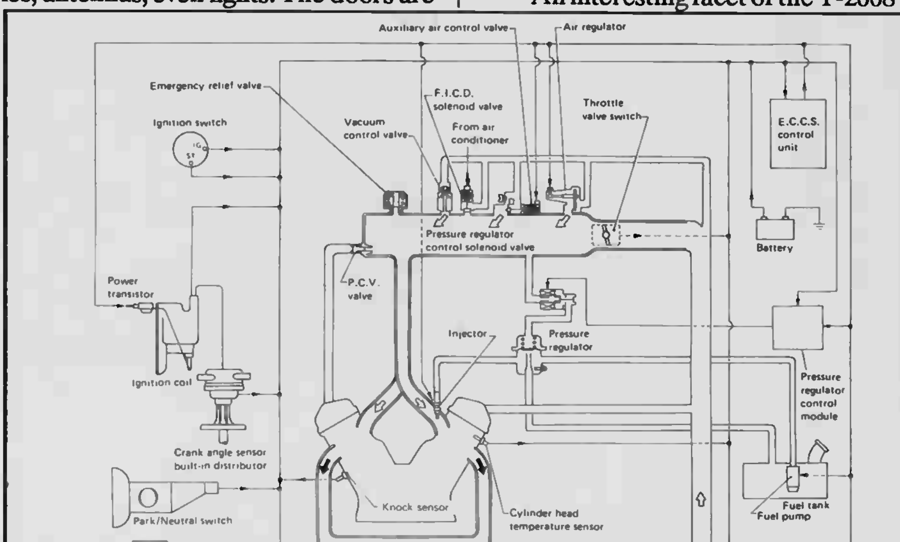
The styling is the usual futuristic aerodynamic type somewhat reminiscent of a smoother, flatter Taurus. In fact, if the car of the future is styled the way all the makers say it will be, it will look 20 years old when it's released.

The car's surface is devoid of handles, antennas, even lights. The doors are opened by touchpads built into the body, and the lights are actually part of the body panel, unseen until illuminated, and can change shape and intensity to "clearly communicate the driver's intent". I wonder how it would communicate "I don't know what I'm doing so I think I'll turn left from the right lane" as many Toronto drivers are wont to do.

The seats automatically adjust to a "best fit" position when you slide in. Now that would be something. I've been in a lot of cars that had seats that adjusted tens way to Sunday, and not one provided a "best fit", a particular problem if you're tall. I think that's why they invented the sunroof — it's to let the top of your head poke out.

There are no mirrors; instead multiple infrared cameras scan around the car and display on a screen above the "Driver Information Module" (dashboard). The infrared works equally well at night or in bad weather, and there are no blind spots. Good stuff. I hope I don't have to wait for 20 years to see this one implemented. At the moment, stylists and economists rule over safety; some of today's cars have such restricted vision that it's like driving while looking through a keyhole. How do you back up? Close your eyes, cringe, hit the gas and hope.

An interesting facet of the T-2008 is



The present-day computer monitoring of an Nissan engine is shown in schematic form above. These methods will be extended considerably in the future.

that it is constructed from basic building blocks or modules. This means that you can have the configuration of your choice: station wagon, 4-wheel drive, 4-wheel steering and more, not only from the factory, but any time. If you wanted a bigger car for a vacation, you could fit on a larger module.

The T-2008 has 12 pre-programmed instrument panel modes, giving the driver the instrumentation format of choice. Think of that. For years now, automotive critics have been screaming about idiot lights and the lack of gauges. In 2008, there'll be so many you won't understand them.

The T-2008 has the usual handling-safety devices such as anti- skid braking, but Ford also feels that collision-avoidance systems will be fitted to prevent you from making unsafe moves: "In an absolute emergency, the system will take over so that it is virtually impossible for a T-2008 to hit another object." While I don't wish to be cynical about the good folks at Ford, I have to point out that, like the law of gravity, Murphy's Law is not subject to repeal.

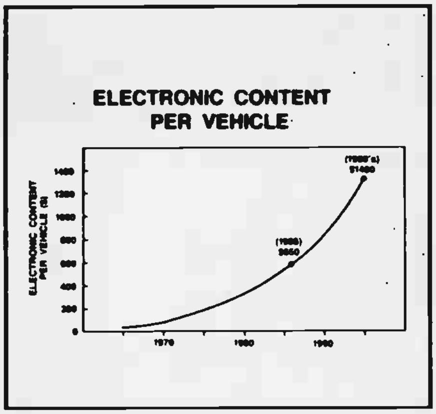
On the subject of fuel: the T-2008 can burn either gasoline or alcohol, and a hydrogen-fueled engine is said (in 2008) to be "in the final stages of development".

Another interesting point is that "all new vehicles on the road will be able to communicate with each other". The idea is to act as an adjunct horns and sirens, but it gives an image of the cars communicating with each other in much the same way that drivers communicate when one cuts the other off in hot, rush hour traffic.

Electronics

Mr. Jerome G. Rivard, Chief Engineer of Ford's Electrical and Electronic Division, gave an address to the Semiconductor Industry Conference, in which he addressed the challenges in automotive electronics.

The real application of electronics and computer control is of course in the manufacturing end. Every facet of the process could be under computer control or monitoring. As far as the car itself goes, computer control will play an increasing part. Low-cost models now have CPUs to run the emission controls and ignition, and on the luxury models we find electronic doorlock codes, distance-to-destination and fuel-remaining computers and similar functions. On



The value of the electronic content has skyrocketed since the advent of low-cost solid-state devices.

future cars we may see just about everything monitored: four-wheel steering, brakes, all engine parameters and so forth.

Mr. Rivard addressed specific problems facing the industry now and in the future. One important topic was protection against Electrostatic Discharge (ESD). The more complex the semiconductor device, the more likely it is to be damaged by discharges, and the car is full of static, high ignition voltages and other glitches that can punch through chip structures. In addition, the device is particularly vulnerable when it has been removed from the car for testing or servicing; mechanics can't always be expected to employ grounding and other ESD-prevention methods. Protection circuits will have to be incorporated in the input and output circuits of the device itself.

Surface-mount devices (SMDs) are a natural for car electronics. These miniature component packages reduce the size of chips, resistors and capacitors, and lend themselves to automated assembly techniques. The small size taken up on the printed circuit (and their low cost) means that complex electronic features are easier and easier to add to regular car models. The lower-priced cars will soon be featuring electronic gadgetry reserved for the expensive marques at present.

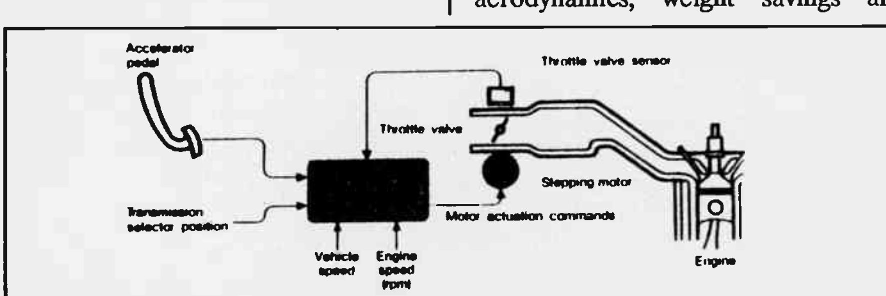
The multiplex wiring system will replace the large, complex cable harness with a single bus; each electrical device will have a smart switch in it, perhaps controlled by computer bits sent over fibre optics or signals riding on the power voltage itself. This technology exists at the present, but has been kept off the production line by the lack of a low-cost switching device. What's needed is a solid-state switch which can be inserted in the 12V line or high side (rather than connecting to ground) and has status feedback and complete overload protection.

The best choice so far is the power MOSFET, a transistor which draws no current from the control line, and has very low on- resistance. At the moment, the best of the power FETs still have a much higher resistance than a closed mechanical switch or relay, and cost considerably more. Further, the P-channel types which lend themselves to insertion in the high side cost very much more than the N-channel types which are best suited for switching to ground.

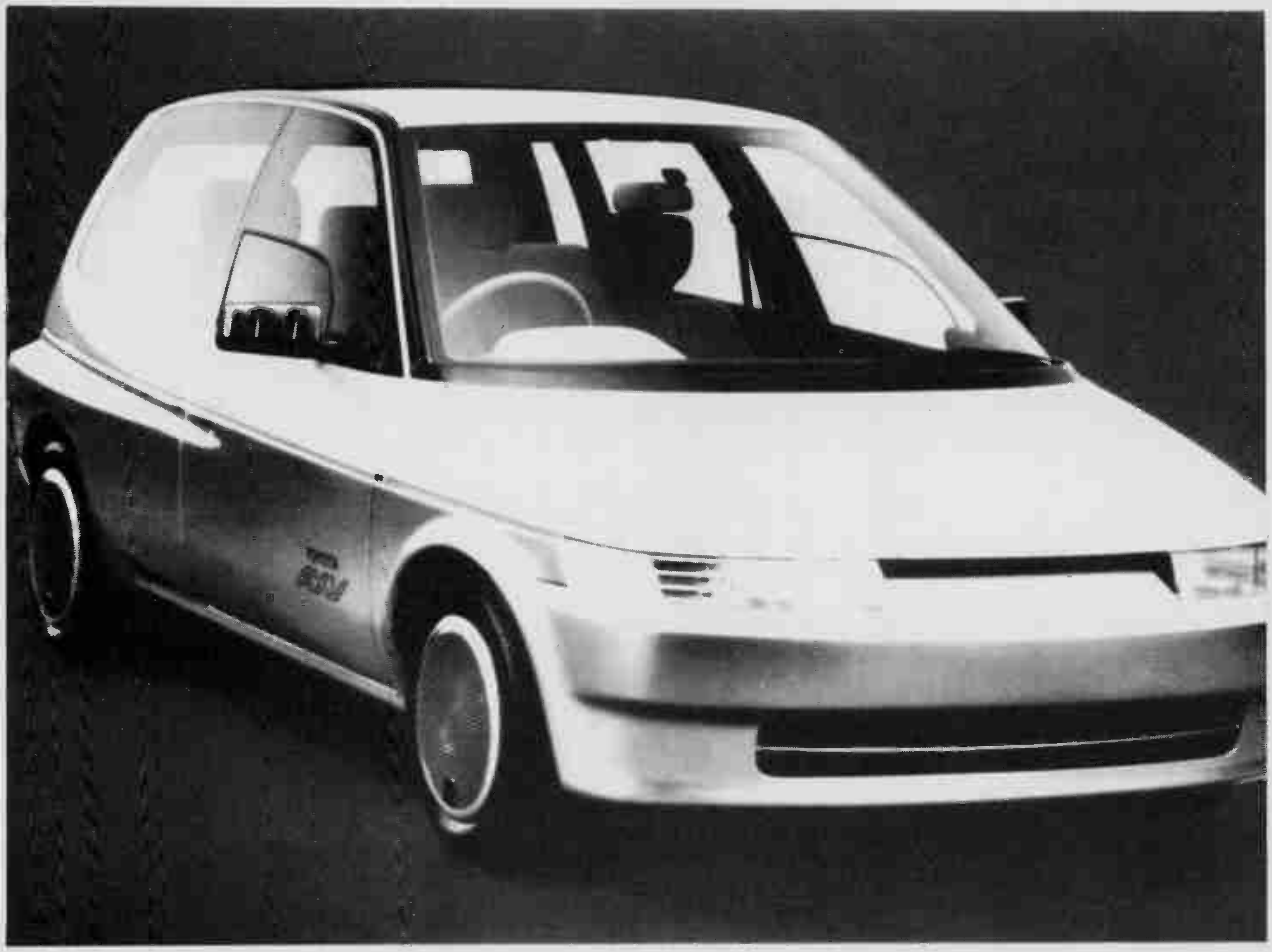
Mr. Rivard said "For starters, we need a maximum cost of $2 for a 20-amp high-side switch which has on-resistance performance of less than one volt. For widespread automotive applications, we need to drive the cost down to $1 and have a one-tenth volt drop across the device."

Toyota

Toyota showed their AXV experimental vehicle at a car shopw in Toronto this year. The AXV is not an all-up luxury car with every possible option, but an attempt to provide the best engineering approach to "a vehicle combining ultra-low fuel consumption, styling and comfort (by concentrating on) aerodynamics, weight savings and



The beginnings of a "drive-by-wire" system as used on the Cue-X.



The Toyota AXV experimental vehicle was shown in Toronto this year. It was designed as a lightweight, ultra-high-mileage car, and bears this out with a weight of only 1340 pounds and a fuel economy of 153 miles per gallon (54km/l).

drivetrain".

Like all the future models, the AVX has the teardrop styling, producing a drag coefficient of 0.26 by means of flush surfaces, shaped wheel arches and a flat floor.

The 1.1 litre engine is a 3-cylinder turbo-diesel mated to a continuously variable transmission. Continuously changing pulley widths provide stepless gear ratios under electronic control. The fuel injected, electronically controlled engine produces 55HP. The fuel economy was 54km/l at 60km/h (153mpg). The remarkable fuel economy was achieved through the efficient engine/transmission and the use of composite materials to reduce the weight to 1340 pounds.

Into the Future

Some of the features described are from a car fan's wish list, while some of the them may become standard equipment on most models. Some good ideas will die out when it's found that they don't adapt to mass production. And, of course, new inventions could change everything drastically at any time, just as the microprocessor revolutionized electronic control. You never know what might come from a research lab.

The car makers who submitted material to us were all concerned with safety, and all of them took the approach of increasing crash-proofing and better collision-avoidance systems. How well these lab models would actually work in crowded city conditions can only be worked out in actual use. Perhaps a city full of collision avoidance beams might make driving a bit erratic, what with the car taking over from you every now and then, or perhaps the microprocessors and software will be smart enough by then to sort it all out imperceptibly.

To sum up: there aren't any real surprises if you base the future on today's technology; as you'd expect, the surprises will come from inventions and discoveries as yet unthought of. 4-wheel drive and 4-wheel steering will become popular, as will complete monitoring of all vehicle functions (*"Beep. Your muffler is two years old and ready to fall out in the street. Beep."*). Car engines will be based on pistons well into the future, and will adapt to gasoline, gases, alcohol, etc. Fuel economy will be much higher thanks to CPU control of engine conditions.

Within ten years, the cars of the early 80s will look like technological dinosaurs.

Bill Markwick is the Editor of E&TT. ■

Model Speed Control

Build this handy DC motor speed control for models.

By Owen Bishop

This circuit gives very realistic effects when used with models, for it holds the motor at constant speed, even though the load on it varies, and even when the motor is set to turn slowly.

The circuit diagram for the Model Speed Control is shown in Fig. 1.

How It Works

When a motor is running, it generates a voltage (called a back e.m.f.) that is opposite in direction to the voltage (driving e.m.f.) applied from the battery. The back e.m.f. is proportional to the speed, is greater if the motor is going at maximum speed, and is zero when the motor is still.

When the motor is running, the back e.m.f. partly cancels out the driving e.m.f., so that the current that flows to the motor is just enough to keep it turning at that speed. If we suddenly apply a mechanical load to the motor, the motor turns more slowly. This means that the back e.m.f. is reduced, so that more current flows through the motor. If the load is enough to stop the motor turning, there is no back e.m.f. and the full driving e.m.f. causes a large current to flow through the motor.

Motors are generally designed to take the small currents that flow when they are running, but not the large currents that can flow when they are jammed. The coils of the motor may burn out if it is prevented from turning. To obtain steady speed and to avoid the danger of burning out, we need to be able to sense the e.m.f. that is actually supplied to the motor terminals (driving e.m.f. minus back e.m.f.) at any given speed and know how it changes under changing load. We also need to be able to increase or decrease the driving e.m.f. so as to keep a steady current flowing to the motor. This is where an op amp can be of great help.

The speed of the motor is set by the voltage we apply to the non- inverting input pin 3 (+) of the amplifier. By altering VR1 we can apply any voltage between 0V and +3V.

When a voltage of 1V, for example, is applied, the amplifier output goes high, sending base current to transistor TR1. this turns TR1 on and current flows through the motor. As this happens the voltage at A rises. As it rises, the voltage at the inverting output of the op-amp pin 2 (-) rises too, for this is also connected to point A. The voltage difference between the two op- amp inputs is thus reducing the current to the motor slightly.

Now suppose an extra load is applied to the motor. The motor turns more slowly, this reduces the back e.m.f. and makes the voltage at A rise suddenly. But at the instant that this happens, the op-amp senses the change. As explained above the difference between the voltage at its inputs becomes less than before, so its output current falls.

The transistor TR1 is turned off just enough to keep the voltage at A from rising above the original value. If the load is removed from the motor, it is able to turn more quickly, and the back e.m.f. increases.

The fall in voltage at A increases the difference between the input voltages, output current increases and TR1 is turned on a little. Once again, the op-amp acts to keep the voltage at A constant. In short, a rise in voltage at A reduces the current, making the voltage at A fall again. Conversely, a fall in voltage at A increases the current, making the voltage at A rise again. Thus, the action of the circuit is to maintain a constant voltage at A, its level depending on the setting of VR1. The motor turns

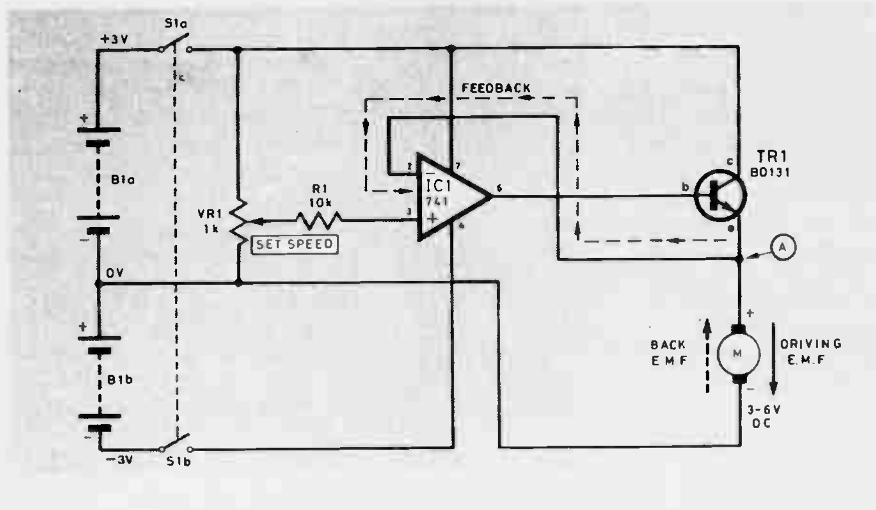


Fig. 1 Complete circuit diagram for the Model Speed Control

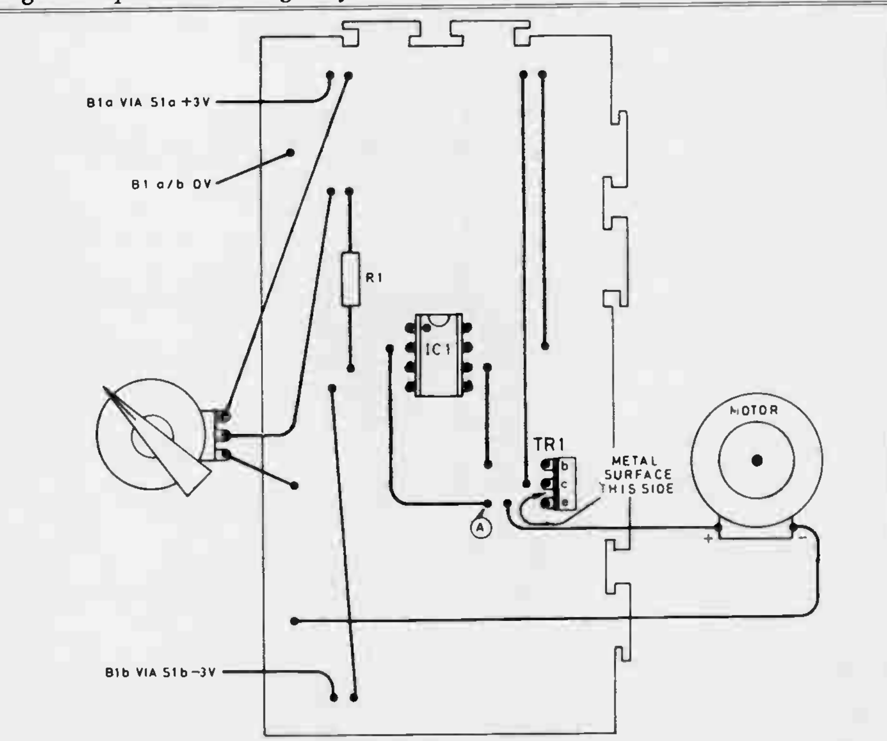


Fig. 2 Breadboard layout of the Model Speed Control.

Parts List

Resistor
R1 .... 10k 0.25W, 5% carbon

Potentiometer
VR1 .... 1k horiz. mini. preset or rotary spindle type

Semiconductors
TR1 .... BD131 or 2N4923 medium power npn
IC1 .... 741 op. amp.

Miscellaneous
S1 .... DPST toggle sw.
B1a,b .... Four 1.5V cells or PSU unit (See Fig. 3)

Breadboard; 8-pin DIL socket; connecting wire.

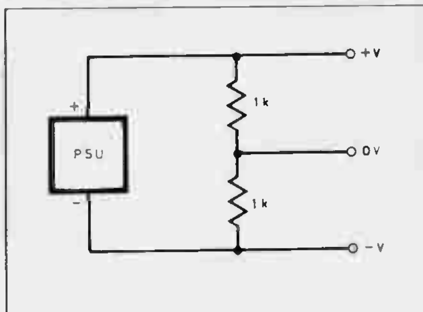


Fig. 3 Using a 12VDC PSU to provide a split supply for the circuit.

at constant speed. If we vary the setting of VR1, the circuit always comes to a stable state with the motor running at a steady speed.

Construction

The demonstration breadboard component layout for the Motor Speed Control is shown in Fig. 2. Commence construction by inserting the IC, resistor and transistor on the test bed. This should be followed by the link wires and lead-off wires to the motor, speed control potentiometer and the power supply via switch S1.

This circuit is designed for small motors that run on 3 to 6 volts supply. If you want to use it with motors that need higher voltage, you may increase the voltage of the supply to the op-amp. Remember to increase both halves of the supply by equal amounts.

The maximum voltage allowed is +18V and -18V; the transistor can take a current up to 3A, which is just enough for most small motors. If you find the transistor gets hot, bolt a heatsink to it. You can buy a heatsink, but it is easy to make one from a small piece of aluminum sheet.

If you need to run a motor that takes heavy current use a 2N3055 transistor, which can take up to 15A. Note that only direct-current motors can be controlled by this circuit.

Feedback

The motor control circuit provides a good example of this technique. The output of the circuit can be considered to be the current arriving at point A. Most of this proceeds to the motor, but a minute proportion of it is fed back to the inverting input (pin 2) of the op amp. As explained earlier, the effect of feedback in this circuit is to counteract any changes in output such as those caused by variations of back e.m.f.

Since the feedback acts to counteract changes in output we call it negative feedback. In general, negative feedback is used to produce stability in the operating condition of a circuit. ■

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Logic Efficiency and the CHMOS Chip

Lowering the power consumption and raising the speed

By Dr. H. Virani

CMOS technology has been in existence for approximately 20 years. During this time it has been applied to specialized applications requiring its unique low power characteristics. The low power consumption of CMOS is achieved by incorporating an n-channel transistor and a p-channel transistor in series to build the basic inverter of digital circuitry.

Because the n-channel and the p-channel devices operate in a complementary fashion, at steady-state conditions one transistor is active while the other is shut off. As a result, only leakage current can flow through the series transistors from the power supply to ground. The transfer characteristic shown in Fig. 1 illustrates the conditions under which current can flow. As the gate potential of the transistor increases, it begins to conduct, and current can then begin to flow through the inverter circuit. When both transistors are in the linear region, region C, current flow is at a maximum. This region is a transitional zone and as such is traversed quickly. It is the current flow during the transition from steady-state logic levels, regions A and E, that cause power consumption. Additionally, circuit capacitance must be charged and discharged as the logic levels change from one state to the other. This also causes power consumption. Once steady-state conditions are reached, power consumption is negligible.

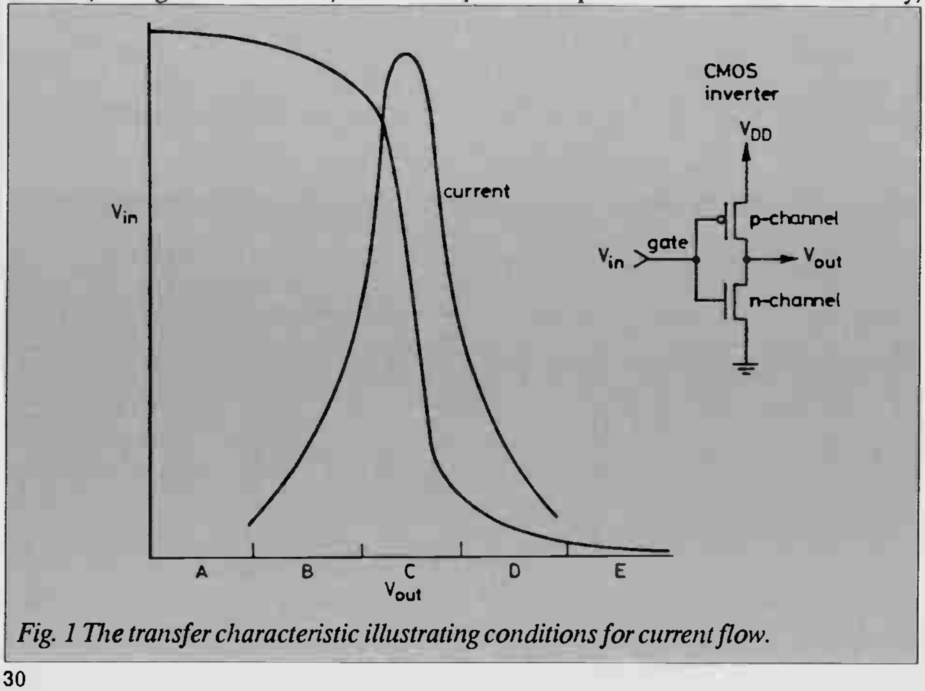


Fig. 1 The transfer characteristic illustrating conditions for current flow.

Speed and Power

Until now, CMOS has not developed into a main stream technology for several reasons. First, NMOS construction uses fewer processing steps and is less expensive to build. Secondly, NMOS offers a higher density of functions. Thirdly, because speed of operation has been sacrificed to keep power consumption low. CMOS is slow in comparison with NMOS and bipolar technologies. A comparison of the major technologies is shown in Fig.2.

The measure of a technology's performance is the product of its speed and power. In Fig.2, inverter power is plotted against inverter stage delay with constant energy levels plotted as diagonal lines. The ideal technology would occupy the lower left corner, consuming no power with delay. In general, however, the faster the technology, the more power it consumes. In the past, the tradeoff of increased power for increased speed was acceptable, and the relatively small power increase of NMOS over that of CMOS was a small price to pay for the tenfold increase in speed.

Two events have changed this. First, systems are becoming more sensitive to power consumption; this is especially true for large systems because of the cost of power and cooling. Also, a new class of personal, portable equipment such as personal laptop computers which must be battery operated and only consume minimal power is being developed.

Secondly, as VLSI circuits become more complex, more transistors are incorporated on the die and power consumption increases. Below 150,000 transistors, this power can be dissipated by conventional means but if there are more than 250,000 transistors on an NMOS device, however, the power dissipation increases exponentially. As a result, a practical limit to the number of devices on a die is being approached. In a search to solve both these problems, CMOS is being reconsidered.

To achieve increased speed, the sealing techniques of Intel's HMOS Process are being applied to CMOS. The result is CHMOS which has the low power consumption of CMOS and the high performance of HMOS. As shown in Fig.2 this technology offers the lowest power consumption and the lowest propagation delay.

The evolution of the speed-power product over the last decade is shown in Table 1; it has been decreasing by half with each new generation of technology. With each new generation, the geometries of the transistors must be reduced by the scaling factor to achieve the lower speed-power product. Physical limitations of the lithographic and electrical properties of the semiconductor material are the limiters in each new technology generation.

Scaling the transistor geometries reduces the channel length and the gate oxide thickness. The reduced gate oxide thickness increases the field strength and there is also a corresponding increase in the susceptibility to oxide breakdown causing catastrophic device failure.

Channel-length reduction increases the susceptibility to not-electron injection. This phenomenon changes the threshold of the transistors and causes the device propagation delay.

Simplified Design

CHMOS not only has low power consumption, but can also enhance the device performance by permitting more efficient device design. For example, consider a dynamic RAM built in CHMOS, such as the Intel 51C64 64 kbit DRAM. Taking advantage of the low power consumption of CHMOS, the device designers are able to employ static circuits in the device and thus simplify the design.

Previously, dynamic RAMs incorporated complicated, timed dynamic circuits to reduce power consumption. Careful timing analyses had to be performed to guarantee that timing variations owing to manufacturing variances in the process would not cause the device to fail. As a result, these clocks had to be slowed for worst- case operation with a corresponding decrease in the overall device speed. A comparison of an MMOS DRAM with the CHMOS DRAM is shown in Table 2. Performance of the CHMOS DRAM is improved by at least 50% over the NMOS DRAM.

Table 2 shows a reduction of the soft error rate (SER) by a factor of 100. Soft errors are failure mechanisms of DRAMs in which a random single memory bit changes state. Alpha particles created by residual radioactivity in the package material penetrate the silicon and generate hole-electron pairs.

If sufficient electrons are generated in the vicinity of the storage cell, the state of the cell can be charged by collecting the generated electrons in the well. One remedy for soft errors has been to increase the charge stored to be greater than the electrons generated by one alpha event. Although not eliminated, the soft error rate has been reduced to 0.1% per 1000h.

In the 51C64, two factors, the increased storage capacitance and the technology, reduced the soft error rate by a factor of 100. The reduced number of clocks and the static circuitry permit more silicon area to be used in the memory array as shown in Fig. 3.

As such, the increased storage area increases the storage capacitance and the

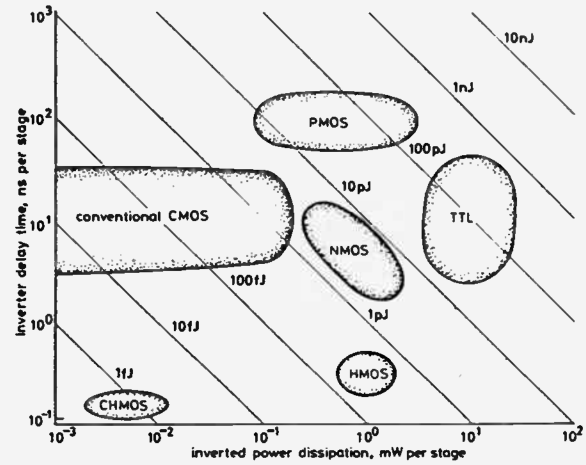


Fig.2 Inverter power plotted against inverter stage delay. Diagonal lines represent constant energy levels.

Table 1 - Evolution of Speed-Power Product

Technology	Speed-Power Product (pj)	Year
NMOS	2.0	1975
HMOS	1.0	1977
HMOSII	0.5	1979
CHMOS	0.04	1983

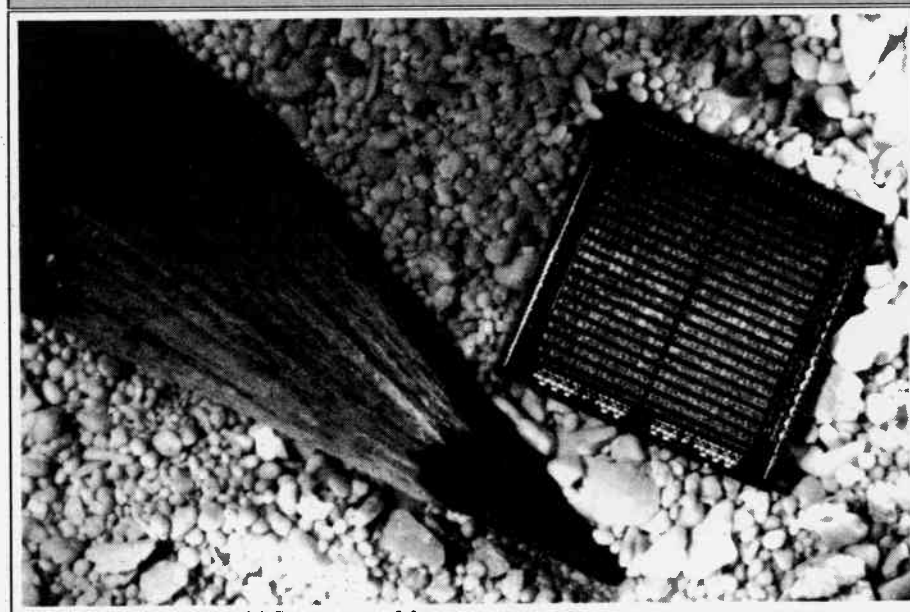


Fig. 3 A typical CHMOS memory chip.

stored charge. Also, the distance between the capacitor plates has been reduced from 25 nm to 12.5 nm.

Secondly, the structure of the array also provides an effective barrier to soft errors. As shown in Fig. 4, the memory cell is contained within an n-well. The P substrate and the n-well then form a p-n junction, with the n-well tied to vcc to reverse bias the junction. Holes rather than electrons are the storing mechanism. Now, when an alpha event creates hole-electron pairs, the electrons are swept to the power supply and the holes are repelled by the reverse-biased junction. Because of the shallowness of then well, even if the alpha particle travels through the well, the probability of sufficient holes collecting in the storage area to cause a soft error is extremely small.

Previously, to obtain acceptable system reliability, system designers incorporated error correction circuits (ECCs). While they did improve the reliability by a factor of approximately 100, the system performance was degraded due to the increased number of devices. A 16 bit word requires six additional bits to include error correction, accompanied by a 37% increase in the memory-device cost.

This additional memory also required more PCB space, an increased power supply and cooling requirements. All this results in a larger, more costly system and the system performance is also degraded. Memory-cycle time is even more dramatically affected. In microprocessor systems, 8 bit write operations are allowed. To maximize the efficiency of ECC, word width is typically 16 bits. To perform a byte write, the system must now read the 16 bit word, correct it, merge the new data with the unchanged 8 bits, create the new error protection code and rewrite the data to the memory. As a result, the memory cycle time is increased by 68%.

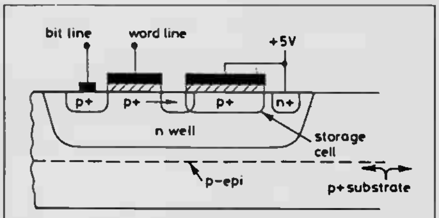


Fig. 4 The location of the memory cell within the n-well.

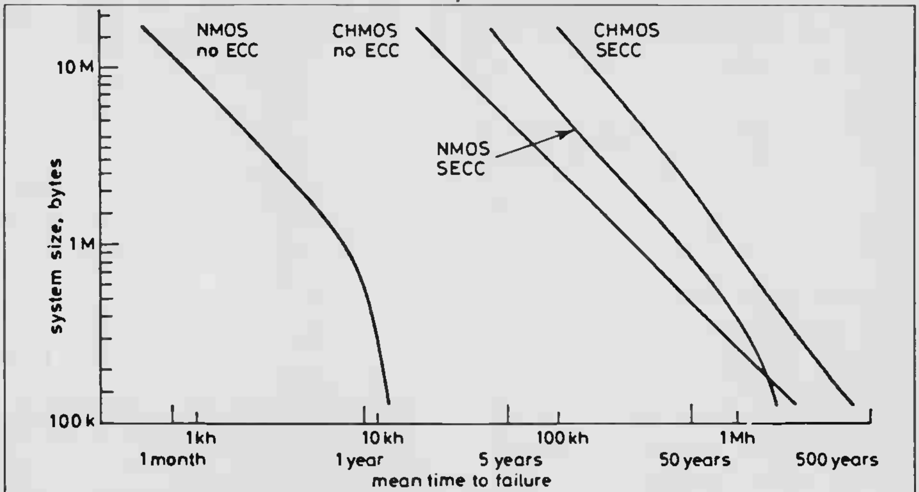


Fig 5. The system reliability plotted against system size for the Intel 51C64.

The low soft-error rate of the 51C64 changes all this. System reliability plotted against system size is shown in Fig.5.

For a 256 kbyte system, reliability without ECC is equivalent to that of an NMOS DRAM with ECC. The increased reliability of the 51C64 is achieved without any degradation in the system performance and it is in fact better for the 51C64 than for an NMOS DRAM.

The evolution to CHMOS from NMOS offers far more than low power. Combining CMOS technology, with scaling techniques provides enhanced device performance with a corresponding system-level improvement and increased reliability without a performance penalty.

Dr. H. Virani is a freelance writer from Mississauga, Ontario. ■

The Electronic Mariner

A look at the changing market for seagoing computers.

By Robert T. Gallagher

The Hewlett-Packard Vectra is at present the only stock computer approved for marine use without modifications.

If the shipping industry appears to have been slow in giving merchant vessels their own data processing capability, and in reaping the advantages of it, that tardiness is not easily explained in terms of conservatism alone. There are many progressive shipping companies that recognize the role of technology in maintaining competitiveness.

There is another practical element to be considered. Any stock computer, taken off the shelf and pressed into service on board a ship, would probably not offer the level of reliability required for general use, let alone for the operation of systems which affect a vessel's safety. The obstacle holding back development of maritime computing has been as much a dearth of suitable hardware as a resistance to new technology. Within the past year this situation has changed significantly. Spurred on by a decision by the International Association of Classification Societies to require most merchant vessels to be fitted with an approved loading indicator system, a host of suppliers is queuing up to sell shipowners data-processing hardware new type-approved for maritime use.

Enter the Micro

Until recently such loading systems took the form of dedicated instruments based on analog computers. Now specialized software running on a standard microcomputer provides a more powerful and economical tool. The main Classification Societies, notably Lloyds Register, Det norske Veritas and Bureau Veritas, have responded by publishing type-approval requirements for on-board computers.

This development presents suppliers of loading instruments with an obvious business opportunity. Once a computer is installed on board a vessel to execute loading calculations, that vessel's operator becomes a potential customer for a wide range of additional ship management and operation software. Though industry experts balk at estimating the potential size of the total market, they reckon that sales of hardware alone for shipboard use will reach some $25 million in 1987.

To benefit from that market, suppliers have to make certain that their gear is capable of operating in conditions far more stringent than those for which they were designed. Before being graced with the stamp of type-approval, resistance to vibration, heat, cold, humidity, salt spray, variations in power supply, dynamic inclination, transients, shock, UV radiation and dropping must be demonstrated.

The Marine Market

The marine market bears some striking similarities to the land-based microcomputer business, plus one essential difference.

The main similarity is that marinised computers are almost without exception standard microcomputers that have been adapted for operation in shipboard conditions. Because most commercially available microcomputers are sufficiently powerful to handle merchant shipping applications, suppliers reason that there is no sense wasting valuable time and resources in what would amount to an effort to reinvent the wheel. What is more, computers developed for marine use would be several times more expensive than standard machines.

Carrying this line of reasoning further, the majority of suppliers have chosen hardware based on the MS-DOS operating system as the backbone of their product offering. Most reckon that a standard IBM-compatible computer can handle all conceivable shipboard applications with the exception of maintenance planning. But even these programs, with their extended data bases, can be run comfortably on the more powerful PC-AT.

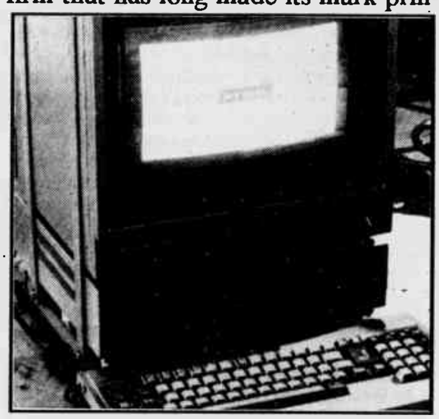
Another reason for offering IBM PC compatibility is that users automatically gain access to an enormous library of already available software while infinitely simplifying the task of programmers wishing to write dedicated maritime software. What is more, this affords an opportunity to assure that software purchased for operation on a given machine can be run on others. A customer's software investment is thus protected. A final point is that most of these standard machines can be easily serviced anywhere in the world.

The main difference between standard microcomputers and their marine counterparts is that almost all marinised versions are being offered by companies whose principal business is software and/or marine management systems rather than computer hardware. Presumably, the predicted marine computer usage is too small to temp giants like IBM, Apple, Olivetti and Compaq, companies used to competing in a worldwide personal computer market several orders of magnitude larger than the potential commercial marine market.

Software and marine systems houses are therefore filling the void by making the investment to have hardware type-approved for marine use and putting it in their own catalogs. The attraction in so doing is that they are simultaneously broadening the potential market for their own marine software. In addition to load analysis, many are offering proprietary programs for vessel performance analysis and maintenance trim and stability, stock control, and victualling accounting. Microcomputer equipped vessels will also be able to use standard software packages for spread sheets, planning, accounting and word processing.

Among those companies offering, or planning to offer marinised computers are the BSRA subsidiary of British Maritime Technology, Sira Ltd, Marine Management Systems, Keel Marine and Anchor Marine in the UK, Japan's Nippon Marine, Kokumation in Sweden and Consultas in Norway.

A notable exception is the US multinational company Hewlett- Packard, probably the only computer hardware manufacturer capable of delivering a marinised machine from stock. It is a firm that has long made its mark principally in certain specialized areas of the data processing market such as scientific and engineering applications and instrumentation. It is therefore reasonable to expect HP, more than the four largest personal computer manufacturers, to aim at serving the idiosyncrasies of the marine market.



HP's offering is its Vectra, a desktop computer compatible with the IBM PC-AT. According to a company spokesman, the Vectra required only a single modification to meet the type-approval requirements of Lloyd's register: a change of power supply to make it immune to the voltage swings common aboard ship. He also pointed out that the company is investigating the possibility of substituting that new power supply in the company's entire Vectra production. That would make even the standard Vectra a type- approved machine.

Type-approval

Many organizations trying to win type-approval for computers ran into power supply difficulties. But an official at Lloyds Register points out that by far the most common problem facing computers is a lack of resistance to vibration. Most need to be generally ruggedized and reinforced with external straps to qualify. A smaller number has required certain metal parts to be plated — usually recording arms of disk drives — to make them rust resistant in the corrosive marine atmosphere.

Nonetheless, the marinisation process for computers themselves appears to be well in hand. But some potentially stickier problems could be posed by efforts to marinise peripheral equipment, particularly for use in extreme conditions like those encountered on deck.

A typical problem is that such type-approval often required that the equipment function correctly at temperatures as low as −25° C. In the case of printers, operation of most models is impaired because ink is frozen at that temperature. In an effort to solve that snag, some suppliers have tried solutions as baroque as adding antifreeze to the ink. Most, however, are looking at the possibilities offered by less conventional technologies like thermal transfer and laser jet.

Neither of these, however, is sure to be appropriate. Thermal transfer is an old technology which required special paper, a nuisance most printer manufacturers have been trying to avoid for some time and which could create problems of supply on long sea voyages.

Laser jet printers undeniably avoid both the special paper and frozen ink snags. But they suffer from another inherent disadvantage. Laser printing technology was originally developed for high-speed, high-volume applications where increased productivity would offset its unavoidably high cost. It is difficult to imagine that any merchant vessel would generate enough paperwork to justify the purchase of a printer which costs several times the price of the computer driving it.

Perhaps the next milestone in the future of maritime computing lies in the solution of obstacles such as this one.

Robert T. Gallagher is the Technology Editor of Ocean Voice, the journal of the International Maritime Satellite Organization, in which this article originally appeared. ■

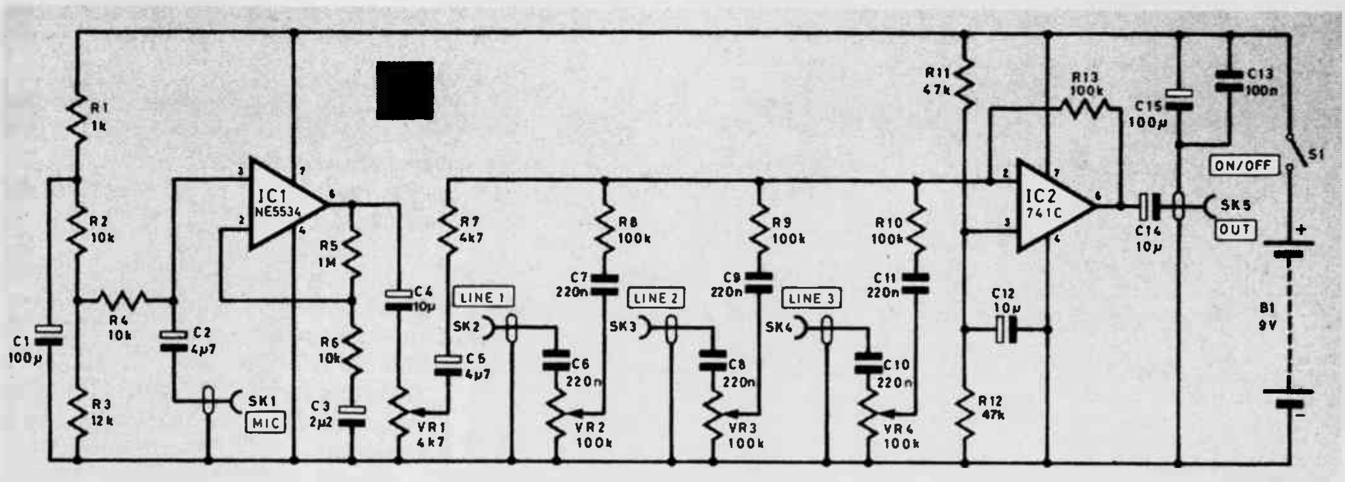


Fig. 4 Circuit diagram of the four channel Monomix.

two inputs are totally isolated, but this would give no output signal, and in practice RC is given the lowest practicable value. A low value means high losses through the circuit even with the faders at maximum gain, and normally a circuit of this type has to be followed by an amplifier to compensate for the losses.

Summing Mixer

If an active circuit is to be used there is a better way of doing things than simply having a passive mixer followed by an amplifier, and this alternative is to use an operational amplifier in the summing mode mixer configuration. Although this often seems to be regarded as a totally different concept to the passive mixer configuration, it is really very similar in principle. It is based on a standard inverting amplifier circuit (Fig. 2).

Operational amplifiers were originally intended for use in DC amplifying applications where they operated from dual balanced supplies, and in the inverting mode the non-inverting (+) input would be biased to the central 0V ground rail. In audio applications it is more usual for operational amplifiers to be powered from a single supply with a potential divider (RC and RD) providing a bias voltage of half the supply voltage for the non- inverting input. D.C. blocking capacitors are not included in Fig. 2, but would normally be included at both the input and the output of the circuit.

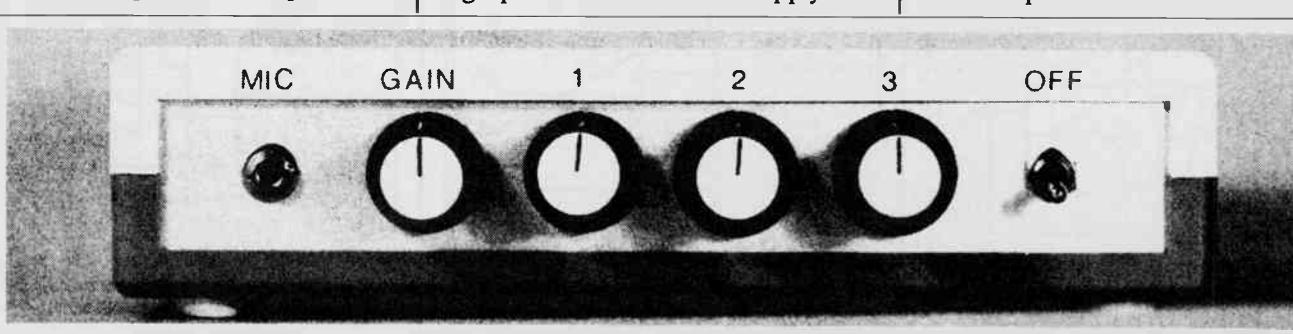
Operational amplifiers can be a little confusing at first as they have two inputs. What is actually being amplified is the voltage difference between the two inputs, and the output goes positive if the non-inverting (+) input is at the higher voltage, or negative if the inverting (-) input is at the higher potential. The voltage gain is extremely high at typically 100,000 times or more, and only a fraction of a millivolt is needed across the inputs in order to send the output fully positive or negative.

In this circuit the output assumes the half supply voltage bias level under quiescent conditions due to the negative feedback via RB. In other words, if the output should go more positive than this for some reason, even very slightly, the coupling through RB results in the inverting input also going more positive.

Bearing in mind that the non-inverting input is biased to half the supply voltage, this results in a voltage difference across the inputs which sends the output negative to reestablish the balance. If the output should drift negative of the bias level for some reason, this would again produce a voltage difference at the inputs, but of the opposite polarity so that the output is sent positive and the voltage difference is again eliminated.

If an input signal is applied to the amplifier, this upsets the balance of the circuit by altering the voltage at the inverting input. The output voltage will change in an attempt to correct this and rebalance the input potentials.

If we take a simple example, with the input taken one volt positive of the bias level, the output will go one volt negative. A potential divider action across RA and RB then sets the inverting input at the half supply voltage bias level, but this assumes that RA and RB are equal in value. If Rb is higher in value, then a higher output voltage swing is required in order to balance a given change in input voltage. The voltage gain of the circuit is equal to Rb/Ra, and this is termed the "closed loop" voltage gain, which should not be confused with the very high "open loop" gain of the operational amplifier itself.



The basic summing mode mixer circuit is shown in Fig. 3, and it only differs from the inverting amplifier mode in that there are additional input resistors (Re and Rf) which provide the circuit with its extra inputs. In operation it is essentially the same as the inverting amplifier, but the output takes up potentials that balance the sum of the input voltages. Taking a simple example, with input of +1, +3, and -2 volts with reference to the bias level, this would give a total input potential of +2 volts, and the output would be 2 volts negative of the bias level. This again assumes that all the resistors in the feedback circuit are of the same value, which they need not be. By making some input resistors lower in value than others, some inputs can be made more sensitive than others. The fact that the signal is inverted through the circuit is of no consequence as it makes no audible difference to the reproduced audio.

What is called a "virtual ground" is formed at the inverting input. In a DC amplifier circuit the inverting input is stabilized at the 0V ground potential by the negative feedback action, and although it is not genuinely connected to ground, the effect is much the same as if it was. In an AC circuit the inverting input is stabilized at a fixed potential above the (negative) ground rail, and still forms a virtual ground. In many cases this is all of purely academic importance, but in a mixer circuit it is of crucial importance as the virtual ground provides total isolation between the inputs. It seemingly provides the impossible by feeding the input resistors to a short circuit to ground but still providing an output signal, and an output signal which can be a greatly amplified version of the input signal at that. With the input resistors effectively feeding into a short circuit, the input impedance is equal to the value of the input resistor.

Circuit Description

The full circuit diagram of the Monomix mixer appears in Fig. 4, and this breaks down into two main sections; the microphone preamplifier (IC1) and the mixer (IC2).

Starting with the microphone preamplifier, this has operational amplifier IC1 in a simple non-inverting mode amplifier. R5 and R6 form a negative feedback network which sets the voltage gain at about 40dB (100 times) and R4 sets the input impedance at about 10K. The circuit is primarily intended for use with medium impedance dynamic microphones, or types which have comparable output characteristics (such as electret types with a built-in step-up transformer). The circuit has sufficient gain to operate with low impedance dynamic microphones as well, but it is not suitable for operation with crystal microphones.

Note that IC1 is a high quality low noise device which consequently gives the circuit an excellent signal to noise ratio. Inexpensive alternatives such as the 741C will work in the circuit, but will give something approaching ten times the noise level obtained with the NE5534.

The mixer circuit closely follows the basic circuit described previously, but the number of inputs has been increased to four, DC blocking capacitors have been added at the inputs and output, and a fader control has been included at each input. The input resistor for the channel which is fed from the microphone preamplifier is much lower in value than the other input resistors and feedback resistor R13. Whereas there is unity voltage gain from each of the other inputs to the output (with faders at maximum gain), there is over 26dB of gain from this input to the output. This gain is needed to augment that of the preamplifier which on its own would be too low for satisfactory operation with most microphones, especially low impedance types.

The circuit is powered from a small nine volt battery, and as the current consumption is only about 4.5 milliamps this is an economic way of powering the unit.

Construction

Construction is greatly simplified by having practically all the components, including the four potentiometers, mounted onboard. Details of the printed circuit board are shown in Fig. 5.

Neither of the integrated circuits are static-sensitive types, but the NE5534 is not a particularly cheap device and it would definitely be advisable to use a socket for this one. The capacitors must be miniature printed circuit mounting types if they are to fit into the available space, and obviously the potentiometers must also be of the printed circuit variety if they are to be mounted direct on the board. Make sure that they are fully pushed down onto the board before connecting them, and use plenty of solder. The four potentiometers provide the only form of mounting for the board which they effectively bolt to the front panel via their mounting bushes. The mounting holes in the front panel must be accurately drilled at the correct pitch.

The specified case gives a neat and compact finished unit, but it provides only very limited "headroom" which causes one or two problems. One of these is that some of the mounting pillars moulded into the case might get in the way and prevent the panel and board assembly from being fitted into the case. As the pillars serve no useful purpose in this application, any that should obstruct assembly of the unit can be carefully drilled out. Another possible problem is that of the pins of the potentiometers protruding too far on the underside of

Parts List

Resistors (All 0.25W, 5% carbon)

R1	1k
R2,R4,R6	10k
R3	12k
R5	1M
R7	4k7
R8,R9,R10,R13	100k
R11,R12	47k

Capacitors

C1,C15	100u rad. elect. 10V
C2,C5	4u7 rad. elect. 63V
C3	2u2 rad. elect. 63V
C4,C12,C14	10u rad. elect. 25V
C6,C7,C8, C9,C10,C11	220n mini.
C13	100n ceramic

Potentiometers

VR1	4k7 carbon
VR2 - VR4	100k carbon

Semiconductors

IC1	NE5534 ultra low noise op. amp.
IC2	741C op. amp.

Miscellaneous

SK1 - SK5	3.5mm jack sockets
S1	mini. SPST toggle sw.
B1	9V battery

PCB; case approx. 180 x 120 x 39mm; battery connector; small control knobs (4); 8-pin DIL sockets (2); wire; solder, etc.

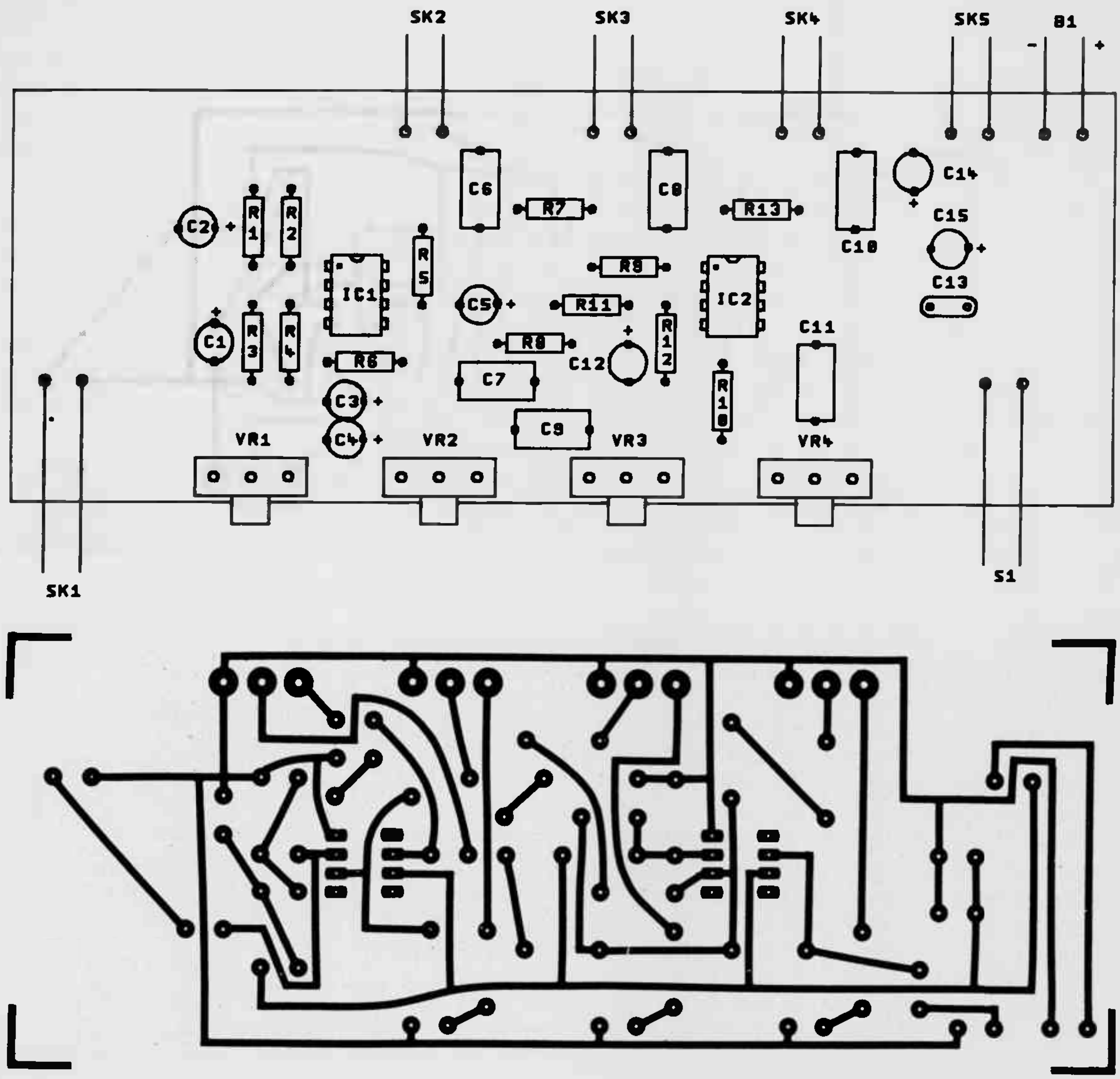


Fig. 5 Parts overlay and wiring details (top) and PCB layout.

the board, but if necessary these can be trimmed down slightly using wire clippers.

It is not essential to use printed circuit mounting potentiometers, and there is plenty of space on the board for mounting bolts so that it can be fitted on the base panel of the case in the usual way, with the potentiometers being hard-wired to the board.

Socket SK1 and S1 are mounted on the front panel, and it is logical to position them close to their wiring take-off points on the board. SK2 to SK5 are mounted on the rear panel of the case, and again, should be positioned such that they match up with the take-off points on the board. The sockets on the prototype are all 3.5 millimeter jack types, but any audio type is suitable from the electrical point of view. However, the amount of space available is quite limited, and this precludes the use of anything but miniature types unless a suitably modified layout is adopted. Ideally, the cable from SK1 to the board should be a screened type, but this is not essential provided this lead is kept short and direct. None of the other lads need to be screened types either.

In Use

In order to test the unit it is just a matter of connecting the output to a crystal earphone, amplifier and loudspeaker, or other equipment which enables the output signal to be monitored, and then trying out the various inputs to ensure that their respective gain controls have the desired effect. If the unit is used with a low impedance dynamic microphone (the type sold as inexpensive replacements for cassette recorders) the gain control will need to be well advanced in order to give an output signal of adequate strength. Medium impedance microphones give better results, as apart from generally having a higher quality output, they will need the gain control advanced less so that a better signal to noise ratio is obtained. The line inputs can handle signal levels of up to about 2.5 volts RMS before the onset of clipping, and this is more than adequate for normal signal sources. ■

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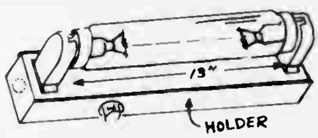

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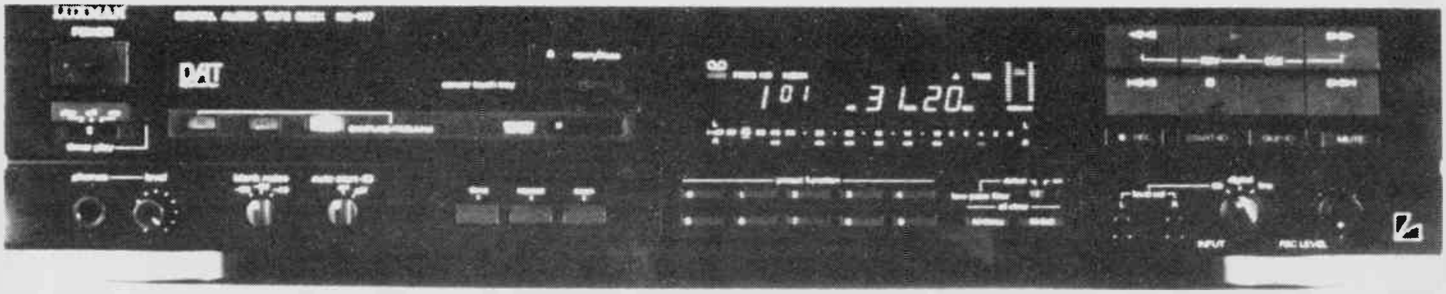
The Luxman KD-117 Digital Audio Tape Deck

CD quality on a two hour, erasable, tape format.

By Edward Zapletal



Last month we filled you in on what was happening in the Digital Audio Tape saga. At that time, with all attention focused on omnibus trade bills south of the border, CD copy protection etc., it was difficult to get manufacturers of consumer audio products to even admit that DAT existed. Not much has changed in that respect. However, one company, Alpine Electronics of Canada Inc., has targeted the first sales of their Luxman KD-117 Digital Audio Tape deck for the end of November. We recently had a chance to preview the KD-117 and get some hands-on experience with it; here are our first impressions.

The Basic Works

The first thing you'll notice about the KD-117 is its obvious resemblance to a Compact Disc player. The familiar sliding drawer, display and controls are laid out pretty much the same as on any CD player. In fact, the KD-117 is actually built into a slightly redesigned Luxman CD player cabinet. Beyond this though, similarities with the CD player end. Enter, VHS video technology.

The DAT medium is contained in a small cassette, measuring 72 x 54 x 11mm, similar in design to a video tape. A push of the drawer's open/close button reveals a recess in which the tape lies flat with its hinged tape cover facing the machine. On closing the drawer, the hinged cover is automatically flipped up, the tape is exposed, and then wound around the VHS-like tape transport system.

To reduce tape wear, as well as improve fast-forward and rewind times, the tape is wrapped only one quarter the way around the head (90 degrees). During normal play and record operations, the head rotates at a speed of 2000 RPM and the tape speed from the cassette is 8.15mm.

The tape itself contains much more than just digitally encoded music. There are several other bits, arranged into blocks, which represent subcode information for such things as indexing, sampling frequency, etc.

Sampling Options

To overcome the possibility of direct digital copying from CDs, the Japanese manufacturers got together and agreed on three standard sampling frequencies for DAT: 32kHz, 44.1kHz and 48kHz. These are selected automatically by the machine depending on the setting of the input selector (CD, digital, or line) or from the subcode information stored on the tape. It may sound complicated, but bear with us.

The 44.1kHz sampling rate on the KD-117 is reserved for "playback only" of prerecorded tapes. This means that even if you had a CD player with direct digital outputs, you still wouldn't be able to make a true digital-to-digital recording onto DAT at 44.1kHz. However, don't despair.

By selecting the 48.1kHz sampling rate, and recording from the analog outputs of a CD player, we obtained a tape which rivalled the quality of the original disc. The problem with this, though, is that the signal is fed from a digital source (CD) to an analog output, and to the analog input of the DAT for conversion to digital on the tape. In doing so, errors occur in the bit stream and the true digital original is lost. For the most part, these errors are virtually undetected by the human ear. This is mostly due to error correction and "best guessing" techniques employed within the machine's software.

With the input selector set to "line' it is also possible to record from other analog sources such as LPs, cassettes, microphones etc.

The 32.0kHz sampling rate is reserved for taping from future services such as Direct Broadcast Satellite etc.

Technical Specs

Recording time on the KD-117 is a healthy two hours, compared to the 72 minute playback-only time of a compact disc. Frequency response is DC-20kHz with a dynamic range of at least 93dB. Distorion is virtually immeasurable at 0.003%. Compare these figures to those of the C-cassette with frequency response figures of 20Hz-

18kHz, dynamic range of 72dB (Dolby C in), and distortion of 0.8%. Also keep in mind that there is absolutely no wow and flutter with DAT or CD.

Fast forwarding with a 120 minute conventional cassette leaves you time to go for a coffee in most instances, but with the KD-117, traversing a 120 minute tape from front to back can be done in approximately 35 seconds. This doesn't come close to the random accessibility offered by the CD, but it is a large improvement for tape.

The access time for skipping one song is given to be 4 seconds on the 117, this compares to 2 seconds on a CD player and 12 seconds on the average conventional cassette.

Fibre Optics

An interesting feature of the KD-117 is its capability to connect to other Luxman dedicated digital audio equipment by way of fibre optics. This was done to optimize the transfer of digital signals between components, doing away with many of the RCA jacks used in conventional audio applications. Chances are though that you won't find this on lower line audio equipment for some time to come.

How About Car Audio?

When DAT becomes available toward the end of this year, much of the interest in it will revolve around its potential as the new car audio gadget. Yes, CDs have found their way into the dashboard, but, don't forget that CDs have a hard time tracking in an environment ridden with potholes etc. This is where DAT could really find a place for itself.

Alpine is planning to market its model 5700 DAT car player at the same time as the KD117. This means that you will be able to record your favorite CDs onto DAT and have them at your disposal in the car. Naturally, the 5700 will be playback-only, but it will offer you two whole hours of playing time with better than a 90dB signal- to-noise ratio. Some might say that the noisy auto environment will never really allow the full potential of the DAT's clean sound, but it certainly will be a vast improvement over conventional audio cassette tapes.

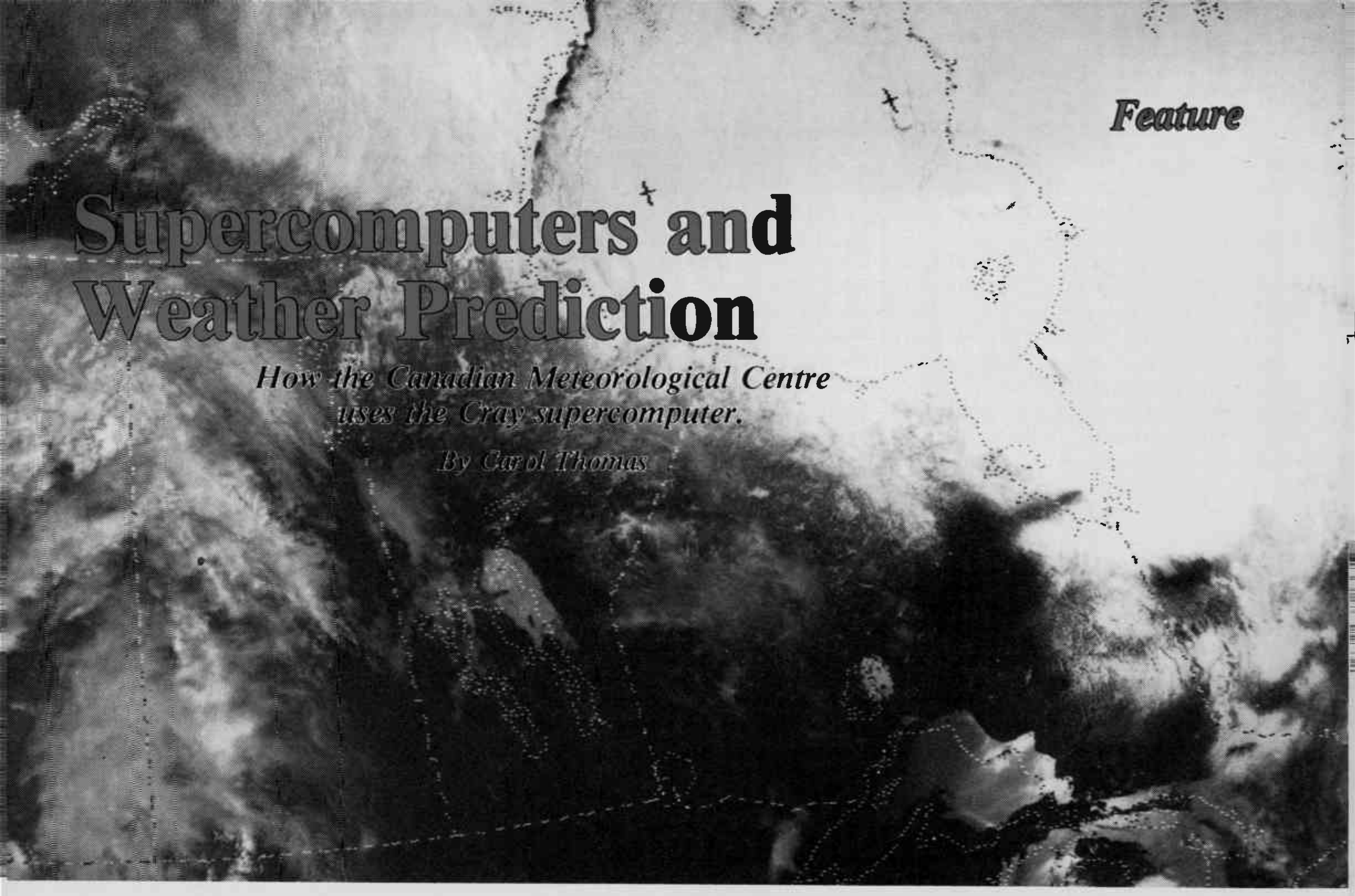
Features of the 5700 include: high speed music search; Key Off Memory; 20 Selection Programmable Memory; Auto Dew Sensor; Auto Loading; Auto Stop for the rotating head; Auto Tape Release and a clutch/brake system for constant tape tension. The unit also features a code-in/code-out Anti Theft system. The fast forward/rewind time is listed at approximately 55 seconds for a 120 minute tape.

The inclusion of the dew sensor brings up an interesting point: VCR-like head mechanisms are susceptible to condensation forming when the conditions are right. This can cause poor transfer of information from the tape to the head meaning loss of sound in the case of the DAT. To overcome this, the 5700's Auto Dew Sensor activates a small heating element in the event that moisture is detected on the head mechanism.

What It Costs

Let's start out by saying that it is not going to be for everyone, at least not at the outset. The KD-117's suggested list for the November release is set at a $2699.95; a price for the 5700 was not available. Don't panic though, forget not that hi-fi VCRs and CD players came onto the market in the $1500 - $2000 range and found stable market prices far below that. DAT players may not sell for $1000 for some time but, if it's marketed as successfully as the VCR or CD player, it shouldn't be long in coming.

For more information on the Luxman KD-117 and Alpine 5700 contact your local Luxman or Alpine dealer. Also, Alpine Electronics of Canada Inc., 605 Alden Road, Markham, Ontario L3R 3L5.



Supercomputers and Weather Prediction

How the Canadian Meteorological Centre uses the Cray supercomputer.

By Carol Thomas

Cool tonight with scattered showers; a low of 12. Tomorrow will be sunny with a high of 19, but look out for a 55 per cent chance of thunderstorms on Sunday. More on the 11 o'clock news...over to you, Bob.

Predicting the weather seems like magic as far as most of us are concerned, and the occasional lapses of accuracy in the daily forecasts do little to dispel our faith in the weatherman who tells us to take our umbrellas to work. However, the magic which keeps us dry if we watch, listen to or read the weather forecasts is the magic of a Cray supercomputer installed near Dorval Airport in Montreal, combined with the super-complex mathematical models that are run on it.

Why A Supercomputer?

A supercomputer is not a necessity for the generation of forecasts, but it makes the process faster, more accurate and gives a longer-range prediction. A Cray supercomputer has been used at the Canadian Meteorological Centre (CMC) since 1983, and an upgraded model was installed earlier this year. The CMC is part of the national Department of the Environment, within the Atmospheric Environment Service, and under the Weather Services directorate.

"The Cray is used to assimilate data from around the world, although we only use the information from the northern hemisphere," said Al Kellie, interim director of the CMC. "It runs sophisticated mathematical models of the atmosphere," including factors such as temperature, humidity and wind, as well as physical parameters like soil, vegetation and snow. The hugh programs which require matrix algebra solutions are ideally suited for vector computers such as the Cray. "We need to use the large memory of the Cray to hold such a big model," said Mr. Kellie, "and we need a high-speed computer to do it fast enough."

Collecting Data

Information about climate patterns and weather around the world comes from the World Meteorological Centre, to which all countries provide data at fixed times during the day. Data is gathered from balloon launches, ships, airplanes, surface stations, drifting buoys and satellites. Polar orbiting satellites cruise from pole to pole at eight to nine hundred kilometers up, while geostationary satellites, which hover over one part of the earth, sit at an altitude of about 22,000 km. A geostationary satellite centred over the United States gathers information about Canadian weather.

Portions of all this information are sent to Dorval, where they are analysed by the computer and a series of forecast charts produced. The predictions are adjusted with models and sent out to communications centres across Canada where they provide guidance for local meteorologists to produce daily and long-range forecasts.

What goes on within the supercomputer program itself is that the information coming in is fed into a model of physical equations describing the atmosphere and the movement currently going on within it. All variables are calculated at 15 different altitudes within the atmosphere. The model is set up at an initial time and told to move ahead in time at 12-minute intervals, up to 48 hours into the future. After the first 12 hours ahead have been forecast, the conclusions are translated into graphical images, or weather charts, which are then produced for every 3-hour interval in the future, up to 48 hours.

The weather charts are sent to the country's six regional weather centres, located in Halifax, Montreal, Toronto, Winnipeg, Edmonton and Vancouver.

They are also distributed to the department of National Defense, to commercial aviation systems and to some local centres. Altogether, there are 140 distribution points to which the Cray charts are delivered electronically twice a day.

At the regional centres, the charts are assessed by meteorologists for agreement with each centre's own observations. This information is then translated into a written description of the upcoming weather for the area, which eventually becomes the forecast delivered to the public.

How Accurate?

The CMC predictions focus on today's and tomorrow's forecasts, but can be predict the weather up to five days in advance. "We couldn't do it with much value on smaller machines than the Cray," said Mr. Kellie. Previous to getting the most recent Cray machine, CMC predictions did not go beyond three days ahead. "Each time we get a new computer system, we upgrade the performance of the numerical weather forecasting system," Mr. Kellie added.

Since the CMC started in 1952, its predictions have been getting steadily more complex and more accurate. The first computer was incorporated in 1963, which used a simple two-dimensional model of one "slice" through the atmosphere. A three-dimensional model was designed in 1968, and in 1973, spectral modelling, which used equations of atmospheric motion on spectral and spherical co- ordinates, began on a Control Data machine. It wasn't until 1983, with a vector generation computer, the Cray 1, that a very high resolution regional forecast model was developed, which was further improved with the latest acquisition, the Cray XMP.

"There are plans for expanding the role of the Cray to produce a written forecast all ready to go," said Dave Greig, head of communications at the Ontario Weather Centre in Toronto, "but there are a lot of variables that the computer models don't yet account for, so I'm holding my breath." However, Mr. Kellie pointed out that work is currently going on towards having the supercomputer produce either a worded forecast or an intermediate worded forecast which a human meteorologist would improve on, so it is possible that this may occur in the fairly near future.

For the present, the Cray is putting out its graphical results in record time.

The Cray XMP supercomputer, capable of processing enormous quantities of numerical information at very high speeds, using two CPUs. Only 170 are in use world-wide.

"Canada's weather service is driven by a numerical model which we operate in less than 40 minutes," said Mr. Kellie. "Observations are collected by communication systems in about 90 minutes, then 30 to 35 minutes later, we have products coming out of the numerical model. We can deliver the 12-hour forecast while the computer is still doing the 48-hour forecast."

Number Cruncher

The reason that so much information can be processed so quickly lies with the machine in use. The upgraded Cray model currently being used by CMC is an XMP, which is three to five times faster than the Cray 1 previously used there. It has two CPUs, rather than one, each more powerful than earlier ones, and a solid-state storage device (SSD) which speeds up the input/output. The XMP at Dorval has a 64-megabyte main memory and a 256-megabyte SSD, which provides for a very fast secondary memory.

Cray Inc., founded in 1972 by Seymour Cray, holds two-thirds of the supercomputer market, with Crays being used in aerospace, the petroleum industry, chemical manufacturing, and health care, as well as by universities and government for research and development. Since the first Cray was delivered in 1976, the company has sold 170 machines world-wide.

"The computer we're using now was designed for our kind of mathematical problems," said Mr. Kellie, "but it's a very longterm acquisition process." A strategic document is being worked on at CMC this year which will outline the future computer needs of the weather service, and another machine may be bought in the early 1990s. "The hardware available changes very quickly in today's marketplace," noted Mr. Kellie.

Climate Modelling

The Cray at CMC is also used for climate modelling and for research. Climate modelling involves long-term seasonal predictions in terms of statistics, i.e., whether this winter will be colder or wetter than the seasonal average. It is still fairly experimental and uses a very long integration program that runs for a day at a time. "The Cray has allowed us to do a lot of the climate modelling more efficiently," said Mr. Kellie.

Environmental emergency modelling is also run on the Cray, such as programs to predict how far pollutants, such as radioactive dust or chemicals, will be transported by the atmosphere and where they will be deposited. This program would be used in a situation like that of Chernobyl.

The Cray is running 24 hours a day, with 50 to 60 per cent of that time being used for Canada's forecast system. Research takes up at least 20 to 25 per cent of running time, and universities with research grants to use the Cray get about 10 per cent. "A lot of research is done on this machine, since we have developed the next generation of models for it," pointed out Mr. Kellie.

What About The Future?

There is still a lot of room for the system to expand. "The acquisition of computer power is what allows computer weather prediction to advance, in resolution, accuracy and so on," said Mr. Kellie, "and we want to advance and increase the resolution of our forecasts. We'd like to give the Canadian public a 50 kilometer resolution forecast." The resolution is 152.4 km in the current model.

As the supercomputers developing predictions of Canadian weather increase in size and abilities, their uses and efficiency will likewise grow. "The science of meteorology is to push forecast accuracy to as accurate a level as possible and as far ahead as possible," said Mr. Kellie. "There's no shortage of future."

Carol Thomas is a freelance science writer from Toronto, Ontario. ■

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Of Shoes and Ships and Binders...

Alice stretched herself up on tiptoe and peeped over the edge of the mushroom and her eyes immediately met those of a large blue caterpillar, that was sitting on top, having a milkshake.

"Who are *you*?" said the Caterpillar.

"I hardly know, Sir," stammered Alice, "but I'm looking for a way to keep magazines tidy and convenient."

"Moorshead binder," said the Caterpillar.

"Pardon?" asked Alice.

"Moorshead magazine binders. Cleverly worked out, with spring rods to hold the magazines without cutting or punching," the Caterpillar replied.

"Oh," said Alice.

"They lay flat for reading or photocopying," he added.

What does he mean? *What* lays flat? thought Alice to herself.

"The binders," said the Caterpillar, just as if she'd said it aloud, and in another moment he was out of sight.

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How It Works: The Lamp Dimmer

Dissecting the inexpensive, versatile dimmer.

By E.J. Wheel

There are a number of ways to control the brightness of household incandescent (tungsten) lamps. One simple method is to put a variable resistor (rheostat) in series with the lamp. Unfortunately this method reduces the power going to the lamp by squandering the rest as heat in the resistor, and a very large resistor it is, too.

Another possibility, and a good one, is to use a *variac*, a transformer with a metallic wiper that slides over the exposed secondary winding, in effect giving the user a variable transformer. This one has the drawback of a large size and an even larger price tag.

Now suppose we could switch the lamp on and off with as precise a control as we could want. If we could turn the switch on and off somewhere in the middle of each AC cycle, we'd be letting bursts of voltage through. The sooner we turned the switch off during the cycle, the smaller the bursts of voltage we'd be sending to the lamp.

This method has the great advantage that the switch is always on or off; only the on/off time is varied. Since it has an extremely low resistance, the switch wastes very little power. Solid-state power devices are a natural for this application.

The Triac

The triac belongs to a family of power-control devices called *thyristors*, a power switch made up of layers of silicon, and a cousin of the familiar power diode. The standard diode allows current to flow in one direction only, that is, it will only pass one half-cycle of the sinusoidal AC that appears at the outlet. The triac, by contrast, won't conduct at all until a control signal appears on the *gate* pin. Then, even if the control signal is removed, it will conduct and stay conducting, looking a lot like a closed mechanical switch, with very little loss as the current flows in either direction.

One essential difference between the triac and the mechanical switch is that the triac will only remain conducting if the current is above a certain value, called the *latching current*. If the supply voltage falls, the current of course falls too, and once the current drops below the latching value, the triac is non-conducting, even if a gate signal is applied.

Now, since the AC voltage goes from positive through zero to negative 60 times a second, we can use the voltage's zero-crossings to shut off our triac.

A Basic Dimmer

In the schematic shown, we have the standard sort of dimmer you'll find at the hardware store for under ten dollars. It fits in place of a regular wallmount light switch, that is, in series with the lamp. The triac is shown inside the dotted line, which also includes a device called the diac. More on the diac below.

Its operation goes like this: picture the input voltage rising from zero (either positive or negative). Imagine that the dimmer control (potentiometer R) is set to maximum brightness; in the schematic, this means that the slider moves upward, shorting the resistance and effectively connecting main terminal 2 (MT2) to the gate.

The small capacitor C (typically a .047u) will charge immediately from the rising line voltage, and thus has no effect on circuit operation. When the incoming voltage rises to a few volts, the triac is triggered and its resistance falls, connecting the load across the 120V mains and lighting the lamp to full brightness.

Now imagine the control being turned down, inserting a resistance in series with capacitor C. As the voltage rises, the capacitor takes its time charging up through the resistance of R. Eventually its voltage rises and the triac fires.

If we have very high resistance in series with C, we can delay triggering until the half-cycle is over, or in other words, no triggering at all.

So now we have a way of controlling how much of the input wave we let through, from all of it to none. With the control at half, for instance, we let through only the last half of each half-cycle.

It's for the above reason that dimmed light bulbs often whistle and sing. The pulses sent to them at low settings are fairly far apart, the tiny filament is quite sensitive to vibration caused by thermal variations, and now you have your annoying noise. The cure, if any, is to try different light bulbs until you get one that isn't sensitive at the lamp dimmer's frequency. The long- life bulbs tend to make a bit less noise because the filament is heavier and less inclined to react to the jagged pulses from the dimmer.

The Diac

The gate of a triac needs only a very small signal, usually several volts. When it fires, it draws current from the capacitor, lowering the voltage that it's

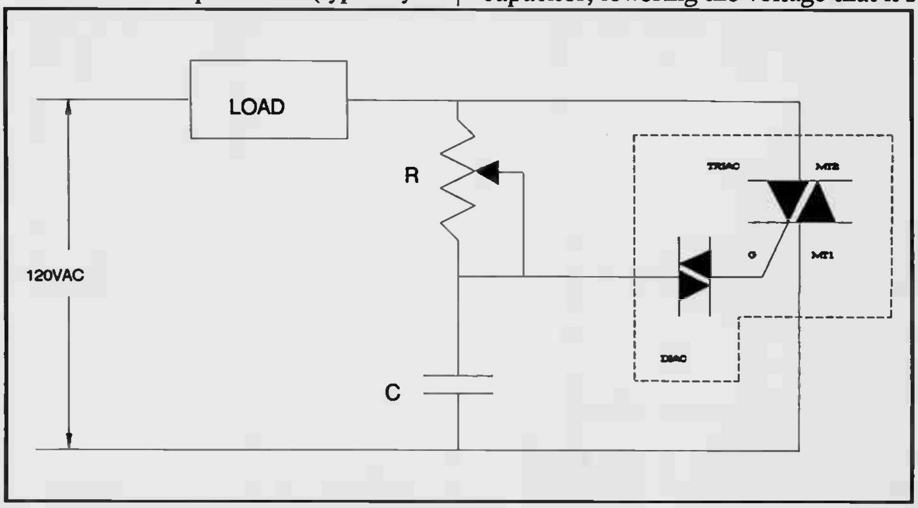


Fig. 1. The circuit of a basic lamp dimmer.

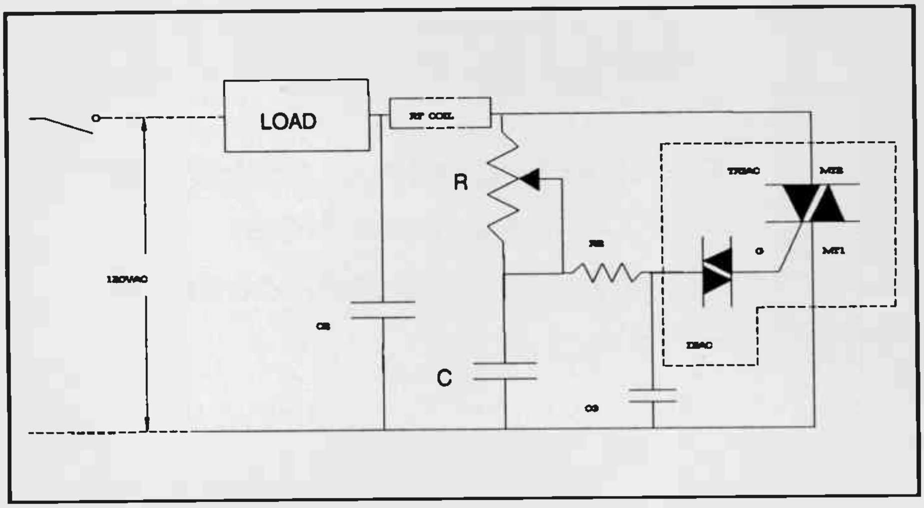


Fig. 2. An improved dimmer with RF suppression.

charged up to. Furthermore, the various specifications of every solid-state device are affected by temperature and manufacturing variations. For this reason, it becomes difficult to reliably trigger a triac from a lamp dimmer circuit, or at least to ensure that every dimmer you make acts the same way.

To get around the problem of the gate and its voltage variations, we use the diac, a triggering device with a simialr structure and schematic. Normally it is non-conducting, but when the voltage across it rises to 30 or 40 volts, it suddenly breaks into low-resistance conduction and fires the triac via the capacitor voltage. This higher firing voltage makes the circuit much more controllable and predictable.

Sometimes the diac is wired in as a separate component, but with low-cost lamp dimmers the diac is internal, part of the triac packaging.

Dimmer Ratings

You may have noticed that the packaging of commercial dimmers reads something like "1500W resistive, 600W tungsten. Not for fluorescent lighting". The reason for the two different wattage ratings is the wide variation in the resistance of the tungsten filament as the temperature changes.

I've just measured a 100W bulb with an ohmmeter, and found its resistance to be 9.2 ohms. If you work out what the resistance to give 100W at 120V should be according to Mr. Ohm, you'll find it calculates to 83.3 ohms. This is a variation of 9 to 1. Obviously, the inrush current will be much higher when the bulb is first switched on; it works out to 13A instead of the expected 1.2A at 100W.

Secondly, when a tungsten bulb burns out, the parting filament often causes a huge arc to form, effectively short-circuiting the bulb's filament. That's why bulbs often give off an enormous blue flash when they burn out. The bulb's filament mount is designed to stop this arc, but for a fraction of a second the current is very high.

For those two reasons, the dimmer is derated well below the wattage capability it would have if it were driving a well- behaved resistor. Should you ever want to control a heating element, you can safely exceed the tungsten rating of the dimmer.

As far as fluorescent tubes go, you can try dimming them if you want to, and in fact I've seen it done. However, the tubes don't seem to like firing with the short spikes from the dimmer, and much flickering happens. Also, the dimmed fluoresecent light is gray and gloomy, like a rainy day. Dimmer manufacturers wouldn't like to see you try it either, because the inductance in the light's current-limiting ballast coil will cause nasty voltage glitches which may damage the triac.

An Improved Dimmer

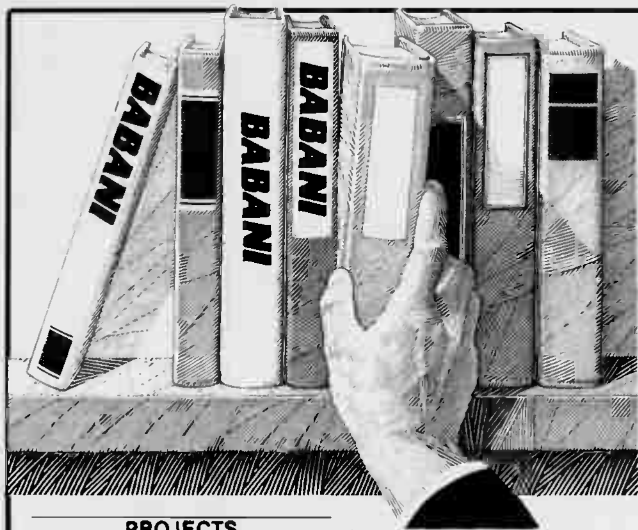
The circuit in the second schematic shows a dimmer with two of the more annoying problems solved.

First, you may have noticed that bargain-basement dimmers suffer from *hysteresis*, the fact that the counter-clockwise just- off point is widely different from the clockwise just-on point. This makes it difficult to set the lamp at a very low setting without a lot of back-and-forth knob twiddling. This problem is caused by the fact that the firing of the triac gate circuit drains current out of the timing capacitor and lowers its voltage. The usual cure on hardware-store dimmers is to use a sensitive-gate triac that won't draw too much current out of the capacitor.

In the schematic, the problem has been cured by the dual-time- constant method. Note the addition of R2 and C3. The extra, isolated capacitor doesn't sag as much in voltage when the triac fires.

Because the triac fires very rapidly, it creates a very steep, almostr vertical wavefront. This is guaranteed to generate a series of high frequency harmonics which just love to work their way into home audio equipment, especially since the house wiring makes a great antenna. In the schematic, a small coil has been added in series with the load, along with capacitor C2. This low- pass filter does a good job of cutting down on nuisance RF interference. It doesn't totally eliminate it, though, and recording studios with their sensitive equipment often substitute variacs for the solid-state dimmers, or eliminate them altogether with low-wattage bulbs.

E.J. Wheel is a Toronto freelance writer who specializes in technology. ■



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F.G. RAYER, T.ENG (CEI), Assoc.IERE
This book contains both simple and more adanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. to help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be build and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike. .

BP99: MINI - MATRIX BOARD PROJECTS $7.60
R.A. PENFOLD
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FYI *Continued from page36*

Laser IBM-compatible

Video Technology Computers, Inc. has announced the introduction of their new IBM-compatible Laser compact XTE personal computer. This expanded version of the original model gives you more memory and more built-in options as standard, plus it far surpasses standard graphic capabilities. It is fully compatible with the IBM PC/XT and its enormous software library. 640K RAM is standard with the LASER Compact XTE, with an internal EMS (Expanded Memory Standard) that allows expansion up to 1 MEG to run all EMS software programs. Also newly built-in is an EGA (Enhanced Graphics Adapter) to run EGA software programs. For further information on the LASER Compact XTE, call or write: Video Technology Computers, Inc., 400 Anthony Trail, Northbrook, Illinois 60062-2536, (312)-272-6760. ■

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The 4-Million-Bit Chip
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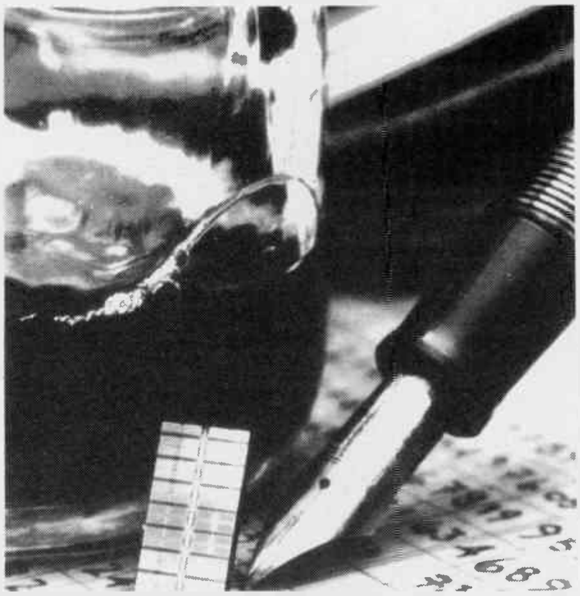


In the race to make computer memories smaller, cheaper and denser, IBM has produced a 4-megabit chip that can be fabricated on the same assembly line as the one-megabit chip. The ability to put more and more circuits into smaller and smaller areas plays a key role in reducing the cost of manufacturing computer components and has led to dramatic reductions in the cost of computing. IBM is already using 1-meg chips in mainframes, and plans to expand the use of megabit technology throughout the range of its product line.

A combination of CMOS technology, advanced photolithography and a novel memory cell make this 4-megabit dynamic RAM significantly faster and denser than its 1-megabit predecessor. The new chip is only 35% larger than the 1-meg, occupying 78 square millimetres and the access time is 65 nanoseconds. At this speed, it could read the data in all of its 4,194,304 memory cells in one-fourth of a second.

A New Memory Cell

The key to the development of the 4-megabit chip is the use of an advanced design for the chip's individual storage cells. The memory cells conventionally used in DRAM chips, whether they hold 64K bits or 4 million, are composed of one transistor and one capacitor. Information is represented by the presence or absence of charge on the surface of the capacitor. The charge is stored or released by switching the transistor on or off, and the flowing charge produces an electrical signal that can be amplified and read by circuits on the chip.

An important problem for chip designers is to provide a memory cell that is as small as possible, but still includes sufficient room for a capacitor large enough to generate a strong signal. A strong signal is needed to produce fast operation and reliable performance.

IBM's 4-meg chip uses a new method for constructing the individual storage cells that make up the entire chip. In this method, a hole is etched deeply into the silicon at each storage location on the chip, the sidewalls of the hole are covered with an insulating material, and the hole is filled with a conductive material to form a capacitor.

This method provides a 3-dimensional capacitor which has a surface area large enough to hold a substantial amount of charge, but does not occupy a large amount of surface area on the chip.

The 3-D "trench" capacitor structure contrasts with the 2-D planar structure conventionally used to form capacitors in memory chips. As implemented in the 4-meg chip, the trench capacitor allows three times as many cells to be packed into an area equivalent to that of a 1-meg chip.

In the new chip, engineers have fabricated circuit elements with dimensions as small as 0.7 micron. These extremely fine lines make it possible to produce transistors with very narrow gate electrodes; the width of the electrode determines a basic characteristic of the transistor called the "channel length". This has led to a very fast switching time for the transistors, as fast as 65ns.

Structure

The chip is IBM's first dynamic random access memory chip developed in Complementary Metal Oxide Semiconductor (CMOS) technology. Earlier memory chips are fabricated in N-type Metal Oxide Semiconductor (NMOS) technology. CMOS technology inherently uses less power than NMOS, allowing cooler operation of the circuits.

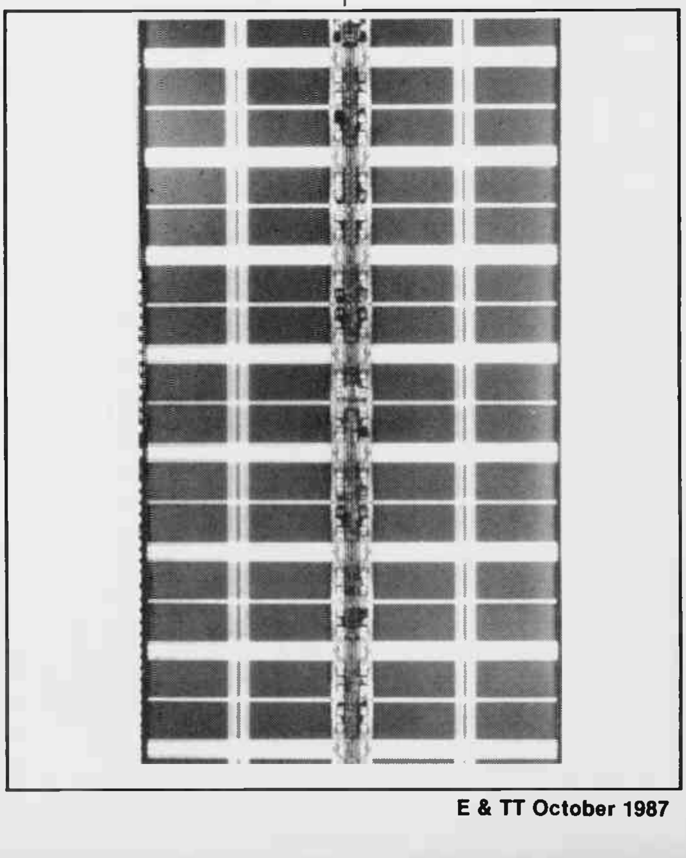
The chip operates on a single 3.3 volt power supply. This results in power savings compared to the 5V supply that is conventionally used with NMOS technology.

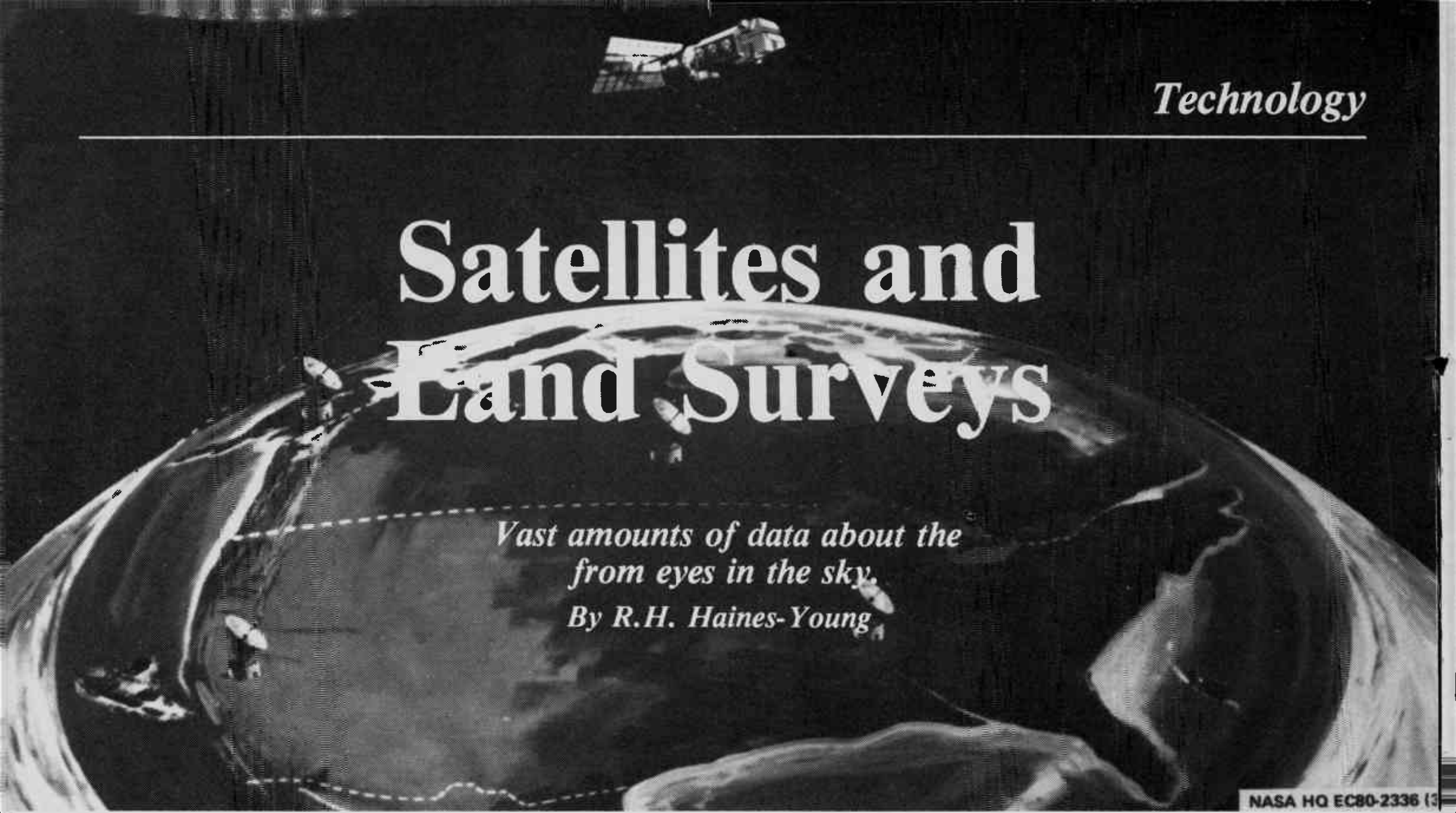
Organization

To provide system designers with flexibility in selecting versions of the chip that best suit their needs, the chip is organized to read data either in groups of four bits at a time or one bit at a time. Special circuits in the chip also provide the ability to write data into the chip in groups of from one to four bits at a time.

The chip also includes 96,000 spare or redundant storage cells, one and one-half times the number of cells in an entire 64K chip, which IBM began manufacturing in 1978. These extra cells are used to substitute for defective cells discovered during the manufacturing process. Redundancy can substantially increase manufacturing yields during the early phases of production, thus significantly reducing manufacturing costs.

To increase the flexibility of the chip for potential use in a variety of systems, two different packaging options are provided. In one option, the chip can be mounted on a 3/4-inch-square ceramic substrate containing an array of pins for connecting the substrate to the next level of circuit packaging. The other option is a package 0.35 inches wide with "j" shaped leads that allow it to be mounted at high densities on the surface of the next level of packaging.





Satellites and Land Surveys

Vast amounts of data about the from eyes in the sky.

By R.H. Haines-Young

The Landsat series of Earth observation satellites has provided scientists with a rich source of data about the natural environment. Given the continuing concern about the scale and speed of change brought about by man's activities, access to such data is timely.

The World Conservation Strategy of the World Wildlife Fund, for example, argues that global, national and regional ecosystem evaluations must be made as a matter of priority. Three aspects of the data provided by projects such as Landsat make them particularly important in such an undertaking.

The repeated and large scale surveillance of the Earth's surface makes possible quicker and lower cost environmental monitoring and mapping programs for large areas. The digital format of satellite data means computer based methods of image processing can be applied, resulting in the discovery of new and unexpected patterns.

Finally, the growth of digital information from these space networks provides a key stimulus for the development of information systems to assist the environmental planner and manager.

Digital Satellite Data

The current British study, supported by the Welsh Office and Britain's Economic and Social Research Council concerns the use of digital satellite data for landscape classification in Wales. Although such data has been used extensively to map individual land cover elements such as forest, pasture, and so on which make up the landscape, little work has concerned the recognition of the larger scale patterns in the land cover mosaic. These constitute different landscape types defined by the combination of the land cover elements, their spatial arrangement and the character of underlying terrain.

The recognition of such landscape units is important for management of the regional landscape resource in Wales, and for the development of environmental survey techniques in general.

One of the study areas investigated is in West Glamorgan, where the Nottingham Image Processing System (NIPS) is used. This provides a comprehensive set of FORTRAN routines for digital image processing which can be run on a DEC PDP11/34 or a VAX 11/730 driving a Gresham-Lion Supervisor 214 image display system.

Image Processing Routines

The image processing routines have been augmented by TWINSCAPE, a package developed for the classification and analysis of landscape. This is based on VESPAN, a set of FORTRAN programs for the handling and analysis of vegetation and species data.

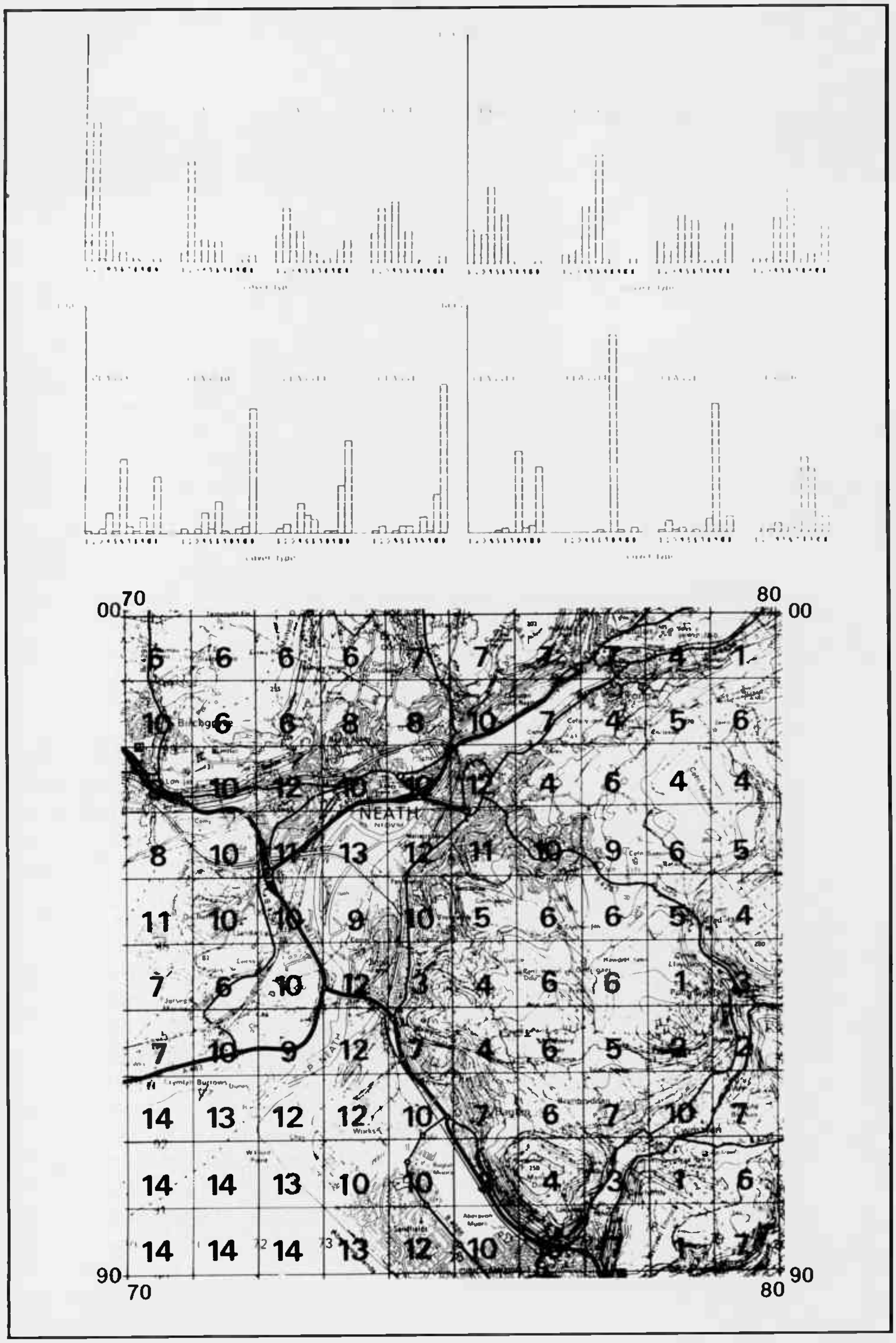
The initial step in the classification of landscape involves that of remotely sensed data for land cover. Both Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) imagery have been used.

Preliminary investigations for other areas in Wales showed that, in general, the highest land cover classification accuracies could be obtained using TM data. Although imagery collected in spring allowed the best discrimination between the target cover types, the only cloud-free TM data available for the West Glamorgan study area was for July. This data was therefore supplemented by April MSS imagery in order to develop multi- temporal classifications.

Both centroid and maximum likelihood classifiers were used in single and multi date mode. Table 1 indicates the level of classification accuracies obtained. No single algorithm proved optimal for all cover types.

Second Major Step

Analysis of the varying patterns and combinations of cover elements in the land cover mosaic forms the second major analytical step. A data base was



Comparison between landscape classes obtained for West Glamorgan (numerical key to cover types is as in Tables 1 and 2). Below: Part of the landscape classification obtained for a 100km section of West Glamorgan. Scale approximately 1:71 000 (OS copyright acknowledged).

created showing the percentage cover of the target types in each of the 1km^2 sections of the Ordnance Survey National Grid making up the study area.

The estimate for each cover type was derived from its optimal classification algorithm. For the purposes of landscape classification the cover data was recorded on a four point ordinal scale.

Given the low per-pixel classification accuracies shown in Table 1, a check on the method's accuracy was made by comparing the estimates for each grid square with data obtained by field survey (Table 2). Despite the low per-pixel accuracies, it seems clear the imagery can be used to estimate the percentage cover in each grid square for the broad cover classes used.

Since the level of correspondence between the methods approaches the level of reproducibility for the field estimates, the quality of the remotely sensed data was considered adequate for the purposes of landscape classification.

Two-Way Table

Landscape is classified by the TWINSPAN algorithm, a polythetic diversive method of classification. It was developed for ecologists who have collected data on the occurrence of certain species in a set of samples and who require a classification of species according to their ecological preferences.

The algorithm produces an ordered two-way table showing the relationship of species to sites. Although developed in a phytosociological context the method is applicable to a wide range of data matrices and is highly suited to the study of landscape.

Classification of landscape types was terminated at the 16-group level. The classification for West Glamorgan identifies a spectrum of landscape types. Classes 1, 2 and 3, for example, pick out the contrasts between areas of blanket conifer cover, and landscapes in which unimproved pasture and health are present alongside large scale forestry, or areas in which mixed upland landscape exists.

Classes 4 to 8 represent different upland and lowland landscapes dominated by pasture in combination with broadleaved woodlands and settlement. Classes 10 to 12 are dominated by settlement and industry, and classes 13 to 16 pick out coastal landscapes.

Environmental Survey

The landscape or terrain units analogous to those described above have been widely used in environmental survey, for example in the context of land systems mapping. In general the data required for such work is provided by field survey, map or air photo analysis.

Satellite imagery, when used for such work, has largely been interpreted by manual methods. The automated routines described here offer the pos-

Table 1:

Classification accuracy for target cover types in the West Glamorgan Study Area

Cover type	Accuracy (%)	Method
1. Broadleaf	51	C,M
2. Conifer	87	C,S
3. Bracken and scrub	54	C,M
4. Unimproved pasture	68	C,S
5. Heath	84	C,S
6. Improved pasture	58	C,S
7. Arable	19	ML,S
8. Water	100	C,S
9. Marsh	88	ML,S
10. Bare ground	73	ML,S
11. Settlement	66	C,S

KEY:

C = centroid, ML = maximum, M = multi-date mode, S-single date mode. Accuracies are assessed as the proportion of pixels of known cover type correctly assigned by classifier.

Table 2:

Cover type	Correspondence (%)
1. Broadleaf	67
2. Conifer	83
3. Bracken and scrub	60
4. Unimproved pasture	54
5. Heath	94
6. Improved pasture	65
7. Arable	99
8. Water	96
9. Marsh	94
10. Bare ground	87
11. Settlement	75

Note: Percentage cover classes were as follows: 1 = 1 to 5%, 2 = 5 to 15%, 3 = 15 to 35% and 4 = 35%. Comparison is made on the basis of a 15% sample of the grid squares making up the study area.

sibility of more rapid and repeatable analysis of such data for landscape. survey than has been possible using traditional methods.

The importance of landscape classification for environmental survey is twofold. Such data provides the basis of a detailed structural analysis of landscape. The typicality, rarity and diversity of different landscape types can be assessed and an evaluation of the landscape resource made.

Such information is an important input into the planning process. Following the current study, for example, an attempt will be made to assess where further afforestation is both feasible and appropriate in the Welsh countryside.

Ecological Impacts

In addition to providing information about landscape itself, landscape units can also be used for the survey of related phenomena which are not directly observable from remote sensing platforms. Using the present results from Wales, for example, an attempt will be made to combine the landscape data with other kinds of information in order to model the patterns exhibited by plants and animals and to assess the ecological impacts of landscape change.

Such techniques are important in areas outside Britain where environmental data is limited. In other kinds of environment, landscape units could be used to survey such factors as land capability, population density, fuel wood resources, soil erosion or pest hazard.

The integration of remotely sensed data with other kinds of information provides the stimulus for the development of spatial or geographical information systems. These will become increasingly important in ecosystem evaluation and in the management of the Earth's living resources on a sustainable basis.

R. H. Haines-Young is with the Department of Geography, University of Nottingham, England. ■

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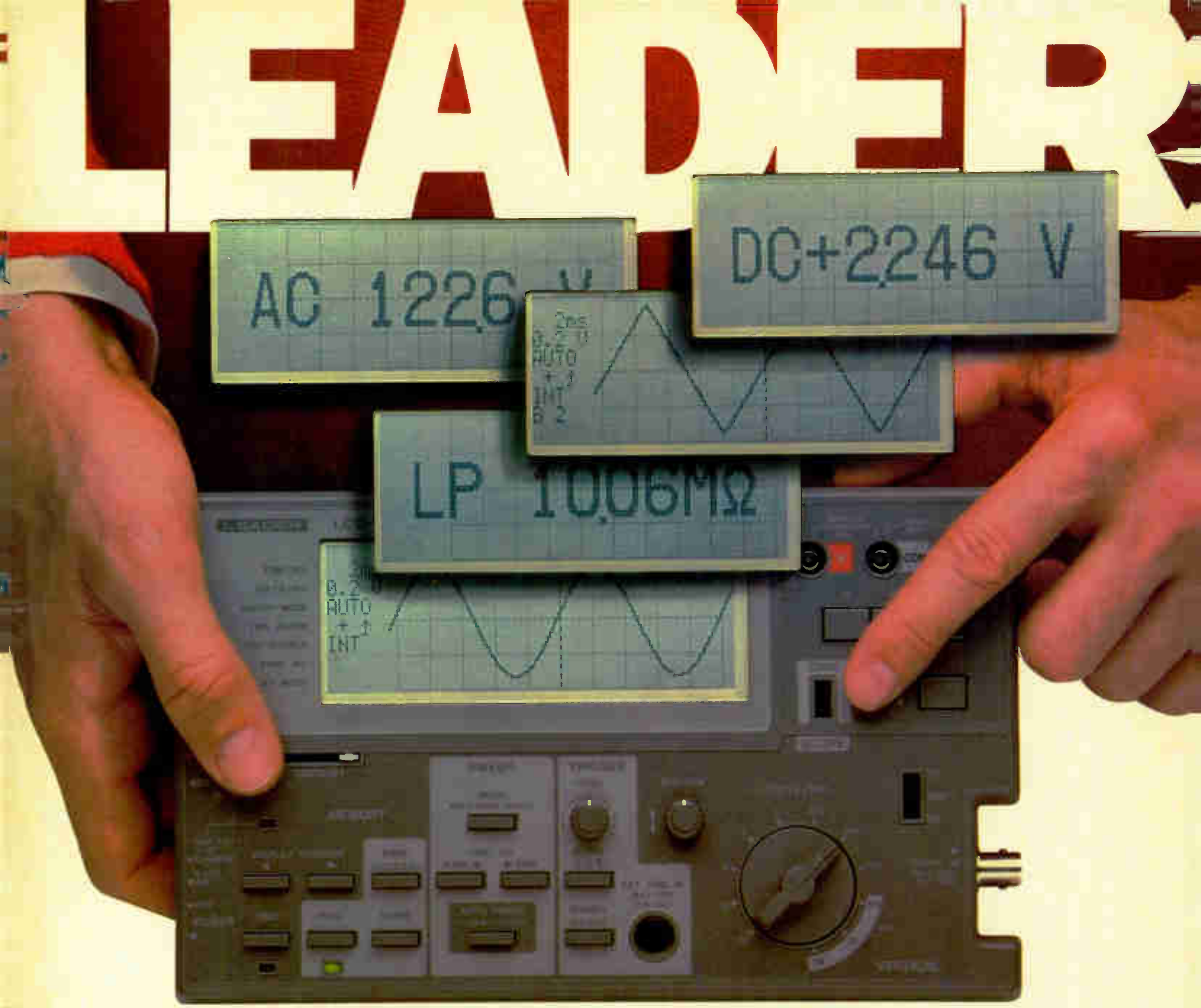
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