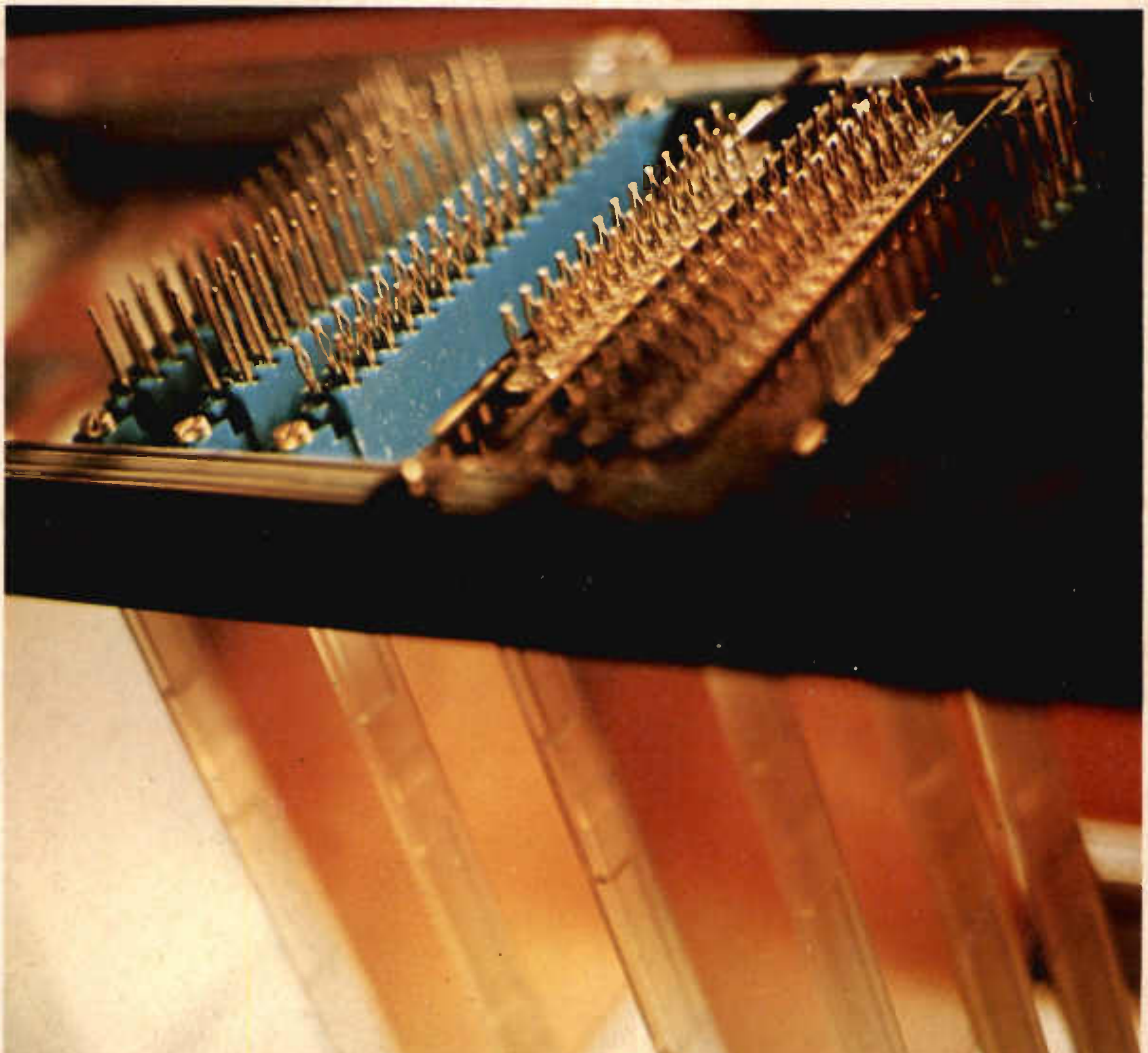
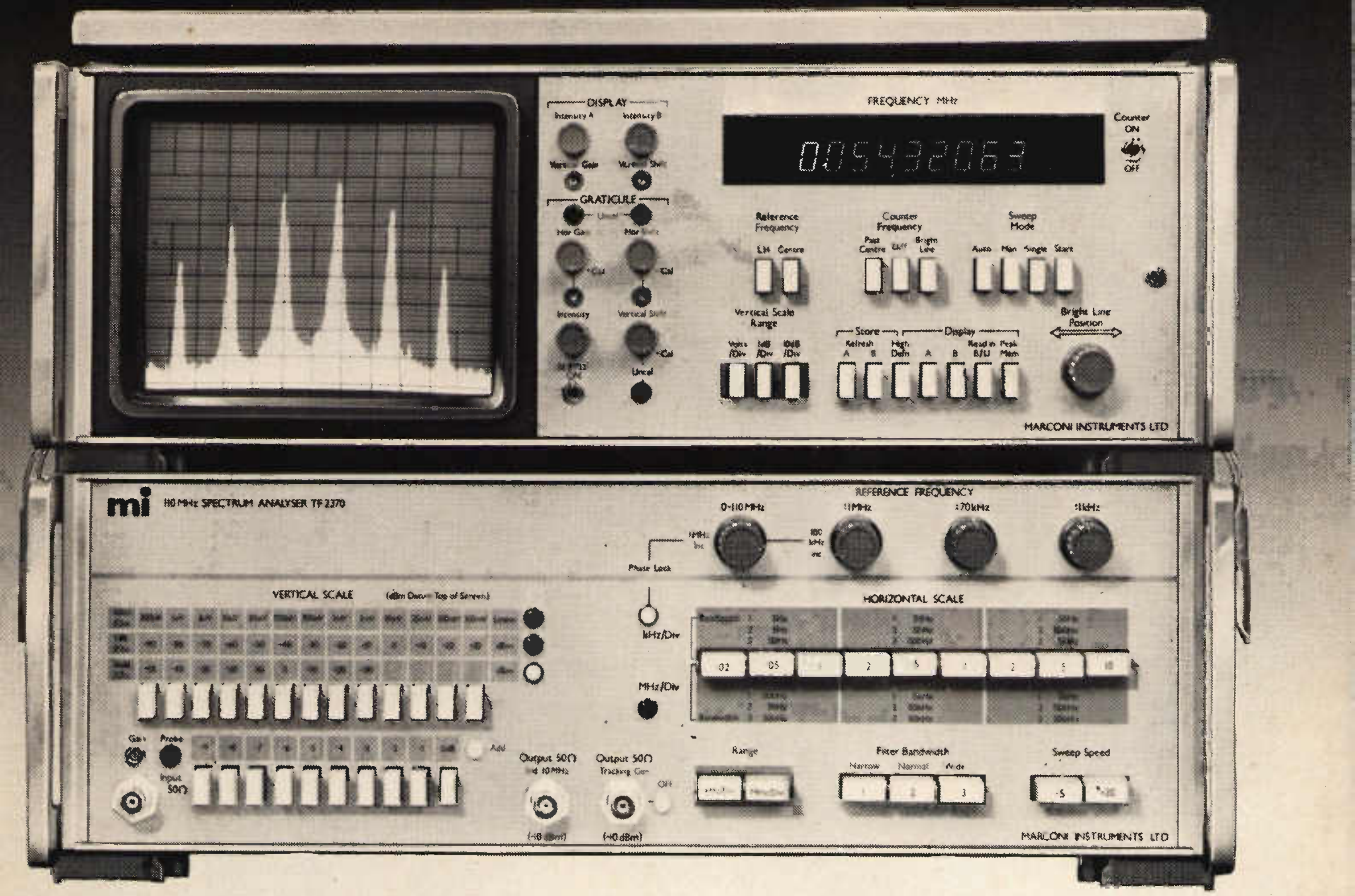
electronic engineering

January 1977



Exploiting pyroelectric effects for thermal imaging



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You've never seen a faster, more accurate way of measuring frequency response from 30Hz to 110MHz

The TF 2370 Spectrum Analyser employs advanced technology to provide a complete system for measuring response, level, frequency, signal purity, modulation and much more, with a speed and degree of accuracy previously unobtainable. A digital memory permits the use of a standard monitor tube and internal logic selects gain ratios and sweep speeds for optimum performance. The specification speaks for itself:

* Flicker-free 100 dB display of frequency response from 30 Hz to 110 MHz on a high brightness c.r.t.
* Electronic graticule, with a ±15% variation of horizontal divisions for pin-point positioning against waveform display.
* Three amplitude scales: one linear and two logarithmic with expansion to 1 dB/div. with an accuracy of ±0.1 dB/dB.
* 9-digit electronic counter automatically gives centre frequency, reads any other frequency corresponding to manually-adjusted 'bright line' position on display, or the difference frequency between the two, at the press of a button. All to an accuracy of ±2Hz ± reference frequency accuracy on high resolution and manual. Internal reference frequency provided with setting accuracy of 1 in 10^7.
* Internal generator supplies synchronous signal source for measuring such items as networks and filters.
* For comparative measurements, unique memory storage system will retain one display indefinitely as required, for simultaneous display with response produced by items under test.
* Automatic adjustment of amplifier gains to give optimum lowest-noise performance with full protection against input overloading.
* Automatic selection of optimum sweep speed.
* With the 5 Hz filter, signals 100 Hz from a response at 0 dB can be measured to −70 dB.

Please send for full information or ask for a demonstration – seeing is believing!

mi: THE INNOVATORS

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1 on enquiry card

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ABC

This month's cover illustrates ISEP2000, produced by ITT's Equipment Practice Division. The system is available in sub-rack heights suitable for 100×160 and 233, 4×160 mm Eurocards. Photograph courtesy of Paul Brierley.

electronic engineering

Vol 49, no 587 January 1977

p

BICC-BURNDY

Parr, St Helens, Merseyside WA9 1PR
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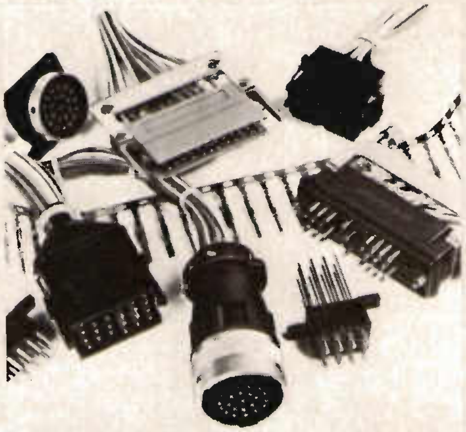
4 on enquiry card

Limitation of design flexibility was a common connector problem. Until TRIM-TRIO.

TRIM-TRIO is a unique system that reduces these kind of complications in design. And in production. Once employed, it is a lasting design decision. Once evaluated it gives you practically all the flexibility you need.

It's simple. Choose any from the three crimp contact families and your choice can be used in a multitude of connector styles and sizes. You can interface with wrapped and soldered techniques without deviating from your original contact choice.

There's an expanding range of connectors which include circular plastic types with metal coupling rings. Low profile styles. Rectangular multipins for many applications. And low cost self mounting types. All constructed for outstanding performance and reliability.



Production becomes more efficient and more economical with TRIM-TRIO. Fewer contact types speed production with less tooling, longer runs and fewer special skills. And there's a comprehensive range of production tooling for low to high volume needs.

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ee comment

Resolution

With Britain making her new year's resolution to adhere to the conditions laid down by the International Monetary Fund we can see some signs at last that the world believes that we will keep our promises in this respect. The pound, for example, has been showing some signs of improvement with our agreement to face up to the realities of economic life.

However we would only be fooling ourselves if we thought that tightening our belts and waiting for a few months would be all that was needed. The loan from the IMF will only cushion the effects of pressures on sterling. It cannot provide the stable platform which we need to build for the futrue.

This is where the electronics industry can help not only itself but also the more antiquated of our industries, by enabling them to become more competitive at home and abroad. The expertise required to do this is here and even the USA manufacturers have acknowledged that. GIM has about three quarters of its products designed in Britain, though production is mainly in America or Asia. Another large semi-conductor company's European head recently suggested that British component designers were without equal in the world.

We used to be a nation noted for its inventiveness and vision but, although the inventiveness remains, our vision has become a little blurred by the lack of commitment to profit. We have seen individual motivation stifled and corporate ambitions have come to be regarded with some suspicion.

We have been placing too much emphasis recently on the unacceptable face of capitalism so much so, that we are not sure, as a nation, whether it has an acceptable face at all.

Our most important resolution must be to recapture our drive and success but, this time, it must be based on vigorous enterprise coupled with a firm self-belief. If our economic splint is to rise from the ashes we need more than a faint spark of optimism.

We cannot expect the world to have any confidence in our abilities to win through if, we have no belief in ourselves.

This is Jubilee year and the eyes of the world will be upon us. It is vital that we do not let the celebrations become yet another excuse for nostalgia. Rather, let them be an expression of the hope we have for the future.

The electronics industry could lead Britain along the road to recovery and, instead of drowning our sorrows, we could raise our glasses and drink not only to a Happy New Year but also the recovering health of the nation.

READOUT

Sybex to hold μP seminars

Three microprocessor seminars will be held in Stockholm next month. Organised by Sybex of Paris, the seminars will cover microprocessors and microcomputers (Feb 7-8), bit-slice systems (Feb 10) and a comparative evaluation of microprocessors (Feb 9).

The first seminar is intended to cover all aspects of microprocessors, from technology to project management, and stresses case studies. All the major microprocessor families and their design aids will be reviewed and selection criteria will be discussed.

The seminar devoted to bit-slice systems will cover techniques for designing microprogrammed systems, analyse currently available devices and examine typical applications.

The seminar to be held on February 9 is likely to be of particular interest to designers who have not yet decided which microprocessor to use. Today's microprocessors are the result of historical evolution and, in some cases, of incorrect predictions by the manufacturer, according to Sybex. This has resulted in devices with inefficient features or architectures poorly adapted to intended applications. The speakers will therefore attempt to identify the types of application best suited to each individual microprocessor family. All major 8-bit and 16-bit microprocessor families will be analysed and compared. The conference will be followed by a discussion between manufacturers which will attempt to define the ideal microprocessor.

Fast cmos with plasma etching

A complete dry plasma etching process developed by Bell Northern in Canada under a US Army contract is claimed to have produced cmos integrated circuits with gate delay times of typically 600 picoseconds. The company maintains that nominal gate widths of two microns have been achieved by this method with ion implanted, plasma etched cmos using either bulk silicon or silicon on saphire substrates.

Bell Northern Research is the r and d subsidiary of Northern Telecom and sees the applications of these devices in low power voice communications. Plasma etching removes material by the action of decomposed gas molecules in weak vacuum under the influence of an rf field at wafer temperatures below 100°C.

To eliminate all wet etching, a technique of etching aluminium had also to be devised.

μprocessor for mines

The first microprocessor has been installed in a mine as part of a safety protection system for a mine winder. The unit was designed and built by Transmitton and the NCB has announced that half of the mines in South Wales will be equipped with the devices in the next eighteen months and, it is intended that every pit shaft in the country will have them within the next few years.

The equipment which costs £3000 has only one mechanical element which is a toothed wheel, keyed to the winder drum shaft, with a tooth pitch corresponding to 0.15 m of rope movement. As the wheel turns at the rotational speed of the drum, pairs of teeth activate inductively two pairs of sensors which feed information into the microprocessor. The microprocessor then determines the direction of travel and the distance of travel of the rope.

Hybrid plant in South Wales

This month sample and prototypes of chip and wire microcircuits will be produced at AB Microelectronics South Wales plant. The company has decided to extend its hybrid microelectronics business and has commissioned new clean room facilities there. Full production is expected in the second quarter of this year.

The chip and wire process itself will use both ultrasonic and thermocompression bonding with aluminium and gold wire. All the devices will be hermetically sealed.

Car safety device hopes

A British firm may have an export winner on their hands with its 'econocruise' device for cars. The device which provides electronic speed control and is a fuel economy and safety device was developed by the Associated Engineering Group.

So much interest has been generated that a new company has been set up by the group to manufacture and market the system.

The managing director Tim Blee, believes that this British invention will be received favourably overseas especially in European countries such as West Germany, France and Italy. Blee claims that independent tests conducted by motoring associations and leading motoring correspondents have proven that the system is both safe and efficient.

The system incorporates a small minicomputer which is installed by qualifed mechanics which have been trained by Econocruise.

Norwegian agreement

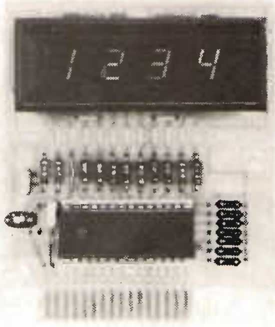
Three of Norway's leading electronics companies have announced a major cooperation agreement. The companies involved are Tanbergs Radiofabrikk, Elektrisk and Kongsberg Vapenfabrikk. Under the terms of the agreement, Tandberg and KV will acquire two fifths of the 43.25 per cent stake held in Electrisk Bereaus by LM Ericsson.

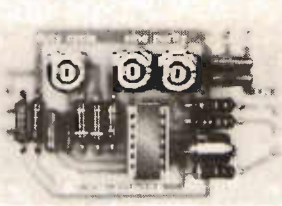
Also the three companies have bought a majority interest in a small firm Noratom/Norcontrol which specialises in the production of marine data systems..

The main purpose behind the agreement is to create an international group with the facilities of research, product development and marketing. Until now such agreements had been impractical for small Norwegian firms since their chances of success in international markets had been impaired by high costs in relation to earnings.

This is seen as a much needed boost to the electronics industry in Norway, and has been encouraged by the Norwegian government.

Lascar launches modules





A new company, Lascar Electronics, has been formed to manufacture and distribute electronic circuit modules. Lascar is the brainchild of Brian Currie, formerly with RS Components.

Lascar's circuit modules will be marketed under the name 'Cirblocs' and the range includes amplifiers, timers, power supplies, waveform generators, led displays and several other basic building blocks.

The modules are available fully assembled on small printed circuit boards or with certain components omitted so that users can program the modules by adding resistors. These additional components are inserted into pre-drilled holes in the board according to the diagram printed on the component side of the pcb.

The modules are intended, says Currie, to allow the assembly of complex systems in the shortest possible time. For example, a four-digit digital frequency meter can be constructed from three of the modules.

Liquid crystal production

This year's display's 76 exhibition had its venue as the Royal Mount Hotel once more. Although the exhibition seemed to be smaller than last year's effort the organisers claimed that there were in fact nearly the same number of stands.

The main news of the event was the imminent opening of two liquid crystal production plants one by ITT and one by Rank. The latter company will be manufacturing the twisted nematic type display which has a biphenyl structure and is a very stable type of display. Production of the liquid crystal elements will be at Leeds which is currently concerned with the manufacture of fibre optics components.

The manager of the new facility is Bill Freer who was in charge of the development of the crystal at the research facility in Brentford where the r and d will continue to be carried out. Customers had been pressing Rank for a long time to increase its output of liquid crystals to avoid having to obtain displays from America which incurred delays and inconvenience.

Vero sets up new company

Vero has set up another company within its group called Vero Systems (Electronic) Ltd. The company is intended to bring together the equipment division and the assembly and wiring division from two of Vero's other companies.

The new company will be installed in a modernised factory in Southampton and will distribute wire wrapping tools and equipment on behalf of OK Machine and Tool Corporation, together with other production aids such as automatic test equipment.

The company will also be responsible for the marketing of numerically controlled printed circuit board drilling and routing machines.

Also another company trying to lift itself out of the economic gloom is Computer Instrumentation which is embarking on what it calls a programme of enlarging its own system capability. In order to achieve the increased business the company is looking for, restructuring of the marketing organisation at senior level has occured in the computer systems division.

Telecomms report for NEDC

With the current cutbacks of the PO's ordering having an effect on the entire telecommunication industry it is no surprise to anyone that the government is getting worried. STC, GEC and Plessey have already had to undergo the agonies of reducing staff but with the further belt tightening of the PO these companies have to undertake further amputations.

Overseas trading too has been going downhill for some time and a report has been prepared by Sir Raymond Brown for the National Economic Development Council (NEDC) on exports of British telecommunications equipment. The report will not be considered until the next NEDC meeting early this month, but it does make some strong recommendations to boost Britain's telecomms industry.

Within the last ten years Britain has been toppled from its first place in the world market in telecommunications to fifth. Although system X is still in its infancy it could help to put Britain back at the top of the tree. It needs to be designed with exports in mind and to be ready as soon as possible to catch the markets of the developing countries whose telecommunication standards have not yet been established.

Sir Raymond, in the report, sees three major issues which have to be faced if Britain has any chance of winning significant contracts. They are, to produce an export marketing strategy which will guide the development; improve the relationship between the PO and the supplier and to investigate the structure of the supplying industry.

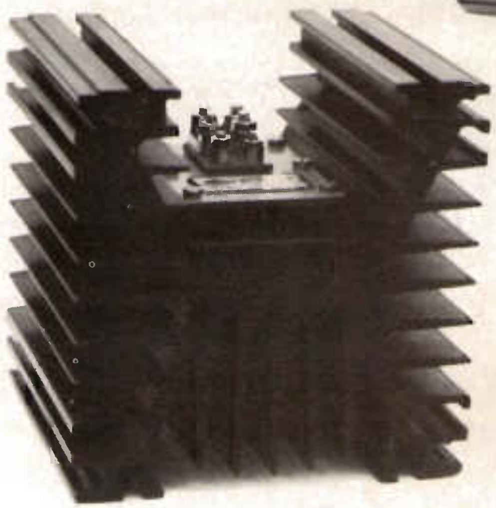
He also made three recommendations related to improving exports. The first was to set up a Telecommunications Export Corporation which would be similar to the Defence Sales Agency. The second recommendation was the rationalisation of the three publicly owned telecommunication consultancies—Cable & Wireless, International Airadio and Millbank Technical Service. Finally the implications of these developments on the supply of equipment to the PO should be considered.

5 on enquiry card

HIGH CURRENT REFERENCE RESISTORS

NEW HCRR range

To supplement low value wirewound precision resistors utilised as current shunts or for current monitor/control applications.



Manufactured in a sandwich for mounting on heat sink together with solid state power devices, or permanently laminated to a self-contained heat sink section.

Designed to meet special low value/high current requirements having small overall variations arising from self-heating and ambient temperature changes. Combines the low temperature coefficient resistive alloys especially selected for each requirement, with low internal thermal resistance to minimise the effective temperature gradient within the construction.

TYPICAL DESIGN CONSTRUCTION

TCR	40ppm/C°	10ppm/C°
Dissipation	1 Watt/100(mm)²	1 Watt/25(mm)²
Range of Values	2.9100 milliohms	
Tolerance	±2% to 0·5%	
Stability	Better than 0·1% per annum	
Insulation	100V test between resistive element and heat sink	
Inductance	Low inductance and pick up from external fields	

Please send for further details and data sheet

ALMA COMPONENTS LIMITED

Park Road, Diss, Norfolk Telephone Diss 2287
Telex 98162

05-29 and C.A.A. Approved Inspection

The All-Electronics Show. 19~21 April 1977

Already The All-Electronics Show invites you to put your stamp on the event.

The All-Electronics Show opens its doors for its second year on 19th April 1977. An annual exhibition held at London's Grosvenor House hotel in Park Lane, it is open to visitors from 10.00—6.00 daily for three days and is sponsored by *Electronic Engineering*.

Already the organisers have received many requests from people for tickets to visit the exhibition.

Said Samantha Clarke, Administrative Director, "Part of our success last time can be attributed to the fact that we invited the industry to attend free of charge—so long as they registered in advance.

"The same applies this year. In return for a postage stamp and a completed coupon we will send applicants a free season ticket . . . as well as an extra one for a colleague.

"Without a ticket admission on the door will be 50p.

The exhibition attracts both large and small companies alike with its philosophy that no exhibitor may overshadow another—no matter how big a name it is. All exhibiting companies have the same style of shell stand and floor area allowed to each company is strictly limited. With this system it is easy for visitors to see everyone and everything in one day without a route march, and without becoming absorbed into the background of large stand building.

The view exhibitors received from the Great Room Balcony just before the exhibition was opened.

STOP PRESS: The most recent companies to take stands are: Thomson CSF, Wavetek and Farnell.

One criticism levelled at the show last year was that exhibitors in the Ballroom were not easily found by visitors. This has been remedied for the 1977 event by altering the main entrance to the exhibition to make it directly opposite the Ballroom, thus ensuring a much smoother flow of traffic around the exhibition areas. There will also be greatly improved sign-posting and lighting in connecting corridors between the two exhibition halls.

As the name implies, The All-Electronics Show has exhibitors from all fields of the electronics industry and really does offer something for everyone. But bearing in mind the fact that it is the only major showcase for instrument companies in London in 1977 there will be a large representation from the instrumentation sector of the industry, including Fluke, Farnell, Tektro nix, Pye Unicam and J J Lloyd.

It is never easy to know whether or not a new exhibition will be successful, but the fact that the majority of the exhibitors at the first event have re-booked puts it well on the road to a successful future.

There are still a few stands available, and if you are interested in taking one for your company, telephone Samantha Clarke on Saffron Walden (0799) 22612 and she will give you full details.

I enclose a 6½p stamp to cover second class postage and I look forward to receiving my ticket to The All-Electronics Show.

NAME ....

POSITION ....

COMPANY ....

ADDRESS ....

....

Attach stamp by its corner here. *"Please: no stamp, no ticket."*

Have you booked your

intel

microprocessors workshop

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The Intel range of single board computer products offer tremendous cost and time advantages to the Original Equipment Manufacturer; this course covers the selection of level of integration i.e. single board, crated boards or fully packaged, system configuration, I/O and power supply requirements, standard and custom software design. Demonstrations and student exercises feature the SBC80/10, SBC80/20, crated systems, PROMPT 80 and SYSTEM 80/10. Supporting development and maintenance hardware (MDS, ICE etc.) will be discussed, and available software packages including CORAL 66 may be demonstrated.

Intel SBC Systems Workshop (2 days £80+VAT)	January	12/13
	July	6/7
	November/December	30/1

and your Coral 66 Compiler Workshop

GEC SEMICONDUCTORS WORKSHOP DATES FOR 1977

RCC 80 (3 days £110+VAT)	March	8/9/10
	June	7/8/9
	November	22/23/24
Intel 8085/8080A (3 days £110+VAT)	February	22/23/24
	May	10/11/12
	October	11/12/13

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(The Meaning of Sprague Leadership; a series)

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On the surface ... no more than you'd expect of any serious component manufacturer. Yet, there is decidedly more to this statement than meets the eye.

That's because, although many manufacturers are willing to go to the wall these days to meet customer specifications, non-standard components – especially when ordered in small quantities – can still cost the earth.

On the other hand, SPRAGUE's broad line capability in Electrolytics, Ceramics, and Semiconductors usually allows us to supply one of our catalogue items.

Or, we may be able to suggest a slight design modification which will also permit utilisation of a standard component – without sacrifice to customer production or performance requirements.

Exceptionally, certain applications call for a customised product. In these instances, our engineering specialists, drawing upon their indepth knowhow and SPRAGUE's advanced State-of-the-Art, can be relied upon for a practical solution.

This combination ... the right people – the right product ... means leadership. SPRAGUE LEADERSHIP in service to our customers.

All inquiries, on any aspect of this advertisement, should be addressed to: Mike Jones, Sales Manager, Sprague Electric (UK) Limited, 159 High Street, Yiewsley West Drayton, Middlesex. Telephone W. Drayton 44627, telex 261524.

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THE MARK OF RELIABILITY

B05

Until now, bought only half the synthesized

Now Racal Instruments bring you a new concept in signal generation – the 9081. Take a good look at its features and see why this Synthesized Signal Generator will become the standard by which others will be judged.

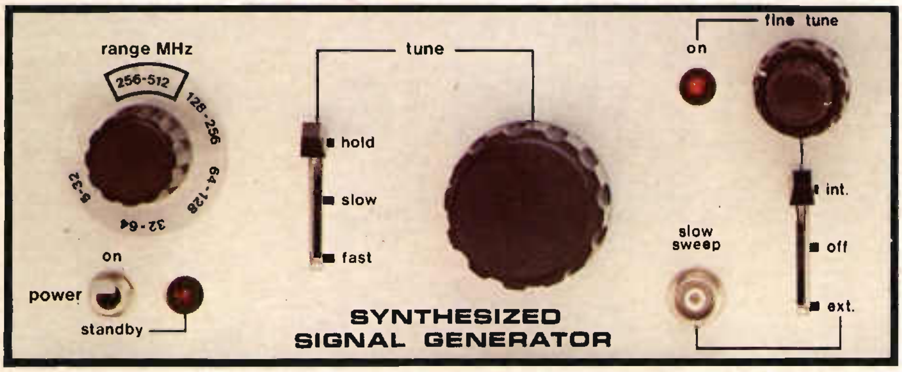
The 9081. Synthesized precision and analogue tuning from 5-520 MHz

You set the output frequency by means of conventional analogue tuning controls. Once you've selected the appropriate frequency range you simply spin the main tuning control and stop it when the display shows the desired frequency. No longer is it necessary to adjust a formidable array of decade switches.

When tuning has been completed the output is automatically locked to an ovened crystal oscillator which has a very fast warm-up and a stability of better than ±3 parts in 10^9 per day. You can forget about the usual add-on extras such as synchronizers or lock boxes – they're just not required.

There's also a fine tune vernier control that gives the 9081 a continuous tuning capability – something quite new in a synthesized instrument. And even when using this facility the output signal is still locked to a crystal oscillator and has a stability at least one order better than any analogue generator.

You don't need a frequency meter to check the output, because we've built in an l.s.i. counter that continuously monitors the output frequency and updates the eight digit l.e.d. display. So you are always certain exactly what frequency the 9081 is generating. The counter has a maximum resolution of 10Hz at all frequencies and derives its high accuracy and stability from the same internal frequency standard used for the synthesizer.



The 9081. Channelised tuning

In channelised radio communications the need is to generate precise spot frequencies separated by internationally agreed channel spacings. With the 9081 this couldn't be easier. In fact, it takes just the flick of a switch. Simply select the channel spacing you require, tune to the first channel frequency and press the step switch for the next channel. You can then step up or down through the entire frequency band one channel space at a time. Very fast, very simple, and with guaranteed synthesized precision all the time. We've provided all ten channel spacings between 5 and 60kHz so you can use the 9081 wherever you're based.

The 9081. Automatic Output Levelling.

As you'd expect in a top quality signal generator, the 9081 includes automatic voltage levelling to maintain the output amplitude substantially flat over the whole frequency range – typically within ±0.5dB in fact. There's an accurate switched attenuator and a vernier control which provide an output range from -130dBm to + 3dBm. So you can vary the output amplitude from 0.7µV up to 316mV into 50Ω.

- *5 to 520 MHz*
- *Synthesized Performance-Analogue Tuning*
- *Channelised or continuous operation*
- *Stability ± 3 parts in 10^9 per day*
- *AM, FM and Phase Modulation*
- *Output automatically levelled*

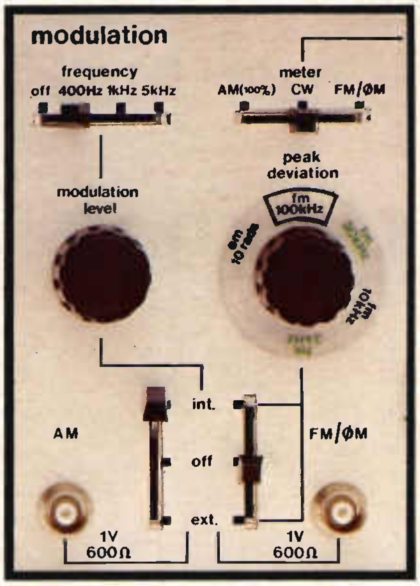
RACAL
The Electronics Group

£1995 Signal Generator you wanted.

The 9081. Comprehensive modulation facilities

Full a.m., f.m. and phase modulation facilities are provided to enable you to check most types of radio communications systems. The r.f. output can be modulated either at the fixed 400Hz, 1kHz and 5kHz frequencies provided by the internal oscillator or at other frequencies up to 100kHz if you use an external source of your own. In both cases the front panel meter gives a clear indication of modulation depth, frequency deviation or phase deviation according to the type of modulation being used.

9081 has a simultaneous modulation capability. That means you can modulate with a.m. in combination with either f.m. or phase modulation. And you can use internal or external oscillators to do it.



The 9081 is ruggedly constructed for high performance in both field and laboratory roles. It doesn't just look good. Designed to meet recommended European safety standards and built to satisfy military environmental specifications, the 9081 measures only 133mm x 408mm x 445mm, weighs a mere 13 kg and is readily portable. It's an easy to use, fast to tune, high precision synthesized signal generator and is unique. In fact, the 9081 is unbeatable.

Still need convincing? Why not write today for a copy of our brochure which will give you all the technical details?

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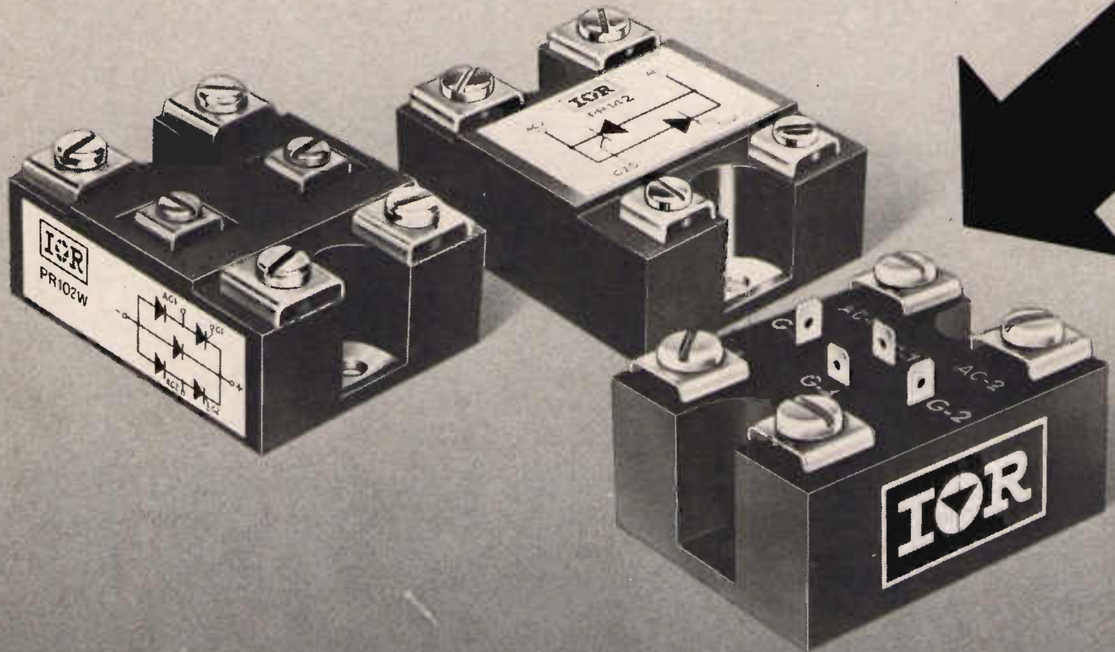
9081 The complete synthesized signal generator from Racal Instruments

You can't integrate POWER!

(better than I.R. can!)



The trouble with all power semiconductors is that they dissipate heat. Lots of it.
This severely limits the amount of integration achievable on one semi-conductor chip.

We managed it with our ACE gate thyristors, with our triple diffused power darlingtons, and with our range of triacs, but we compromised when it came to the power circuit. I.R.'s 'PACE/pak' power circuits consist of power semiconductor chips mounted on metallised alumina or beryllia substrates and aluminium sub-heatsinks, totally encapsulated to form a rugged, compact, isolated, ready built power module.

You'd be surprised at the variety of standard circuits available, (anti parallel, half controlled or full controlled thyristor bridges up to 100 Amps rms), and even more surprised at the "specials" we can tackle.

While we're on the subject, don't solid state relays, encapsulated bridges and h.v. rectifier modules all count as integrated circuits.

Who said you can't integrate power? I.R. CAN!

INTERNATIONAL RECTIFIER

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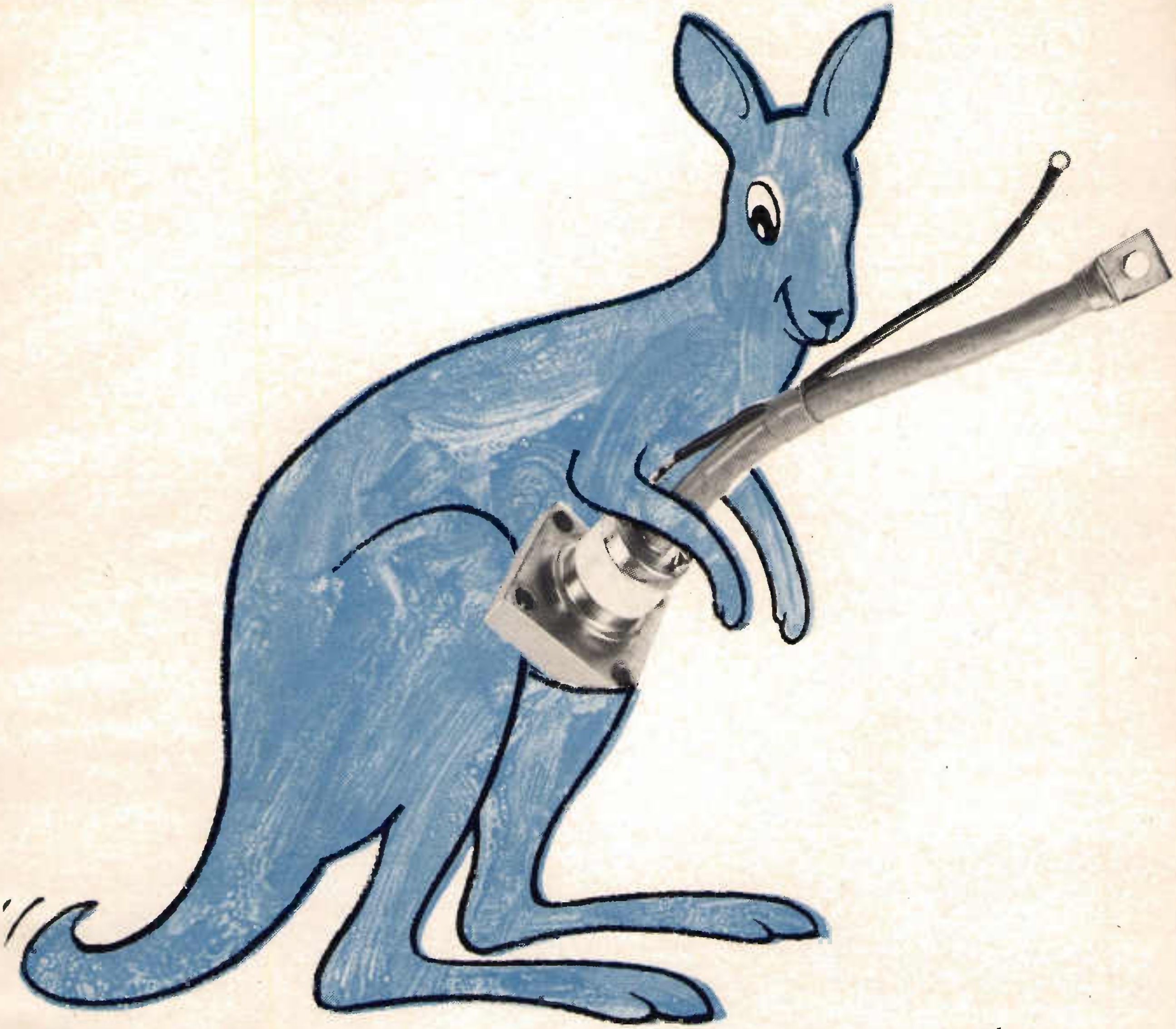

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That leaves us the precious time to spot new trends and new problems in circuit requirements . . . and do something constructive about satisfying new demands with new approaches and new devices.

Keep an eye on Westcode. We've got the future in our pocket.

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Integral cycle thyristor control using a multiplier

Integral cycle firing of thyristors is now an established method of heater power control. The advantages of the method proposed here are that the control signal is digital and the conducting cycles are evenly distributed in time.

Since each half-cycle of the supply corresponds to a fixed discrete pulse of energy, the number of such pulses per second represents the power. The mean power is proportional to the mean pulse frequency, ie, a form of pulse frequency modulation of the power occurs. The binary rate multiplier (brm) provides a very simple method of achieving this. A train of pulses co-incident with the zero-crossings of the ac supply is generated and fed into the brm. The output from the brm is a series of pulses (also co-incident with the supply zero-crossings), the average frequency of which is proportional to the digital input to the brm.

Figure 1 shows how the brm clock frequency, f_i (= 100 Hz), is generated using simple squaring and pulse conditioning circuits. Separate pulse trains are obtained for the positive-going and negative-going zero-crossings and then *or*ed to produce f_i. The pulse width is determined by the capacitors C. The value used here was 1 μF, giving a pulse width of 0,6 ms. The control input to the brm is a 6-bit parallel binary signal (x), the decimal equivalent (x) of which is $\sum_{n=0}^{5} x_n 2^n$ where x_n = *zero* or *one*. This signal was generated using toggle switches. The brm output feeds directly into a conventional thyristor firing circuit, having two isolated outputs. The average frequency of the brm output is given by $f_0 = \frac{x}{2^6} f_i$. The average power in the load can be varied in steps of $\frac{P_m}{64}$ from *zero* to $\frac{63 P_m}{64}$, where P_m = full power. Figure 2 shows the brm output pulse train and the load voltage waveforms for values of x = 28 and 48.

The circuit was used to control the power in a 3-kW heater element in a temperature control system and was found to be satisfactory in every respect. However, for purposes of evaluating the system more fully, a simulation was used. Here it was assumed that each energy pulse was square, having an amplitude = P_m and a duration = $\frac{1}{2}$ of supply period (10 ms). This waveform was readily obtainable. The thermal system was simulated by a simple RC low-pass filter, the time constant of which could be varied readily. It was found that, for a given time constant, the peak-to-peak ripple in the filter output was substantially constant over a wide range of x. This differs from other systems where a large variation in the level of ripple occurs as the power demand signal is varied. Compared with a burst firing system having the same control resolution, the maximum level of ripple is reduced by a factor of 7 approximately. *E P McCarthy, Salford.*

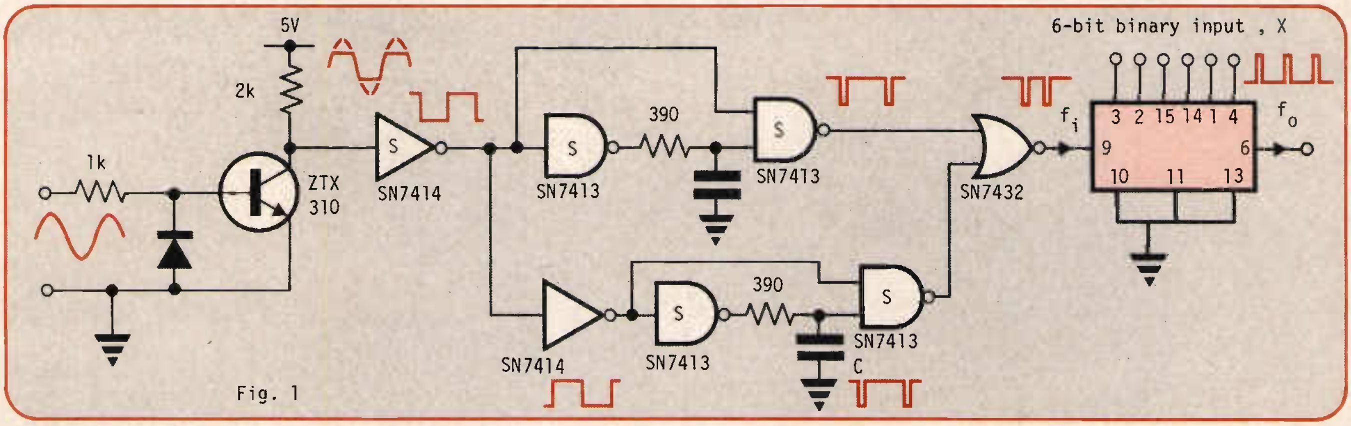

Fig. 1

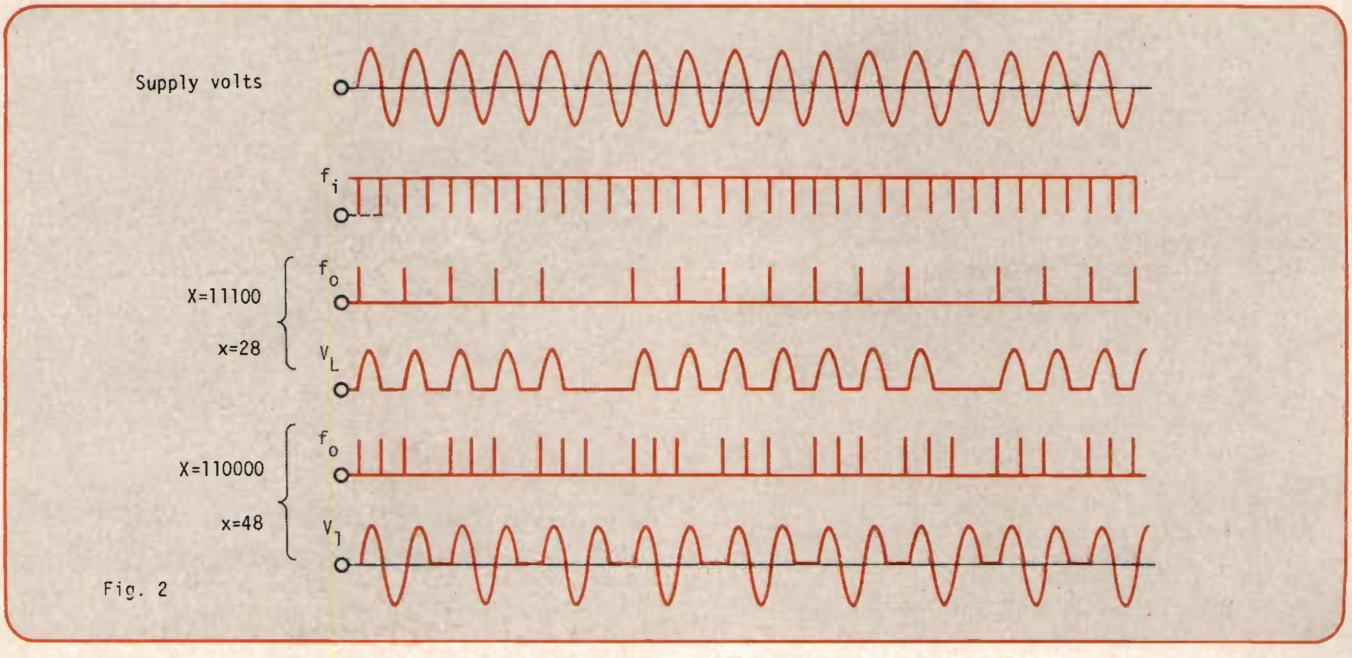

Fig. 2

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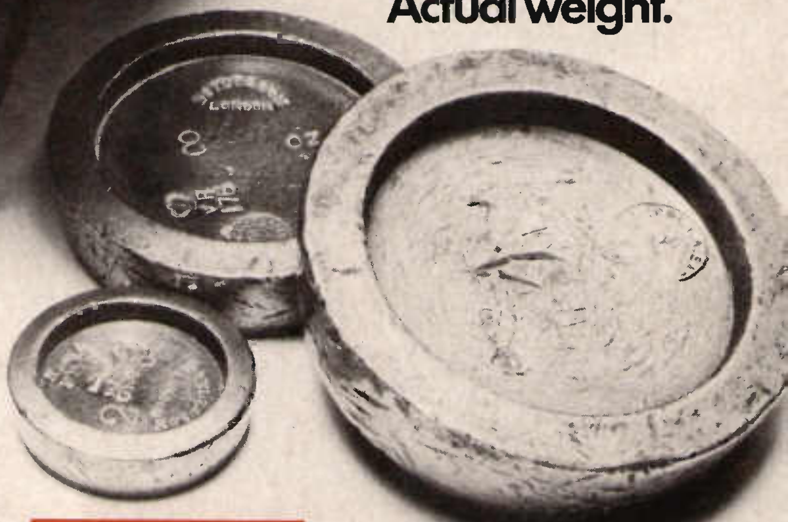

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Constant amplitude triangular wave generation

Voltage to frequency converters generally have square waves as their output wave shape. For transmission (as in outputs from underwater sensors) the square waves are usually converted to sine waves.

The use of fets to convert triangular to sine waves requires the triangular waveforms (derived from the square wave) to be biassed at zero volts and with variable amplitude.

The simple circuit shown in Figure 1 produces constant amplitude triangular waves from a square wave. The basic integrator circuit has already been published[1] and is adopted here.

The closed loop circuit has a common integrator circuit whilst the peak rectifier, difference amplifier and switch are duplicated, one set each for the positive and negative ramps.

Assuming that the operational amplifier has high input impedance and large open loop gain, the positive peak voltage output from the integrator, V_R, will be equal to the set input voltage to difference amplifier. The same is true for the peak negative voltage.

The timing diagrams for the circuit at points A, B and C are shown in Fig. 2. The input square wave is applied to switch 1 controlling the positive ramp. This ensures that the path to the integrator is closed during the first half cycle and opened during the second half. The inverted input is applied to switch 2 to work in a similar but phase reversed manner.

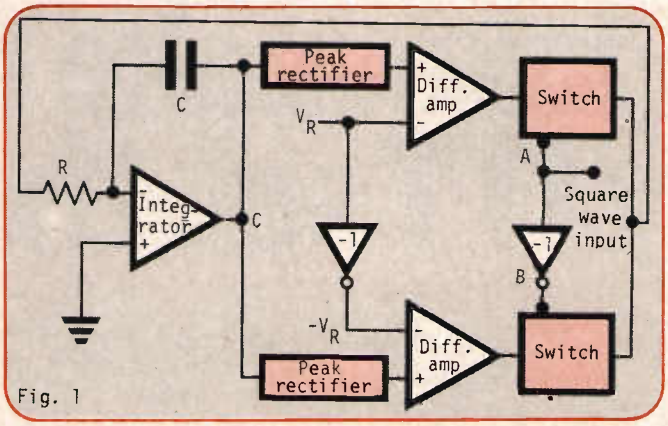


Fig. 1

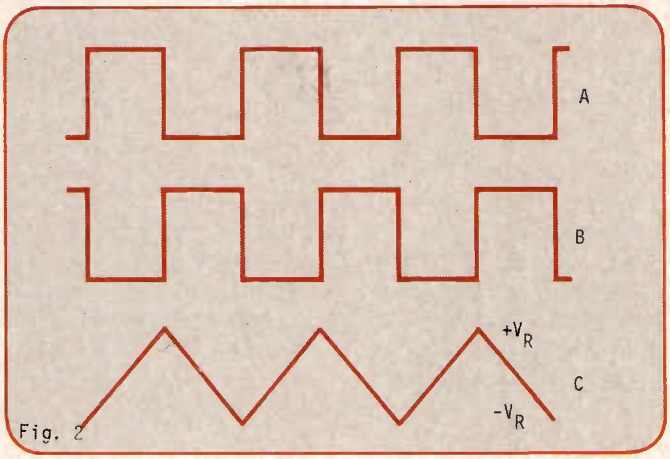


Fig. 2

The peak rectifiers can be replaced by sample and hold circuits if a higher dynamic response to varying frequencies is required. The set point voltages, V_R, and $-V_R$, are obtained from the same voltage source using an inverting amplifier or they may be set independently for different peak levels. The switches could be both n-channel fets or an n-channel and a p-channel. In the latter case the inverting circuit is not required.

To compensate for different values of R_{ds} (*on*) of the switches a small resistor may be placed in series with either switch to ensure that the positive and negative ramps have identical slopes.

Ehrlich Desa and P E Sankaranarayanan, Dona Paula, PO, Goa, India.

Reference

1. Sankaranarayanan, P E, Constant Amplitude ramp generation with op-amps, Electronic Engineering; p.19; September, 1974.

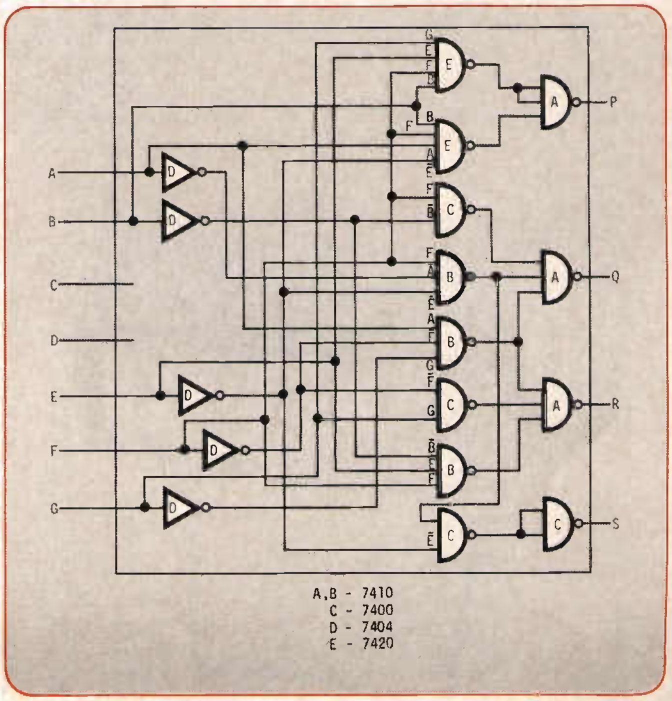
Seven segment to bcd converter uses standard ttl

This solution to the conversion of seven segment to bcd uses only five standard ttl chips and is a cheap solution. In the circuit of Fig. 1, a three or four bit unique term is formed from the seven bit code corresponding to each decimal number zero to nine. The bcd code is then encoded using unique terms. These terms and the relevant output equations are in table 1.

V T Chandrasehkar and R Ramadurai, Bangalore, India.

UNIQUE TERMS	*OUTPUT EQUATIONS*
$0 = EF\bar{G}$	$P = BEFG + AB\bar{E}F$
$1 = \bar{A}F\bar{G}$	$Q = \bar{B}F + \bar{A}\bar{E}F + A\bar{F}\bar{G}$
$2 = EFG$	$R = \underline{\bar{F}G + \bar{B}EF} + A\bar{F}\bar{G}$
$3 = E\bar{F}G$	$S = E + \bar{A}\bar{E}F$
$4 = \bar{A}\bar{E}F$	
$5 = \bar{B}EF$	
$6 = \bar{B}EF$	
$7 = AF\bar{G}$	
$8 = BEFG$	
$9 = AB\bar{E}F$	

Decimal No.	SEVEN SEGMENT CODE							BCD CODE			
	A	B	C	D	E	F	G	P	Q	R	S
0	1	1	1	1	1	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	1
2	1	1	0	1	1	0	1	0	0	1	0
3	1	1	1	1	0	0	1	0	0	1	1
4	0	1	1	0	0	1	1	0	1	0	0
5	1	0	1	1	0	1	1	0	1	0	1
6	1	0	1	1	1	1	1	0	1	1	0
7	1	1	1	0	0	0	0	0	1	1	1
8	1	1	1	1	1	1	1	1	0	0	0
9	1	1	1	1	0	1	1	1	0	0	1



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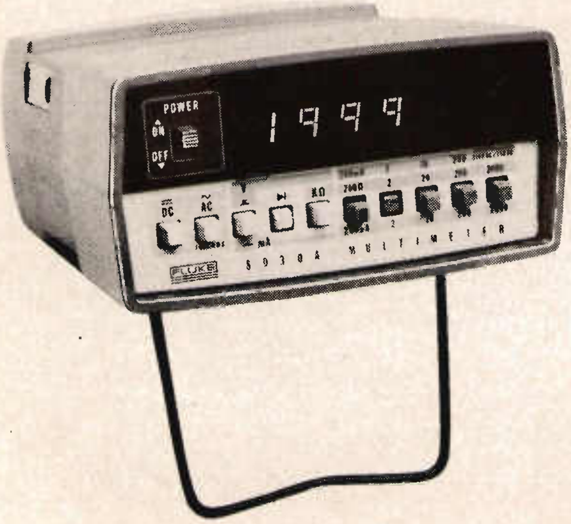


APPLIED IDEAS

Triggered switch makes sweep generator highly linear

The general method for generating linear sweep voltages is charging a capacitor with a constant current. A switch connected across the capacitor provides a discharge path at specified intervals of time or levels of the ramp. For sweeps of very large time periods the changing current is extremely small. For example, to achieve a ramp of 15 V in 3 seconds across a capacitor of 10 μF, the current has to be only 50 μA. In such cases a good constant current source is not sufficient, but the switch across the capacitor should have negligible leakage. In the example, to obtain a linearity of 0,1 per cent the maximum current drawn by the switch while it is *open* should not be more than 50 nA. When the sweeps are of larger periods this requirement becomes more stringent. Fig. 1 illustrates a method of generating highly linear sweeps.

R_1 is valued so that only a negligible fraction of the current is drawn by it. R_2 is of low value compared to R_1 to avoid pick-up voltages appearing at the input of the next state. R_2 is adjusted so that V_I equals V_{ref} at the sweep maximum.

The comparator output is at negative saturation except at the instant the sweep voltages reaches the desired maximum. A fraction of the comparator output (selected by the potential divider arrangement formed by R_5, R_6, and the diode D) less than the BV_{BEO} of the transistor Tr1, reverse biases the npnp switch *off*, allowing it to draw only few nano amps. At the instant the sweep voltages reaches the maximum, the comparator output switches to positive saturation, triggering the npnp switch and offering only a few ohms across the capacitor. The capacitor quickly discharges through it. The diode D does not allow the positive output of the comparator to be divided and ensures the perfect switching *on* of the switch. As soon as the capacitor is discharged, the comparator output switches back to negative saturation. This type of perfect reverse biasing has the added advantage of eliminating the initial steep rise of the ramp.

With $C = 25\mu F$, $I = 125$ μA, $R_1 = 15$ Meg.ohm, a linearity of better than one per cent could be obtained.

For sweeps of very large periods, extending over minutes, it is necessary to operate at still lower currents, when the selection of R_1 becomes impractical. In such cases R_1-R_2 combination can be replaced by an fet-input stage of very high input impedance as shown in Figure 2.

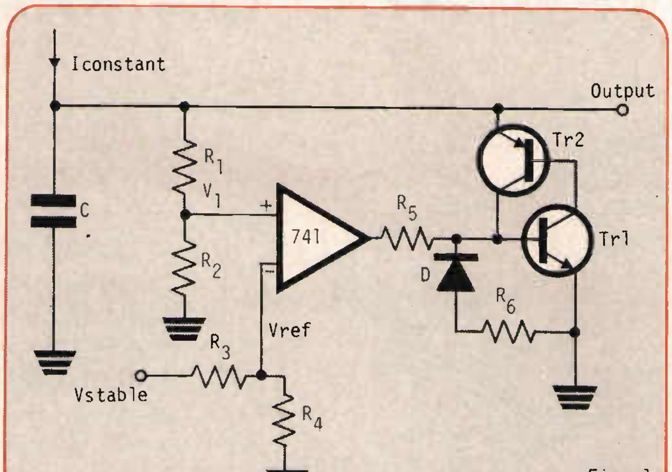


Fig. 1

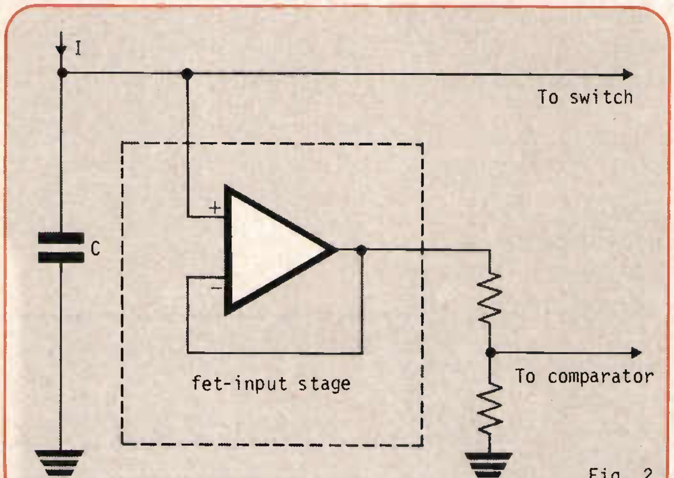


Fig. 2

K O Rose and P R M Panicker, Trivandrum-695 022, India.

A universal sequential element provides flexibility

The SN74150 sixteen-input multiplexer can be used in conjunction with SN74S175 quadruple D-type flip-flops to implement a universal sequential element—*use*, shown in block form in Fig. 1. The *use* is a four-stage shift register with feedback via the multiplexer to the first stage. The multiplexer serves as a five variable Boolean function generator. Three data select inputs A, B and C of the multiplexer are connected to outputs X1, X2 and X3 of the shift register, while the fourth input, D, is controlled by a variable P.

The general state diagram for the *use* is shown in Fig. 2. The purpose of the diagram is to show all possible state sequences. Each state is represented by a four bit word which is the contents (X1, X2, X3, X4) of the register. Each *next state* in the diagram can be found by shifting the *present state* one stage to the right, and letting the first stage, X1, equal *one* if the feedback is *one* and *zero* is the feedback is *zero*. The logic power of the *use* becomes evident when one realizes that two arbitrary state sequences of Fig. 2 can be produced with no additional control logic. The sequence of states and the number of states per cycle is determined by the feedback function. In order to implement desired feedback, each data input E0 to E15 of the multiplexer is connected to one of the following four signals: a logical *zero*, a logical *one*, the assertion, or negation of the X4 variable. An actually used sequence of states—one of the two prescribed—is then selected by letting the control variable, P, equal *one* or *zero*.

The input connection configuration is determined with the aid of the multiplexer input map, shown in Fig. 3. In fact it is a next-state map for the first stage of the shift register. It is

Fig. 1: Block diagram of the universal sequential element—USE.

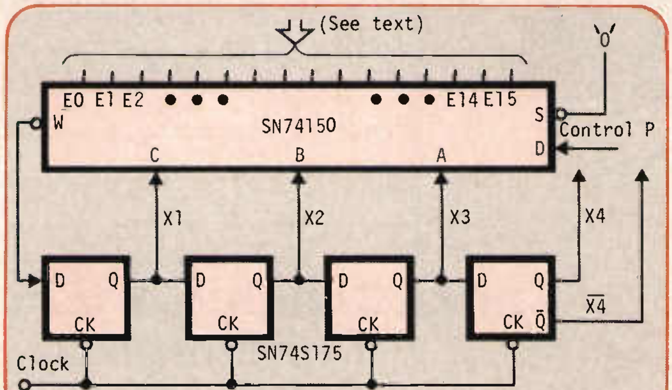
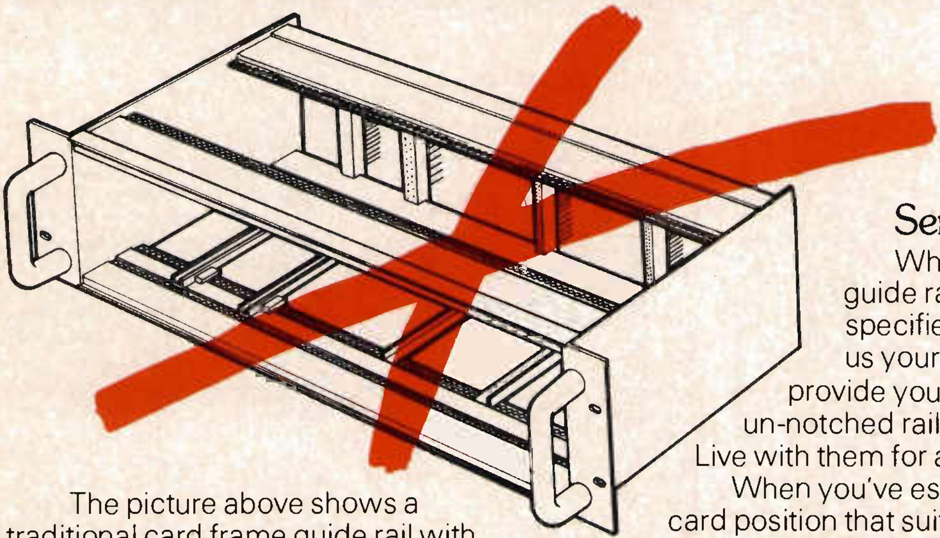


Fig. 1

Most card frames are a waste of money.



The picture above shows a traditional card frame guide rail with location holes pre-set at the standard 0.2ins pitch.

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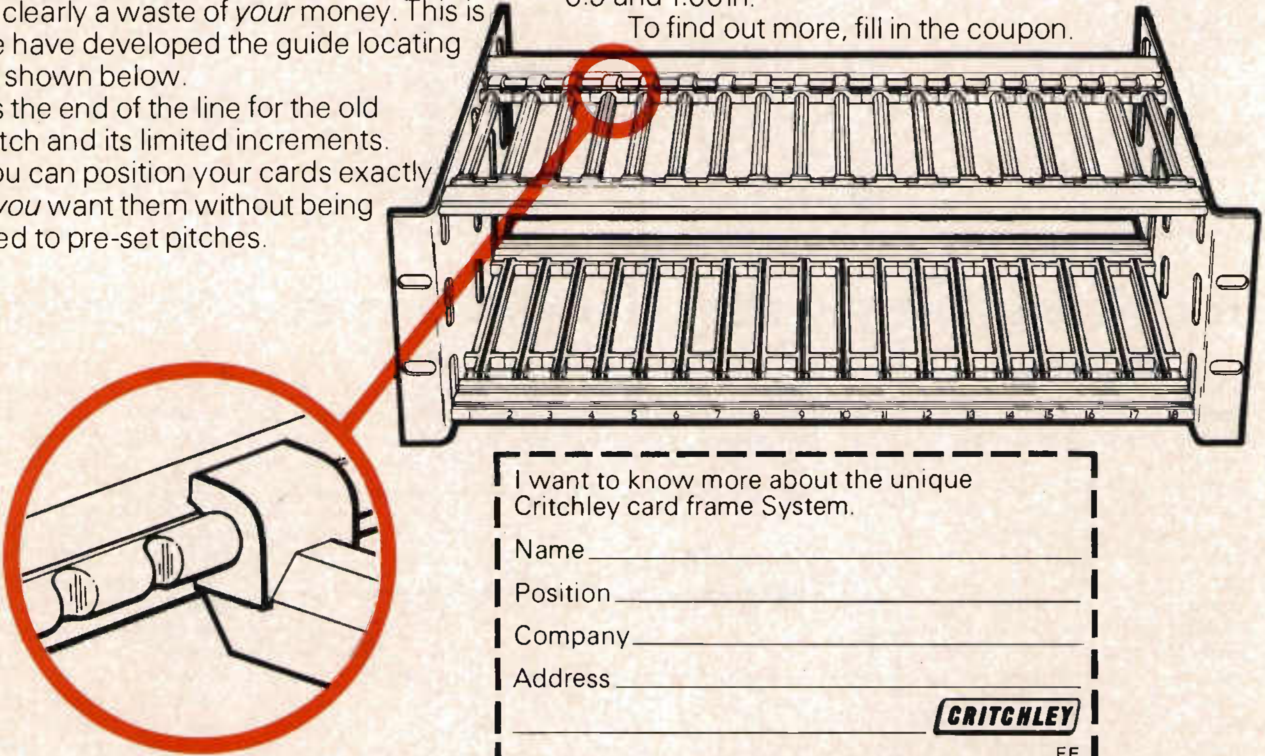

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convenient to label the map so that P = 0 identifies the first desired sequence, and P = 1 identifies the second. The next-state map is generated from required state sequences by finding the value of X1 for the next state. This value is entered in the cell under consideration in the map. When this procedure is completed, the contents of the two circled cells associated with a given input of the multiplexer determine which connection must be made to that input. Since only the inverted output of the multiplexer is available, one should comply with the following procedure. If both cells contain a *zero*, a logical *one* should be connected to the input; if both cells contain a *one*, the input should be connected to the logical *zero*. If the two cells contain a *one* and a *zero* then either the assertion or negation of X4 will be required. If the single *one* (or *zero*) is located in the cell associated with the assertion of X4 then $\overline{X4}$ (or X4) is connected to that input. It should be noted that this technique can make all unused states lead to the cycle of states that is being used, so that self-starting operation is obtained.

An example of the logica design of the *use* is illustrated in Fig. 4. A 12-state sequence (for P = 0) and a 10-state sequence (for P = 1), e.g. such as may be required for variable modulo counters and dividers, are selected. The required state sequences are shown along with the resulting next-state map and input connection configuration.

High speed (at 50 MHz, approximately) operation of the *use* may be achieved with the Schottky SN74S151 multiplexer, but only one arbitrary state sequence can be generated.

W J Szajnowski, Warsaw, Poland.

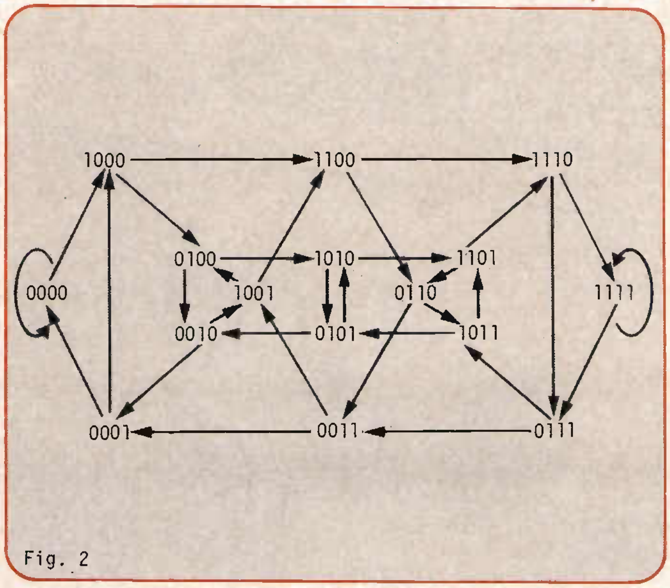
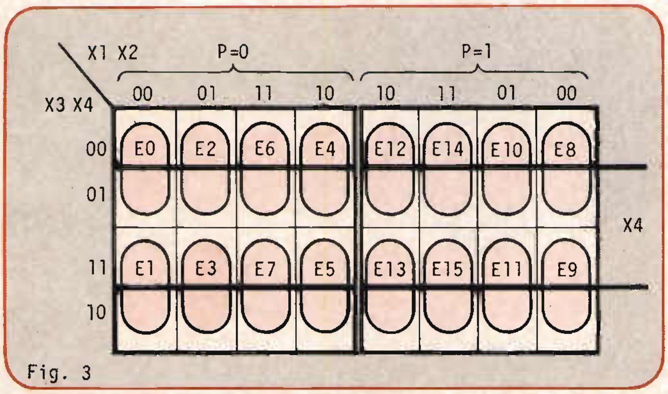
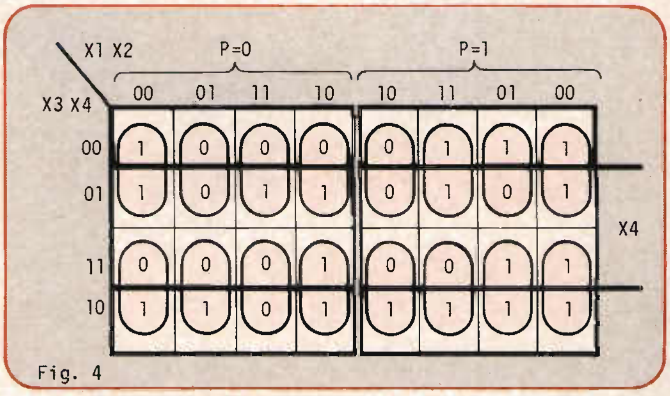


Fig. 2: General state diagram for a four-stage shift register.
Fig. 3: Multiplexer input map for A=X3, B=X2, C=X1 and D=P.
Fig. 4: Logic design of the use generating two sequences.





Simple selective amplifier uses one 709

Most selective amplifiers with RC networks are required with high Q on a specific frequency and need critical components values as well as being complicated.

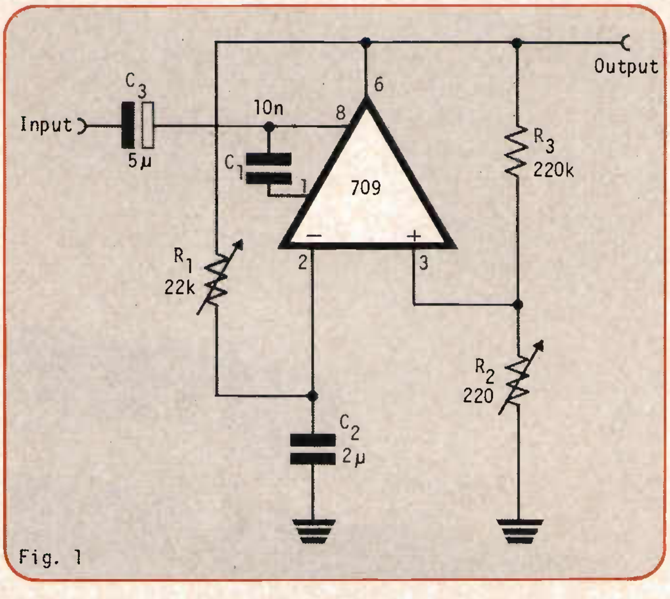
A simple circuit is shown in Fig. 1. This amplifier uses only one µA709. Frequency and Q are easy adjustable with trimms, without using exact components. The fundamental system comprises an astable multivibrator, with a negative feedback loop which determines the frequency R_1C_2, and a positive feedback loop oscillation formed by R_2R_3.

When the input signal is presented to either the inverting, or non-inverting input it would not fit the circuit function. That is why the input signal via C_3 is presented to pin 8 for external frequency compensation. The compensation capacitor C_1 also determines resonance frequency. If the resistance of the signal source is sufficiently low (under about 1 k-ohm), free oscillations depending on the alignment R_2 occur and the circuit is now as a selective amplifier, whose resonant frequency is controlled by resistor R_1 and the Q-factor by R_2. Frequency is defined as

$$f = \frac{2{,}1.10^{-2}}{\sqrt{R_1C_1C_2}}$$

The high cut-off frequency is defined by the properties of the ic, and is minimally 60 kHz for C_1 = 470p, C_2 = 2n2, R_1 = 120. Stable oscillations is only for low values resistance of R_1, and C_1 more than 1 nF.

Vlastimil Novotny, Vokovicè, Czechoslovakia.



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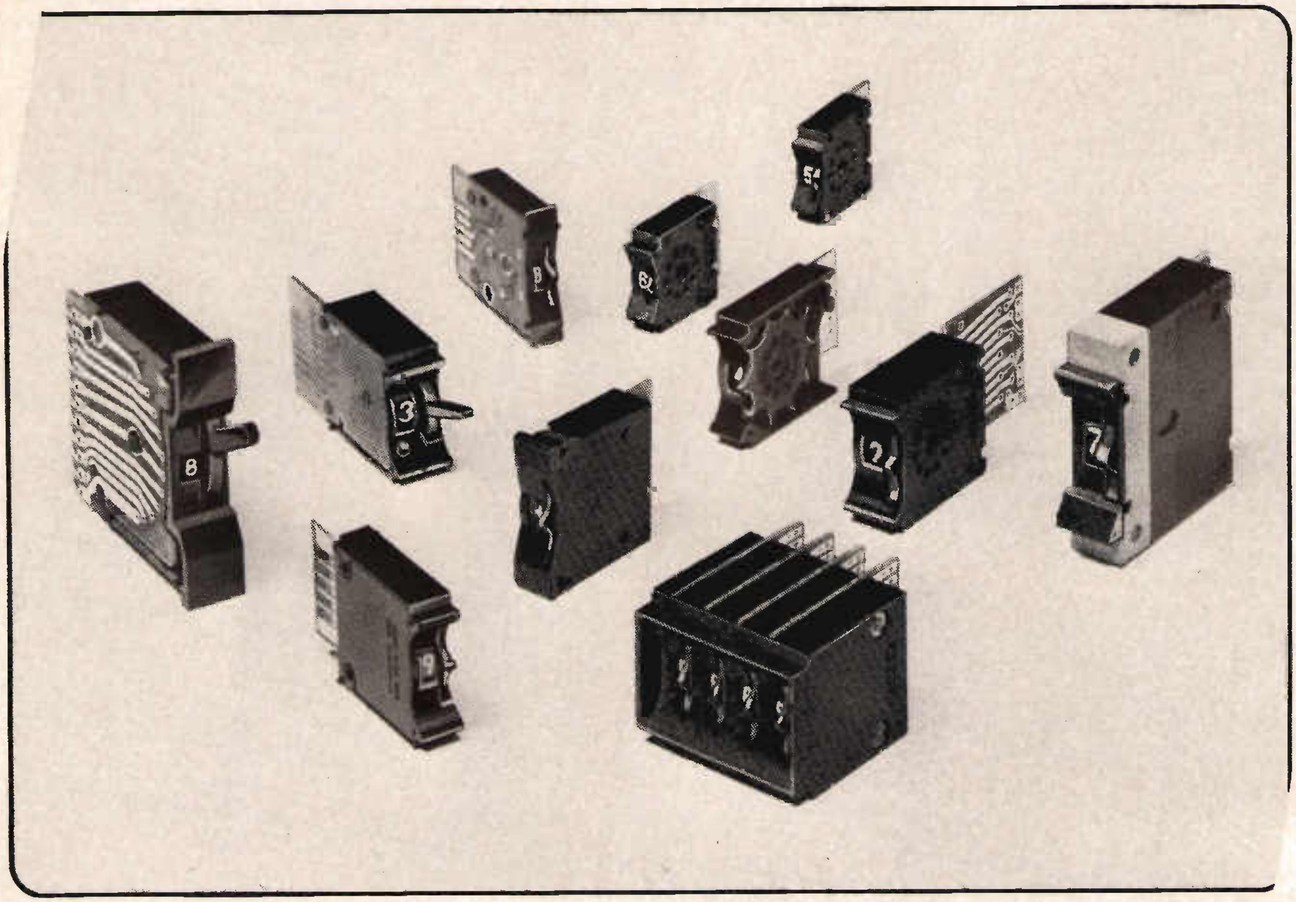

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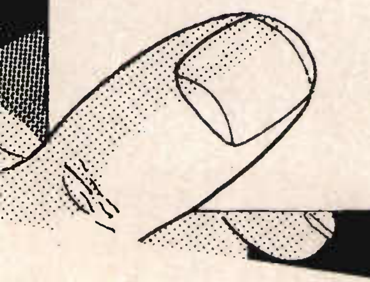

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APPLIED IDEAS

Timer for low frequency oscilloscope

When extremely short duration pulses occur among low frequency signals it often becomes necessary to make them visible on the oscilloscope.

By using the circuit of Figure 1 these pulses can be seen on low frequency oscilloscopes and at low frequency measuring. This is achieved by increasing the pulse-length.

During the *one* state of the *JK* latch the master acts as a *T* latch, and its information appears at the latch output when the level of the clock-pulse goes *low* The Schmitt-trigger oscillator and the RC circuit gives negative clock-pulses. The extremely short duration pulses which appear between the two clock-pulses inverts the master which, for the duration of a clock-pulse will be written over to the slave. In this way it creates a 2 μsec wide pulse which is easily seen on the oscilloscope. Otherwise the *JK* follows the incoming signal.

The frequency of the oscillator is chosen so as not to cause significant time-delay on the oscilloscope screen. This type only imposes one load for the measured circuit, and because it is only a few cms away from the point to be measured, it is suitable for the detection of extremely short duration pulses.

Deáki Tibor, Budapest, Hungary

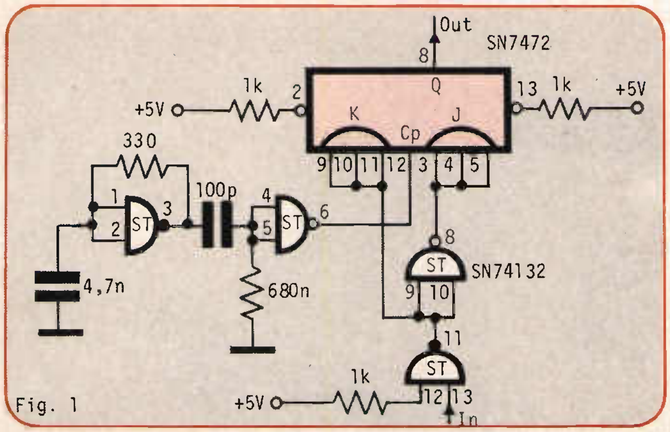


Fig. 1

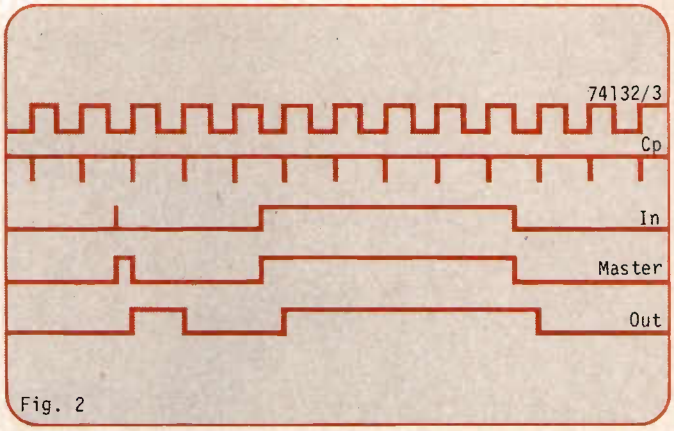


Fig. 2

Pulse subtractor for frequency synthesis

In some systems of frequency synthesis [1,2,3] we face the problem of removing pulses from a pulse train. The difficulty with coincident gate circuits is the proper timing of the suppression process, particularly, if larger propagation delays have to be taken into account.

This problem is solved by the introduction of a memory circuit, consisting of two flip flops and 6 two-input gates, which are activated by a *remove a pulse command* but are otherwise directed by leading and trailing edges of the original pulse train (A). This pulse subtractor finds wide applications and is illustrated in Fig. 1 with the time diagram shown in Fig. 2.

The *remove a pulse* command is supplied to the clock input of the first flip-flop (B input) which is activated by the positive edge. The Q_1 output goes *high* and enables activation of the second flip-flop by the next positive going edge of the sequence $\bar{A}$. Thus Q_2 goes *high* when A is *low;* after nearly a half period later A goes also *high,* the output of the gate G_2 *low,* and that of G_3, *high.* The following change of the state of A activates G_1, G_2 and also gate G_4 because, due to the delay in the interconnecting RC circuit, both its inputs are simultaneously *high* for a very short time. The negative pulse at its output *clears* both flip-flops and prepares them for the next subtracting operation which is performed while Q_2 is *high.* At the same time $\bar{Q}_2$ is *low* and blocks the passage of the sequence A through the gate G_5. The following inversion by gate G_6 supplies the original pulse train with one pulse missing—as shown by Fig. 2.

Venceslav Kroupa, Prague 8, Czechoslovakia.

References

1. Kroupa, V. F., Frequency Synthesis, Theory, Design, and Applications. New York, Halsted, a div. of Wiley, 1973.
2. Becker, G., Quasiperiodic frequency synthesis. Proc. of the 26th Annual Frequency Control Symposium, p. 279, Atlantic City, June 1972.
3. Small, G. W., A Frequency Synthesizer for 10/2 π kHz. IEEE Trans. on Instrumentation and Measurement, Vol. IM-22, No. 1, pp. 34-37, March 1973.

Fig. 1

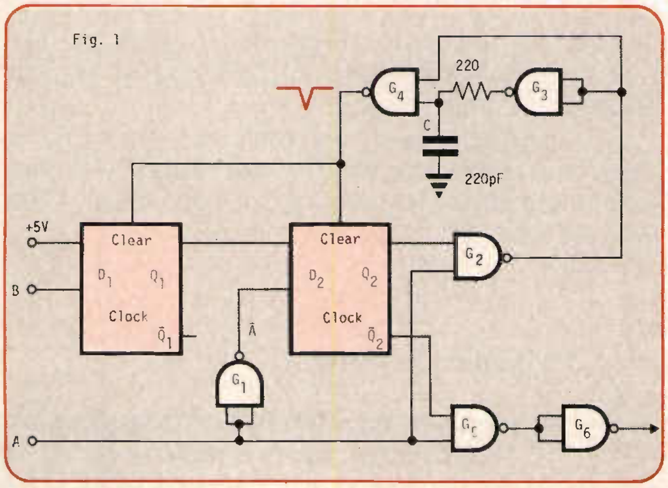
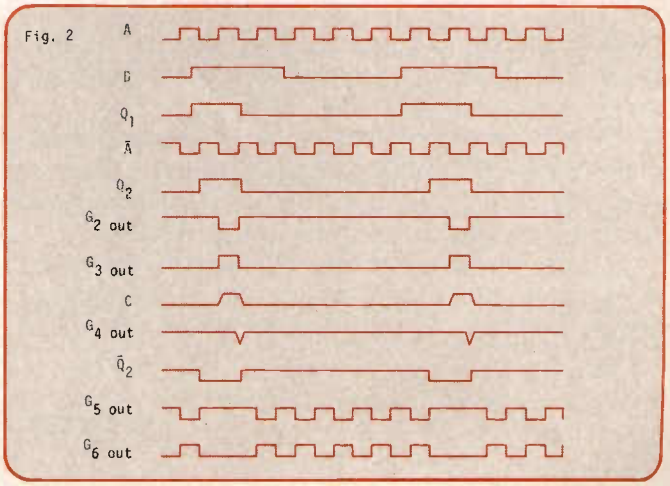


Fig. 2



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Autopositioning of main tap for cyclic equaliser

For high speed data transmission over voice frequency telephone channels, it is necessary to perform cancellation of inter-symbol interference so as to maintain the quality of data transfer. This is best carried out in the sampled baseband domain using an adaptive digital filter known as the automatic equaliser. However, the equaliser requires training-up and this increases system turn-round time. For multipoint polling applications, it is important to keep this period to a minimum.

A scheme (see reference) proposed by Mueller and Spaulding, which utilises the cyclic property of a training sequence, enables good channel equalisation to be achieved within a very short period of time, typically one or two symbol periods. It is called cyclic equalisation. The principle involves setting the length of the equaliser such that it is the same as the length of the training sequence. Once the steady state has been reached, the input to the equaliser is disconnected and the information contained in the delay line of the equaliser cyclically shifted. Now, adaptive equalisation can be carried out at a much faster rate. A local reference store which contains the transmitted training sequence is used to detect the equalised output, hence forcing the signal *eye* to open up quickly. Once equalisation has been achieved, the equaliser is reconnected and detection takes place using estimated reference.

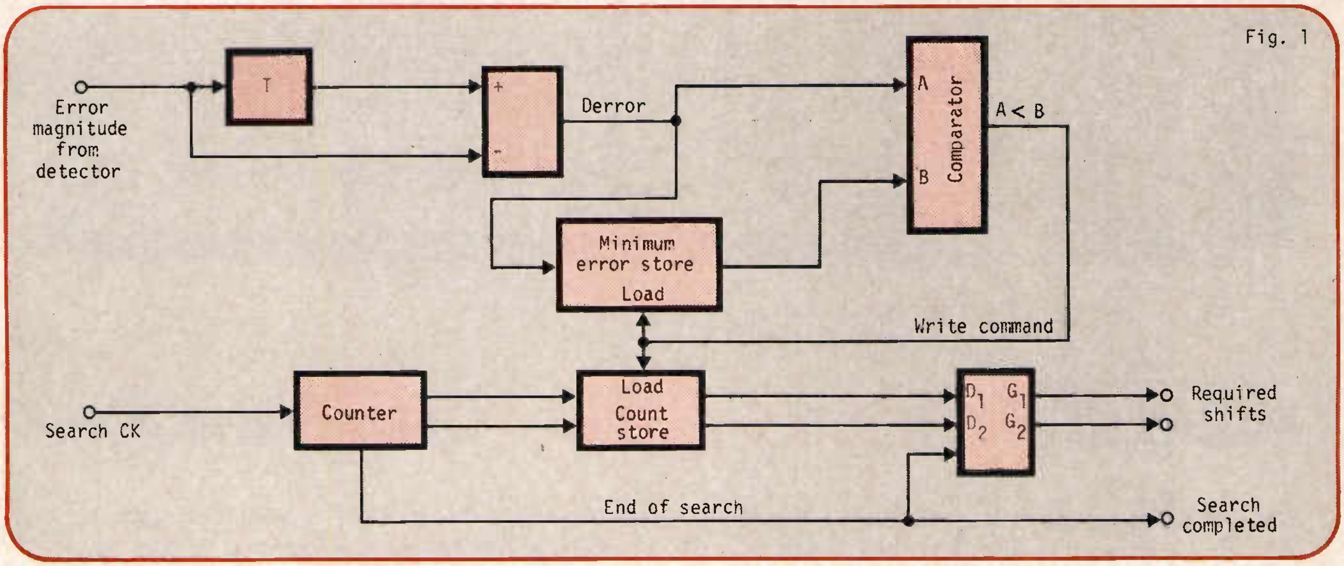
One drawback with this method is that synchronisation between the received signal and the local reference is hard to achieve. Any cyclic shift between these two, yields a cyclic displacement of the tap position. In this situation if all the taps are in use, the system will be less than optimum.

Implementation is straight forward (Fig. 1). When search begins, the equaliser clock is increased by a factor which equals to the number of taps (N). This enables N detections to be carried out for the N different tap positions, all within one symbol period. Each detection provides a corresponding error value which is then subtracted from the previous one to give the first derivative. This is compared to the last minimum Derror. If the present value is less, this is loaded into the store as the minimum. At the same time, a counter is used to keep a count of the number of cyclic shifts that have taken place. The count corresponding to the minimum Derror is also loaded into a count store. At the end of the search, the number which is in this store determines the number of cyclic shifts required to appropriately place the tap coefficients.

This method is message dependent, but the first order filtering is designed to smooth out most of this.

Martin N Y Shum, Harefield Road, Rickmansworth, Herts.

Reference
Cyclic equalisation—A new rapidly converging equalisation technique for synchronous data communication. BSTJ February 1975.

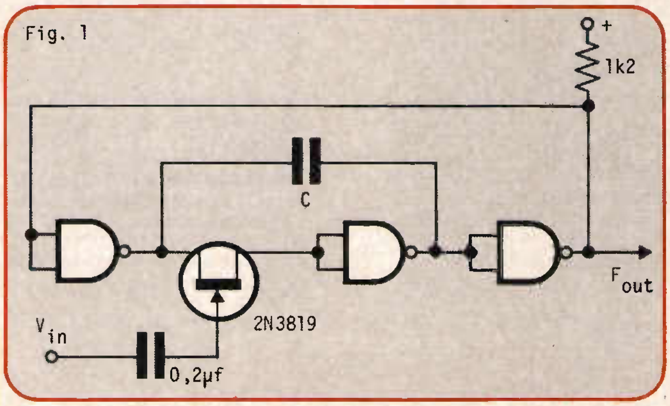


A voltage to frequency converter with one ttl chip

A voltage to frequency converter which employs only one inexpensive ttl chip and a jfet n-type transistor can be constructed quickly and cheaply.

The basic circuit, illustrated in Fig. 1, consists of a free-running adjustable generator which consists of three open-collector 2-input *nand* gates (7403) and a jfet. The frequency of the adjustable generator depends upon the values of its *RC* elements.

Under certain conditions the channel of the jfet behaves almost as an ohmic resistor. In addition, when the jfet is operated near the origin, then the channel resistance r_{DS} is almost linear and depends only on V_{GS}.



When the resistor of the square-wave generator is replaced by an n-type jfet, then variations to the input voltage V_{in} will result in variations to V_{GS} and consequently to the channel resistance of the jfet. This will result in variations to the frequency (F_{out}) of the square-wave generator.

In Figures 2a and 2b the input voltage versus frequency in semi-logarithmic and linear

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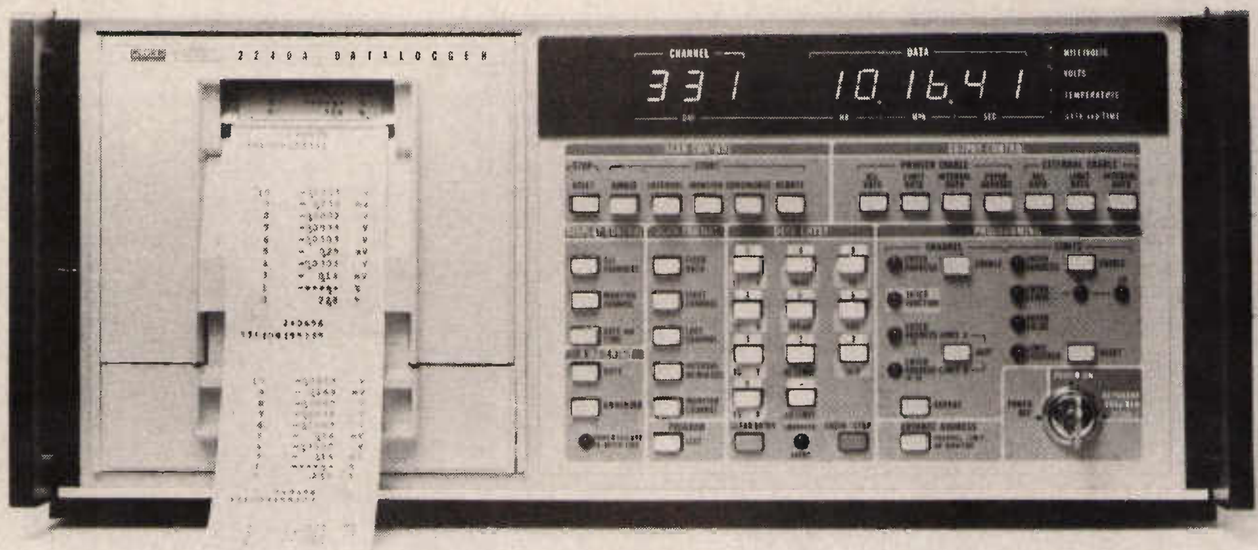

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scales are illustrated, respectively. From the linear scale it is seen that for input voltages from 0 V to −0,7 V the non-linear relationship between input voltage and frequency can be approximated by the linear relationship

$$f = K\,V_{in} \quad (1)$$

In equation 1, the constant K provides the resolution of this voltage to frequency converter and for the above mentioned range and for the particular jfet used (2N3819) is estimated to be

$$K = 4{,}5\times10^{n}\ \text{(kHz/Volt)},\quad n = 1,2,\ldots \quad (2)$$

where n denotes the order of the decade of the working frequency (or carrier frequency) in kHz. For example, for carrier frequencies between 1 kHz and 10 kHz (first decade), n = 1, therefore a resolution of 45 Hz/mV is obtained; for carrier frequencies between 10 kHz and 100 kHz (second decade), n = 2, therefore a resolution of 450 Hz/mV is obtained, etc.

S V Kartalopoulos, University of Toledo, Ohio, USA

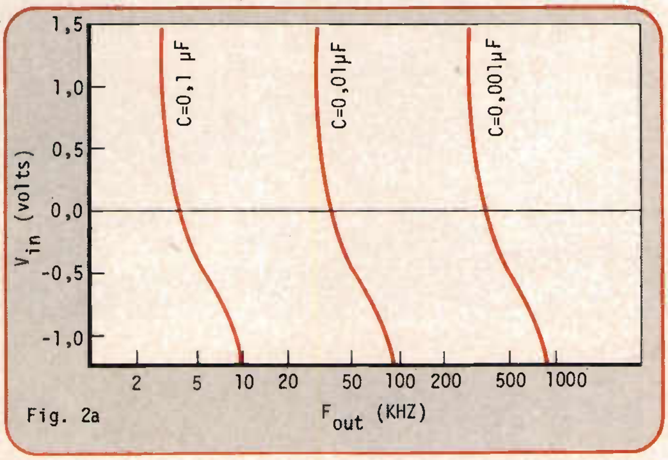

Fig. 2a

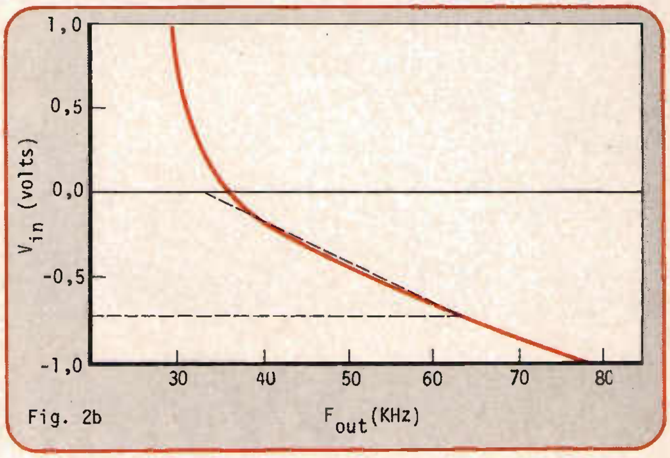

Fig. 2b

Only one line is true detector for digital parallel lines

The problem is a method of selecting those *ones* of digital data being on m parallel lines that are composed from m-1 logical *zeros* and only one logical *one*. The logical or Boolean function is:

$$F_{1-m} = Q_1 + Q_2 + Q_3 + . + Q_m \quad (1)$$

where

$$Q_i = \bar{A}_1\bar{A}_2 \ldots A_i \ldots \bar{A}_m$$
$$i = 1, \ldots, m \quad (2)$$

The $F_{1\mu 2}$ function is the *exclusive or* connection of two logical variables.

For m>2 cases an interesting solution is offered by using SN7442 decoders. Let us rewrite the notation of SN7442:

$$A\to A_1;\ B\to A_2;\ C\to A_3;\ D\to A_4;$$
$$\bar{1}\to\bar{Q}_1;\ \bar{2}\to\bar{Q}_2;\ \bar{4}\to\bar{Q}_3;\ \bar{8}\to\bar{Q}_4;$$
$$\bar{0}\to\bar{O}_{1-4} \quad (3)$$

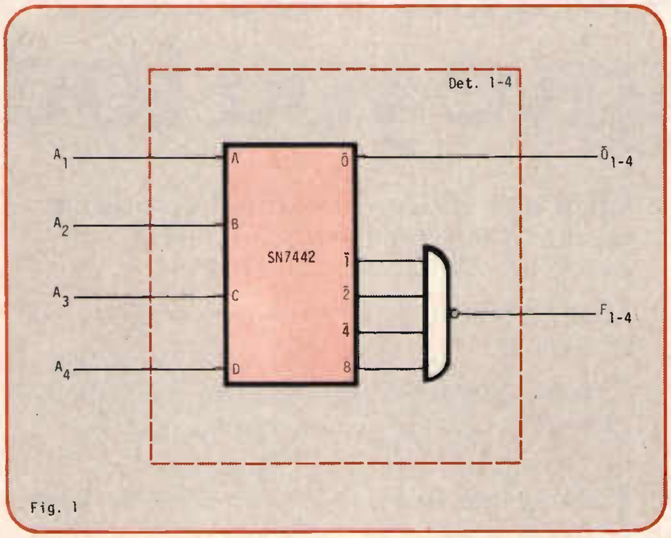

Fig. 1

where $O_{1\mu 4}$ comes from:

$$\bar{O}_{1-m} = \bar{A}_1\bar{A}_2\bar{A}_3 \ldots \bar{A}_m \quad (4)$$

Fig. 1 shows the use of SN7442 to realize the F_{1-m} function at m⩽4 cases. O_{1-4} output is used is m>4 cases.

In Fig. 2 we can see the realization of the F_{1-m} functions at m⩽8 cases. For example at m = 8 the F_{1-8} may be written into the following form:

$$F_{1-8} = \bar{A}_1\bar{A}_2\bar{A}_3\bar{A}_4\,F_{5-8} + \bar{A}_5\bar{A}_6\bar{A}_7\bar{A}_8\,F_{1-4} \quad (5)$$

The extension of equation 18 to m⩽16 cases may be done by the principle used in equation 5

$$F_{1-16} = \bar{A}_1\bar{A}_2\bar{A}_3 \ldots \bar{A}_8F_{9-16} + \bar{A}_9\bar{A}_{10}\bar{A}_{11} \ldots \bar{A}_{16}F_{1-8} \quad (6)$$

The scheme to realize equation 6 can be seen in Figure 3.

Sándor Lökös, Hungary.

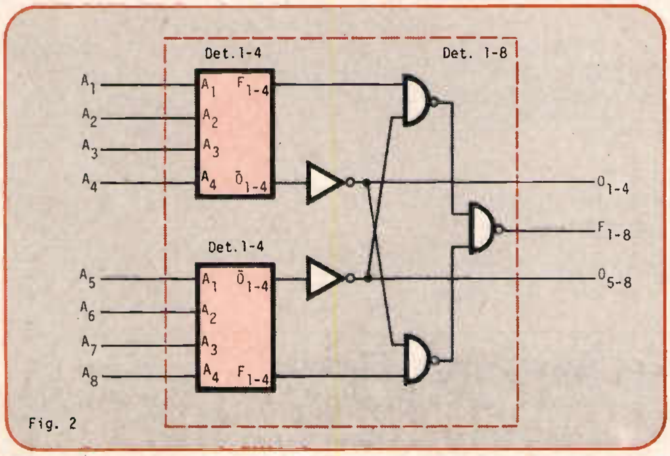

Fig. 2

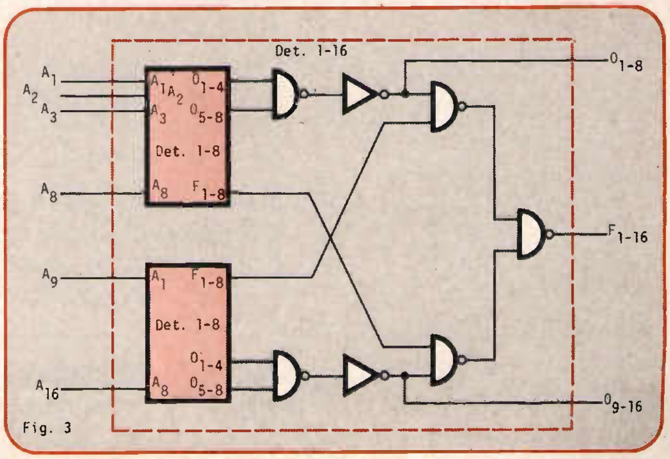

Fig. 3

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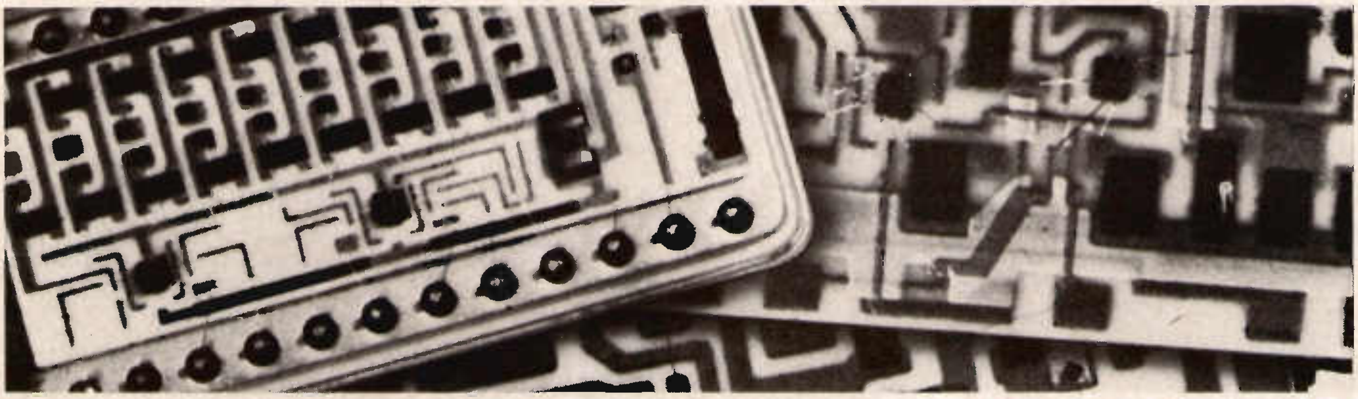

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Temperature compensation via current generators

By tailoring the current generator characteristic to offset an undesired signal variation, significant compensation can be obtained. Figure 1 shows the circuitry employed for this.

The circuit equations are

$$I_G R_G + N V_D + I_D R_D = V_{EE} \quad (1)$$

$$I_G R_G + V_{BE} + M V_D + I_E R_E = V_{EE} \quad (2)$$

$$I_G - I_D = (1-\alpha) I_E \quad (3)$$

Solving these equations for I_E:

$$I_E \simeq \left[\frac{V_{EE}/V_{BE}}{1+R_G/R_D} + \frac{N}{1+R_D/R_G} - M - 1\right]\frac{V_{BE}}{R_E} \quad ...(4)$$

Since $(1-\alpha)$ is very small in most practical cases and the diode voltage drops V_D are approximately equal to the transistors emitter-base voltage drop.

Differentiating the equation for I_E with respect to temperature we obtain the temperature coefficient:

$$\frac{\delta(I_E R_E)}{\delta T} = \left[\frac{N}{1+R_D/R_G} - M - 1\right]\frac{\delta V_{BE}}{\delta T} \quad ...(5)$$

In an integrated circuit knowing the temperature dependence of the emitter-base voltage (typically $-0{,}3\%/°C$) and the temperature dependence of integrated resistors (typically $+0{,}09\%/°C$), it is possible to design the circuit parameters (R_E, R_D, R_G, N and M) for the required current level and nominal temperature coefficient.

These equations are plotted in Figures 2(a) and (b) to show the typical degree of control that can be achieved.

Figure 3 shows the temperature dependence of the output of a sensor before and after compensation with this circuit. The uncompensated characteristic shows a negative temperature coefficient in the region of 0,06%/°C at current of 1 mA.

From the design charts (Fig. 2), one of the following combinations of the circuit parameter values is required:

(a) $M = 0$, $R_E = 1\ k\Omega$, $N = 1$, $R_D/R_G = 2{,}40$, $V_{EE}/V_{EE} \simeq 3{,}0$

(b) $M = 1$, $R_E = 1\ k\Omega$, $N = 3$, $R_D/R_G = 1{,}28$, $V_{EE}/V_{EE} \simeq 3{,}8$

(c) $M = 1$, $R_E = 1\ k\Omega$, $N = 4$, $R_D/R_G = 2{,}06$, $V_{EE}/V_{BE} \simeq 3{,}2$

In practice, better compensation over the full working range may often be obtained with non-minimal combinations such as (b) and (c) above. This arises through second order effects causing curvature in the compensating characteristic matching curvature in the output characteristic.

J E L Hollis, Portsmouth.

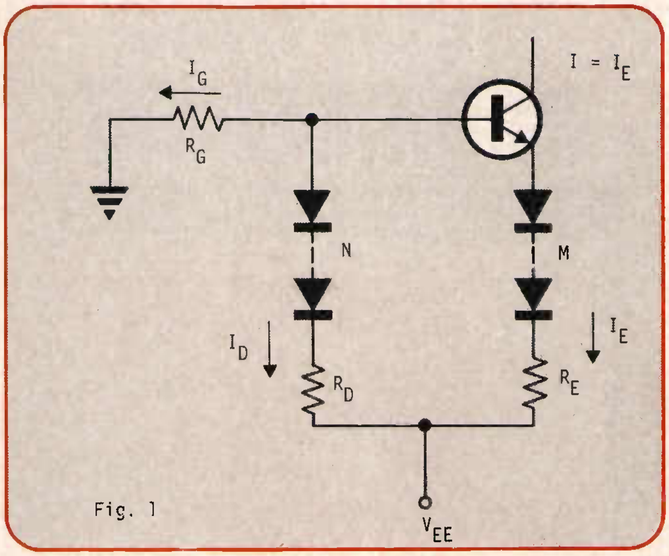


Fig. 1

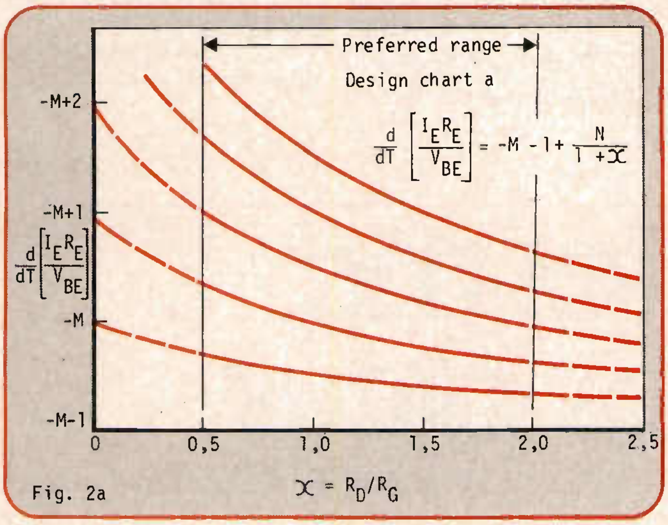


Fig. 2a

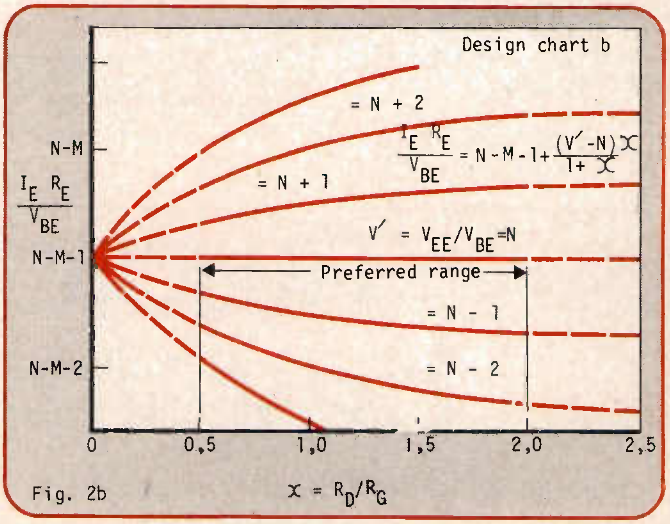
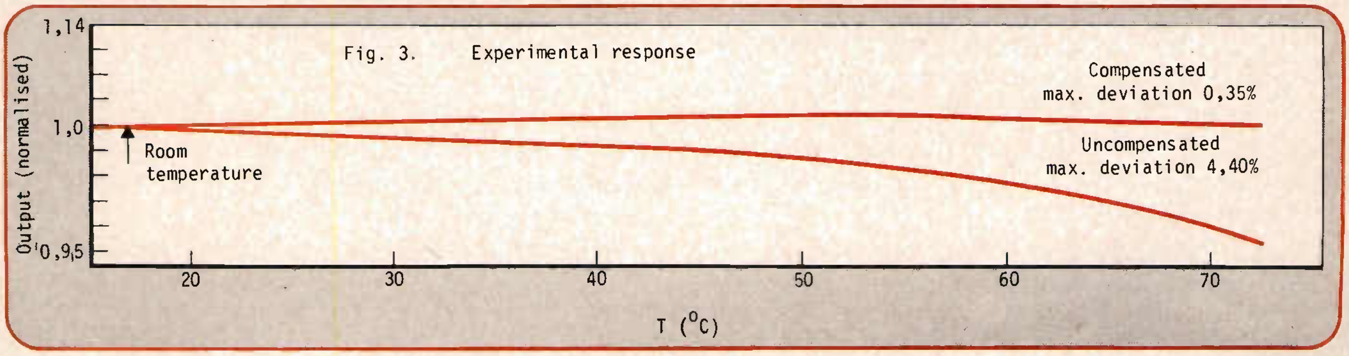


Fig. 2b



Applied Ideas Competition 1977

Once again *Electronic Engineering* will be running the Applied Ideas competition and will be giving away prizes which have a total value of £1000. Jubilee Year marks the fourth appearance of the competition and the co-sponsers this year will be Siliconix, the semiconductor company which is based in Newbury.

Prizes will again be awarded for the best Applied Ideas published in *Electronic Engineering* during the year, Originality, suitability, elegance, adaptability and general usefulness are some of the factors which will be taken into account.

Contributions should give a concise account of the application of the submitted Applied Idea along with design criteria and an indication of performance of the design.

Entries must be from named individuals and must not have appeared previously outside the originating establishment. A contributor's fee of £10 will be paid on publication.

Applied Ideas must be typed, using only one side of the paper, with double spacing and wide margins. Illustrations must be drawn clearly on separate sheets. They should be captioned, show component values and type numbers, and indicate test voltages and waveforms where appropriate. Entries should conform to the usual style of the journal.

Please send entries to the Applied Ideas Editor, *Electronic Engineering*, Morgan Grampian House, 30 Calderwood Street, London SE18 6QH.

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The design ideas will not only be judged by Siliconix but will be eligible for consideration as an Applied Idea. This means that any vmos circuits published as an Applied Idea will automatically be entered for the 1977 Applied Ideas competition.

The standards and format required for the vmos circuit ideas should be the same as those specified in the rules of the Applied Ideas competition, explained above.

Entries must be accompanied by an application form which will be supplied by Siliconix, but requests for forms through *Electronic Engineering* will be answered. Full details of the competition ie the rules and conditions Siliconix have laid down will be given in the next issue of *Electronic Engineering*.

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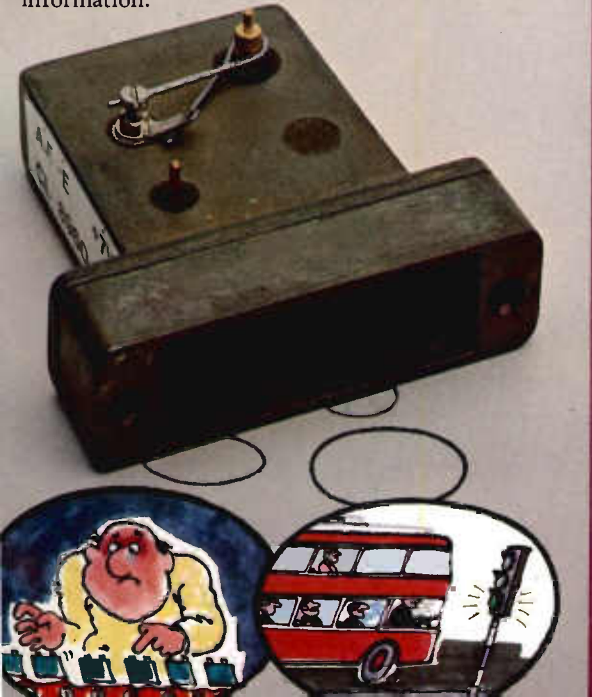

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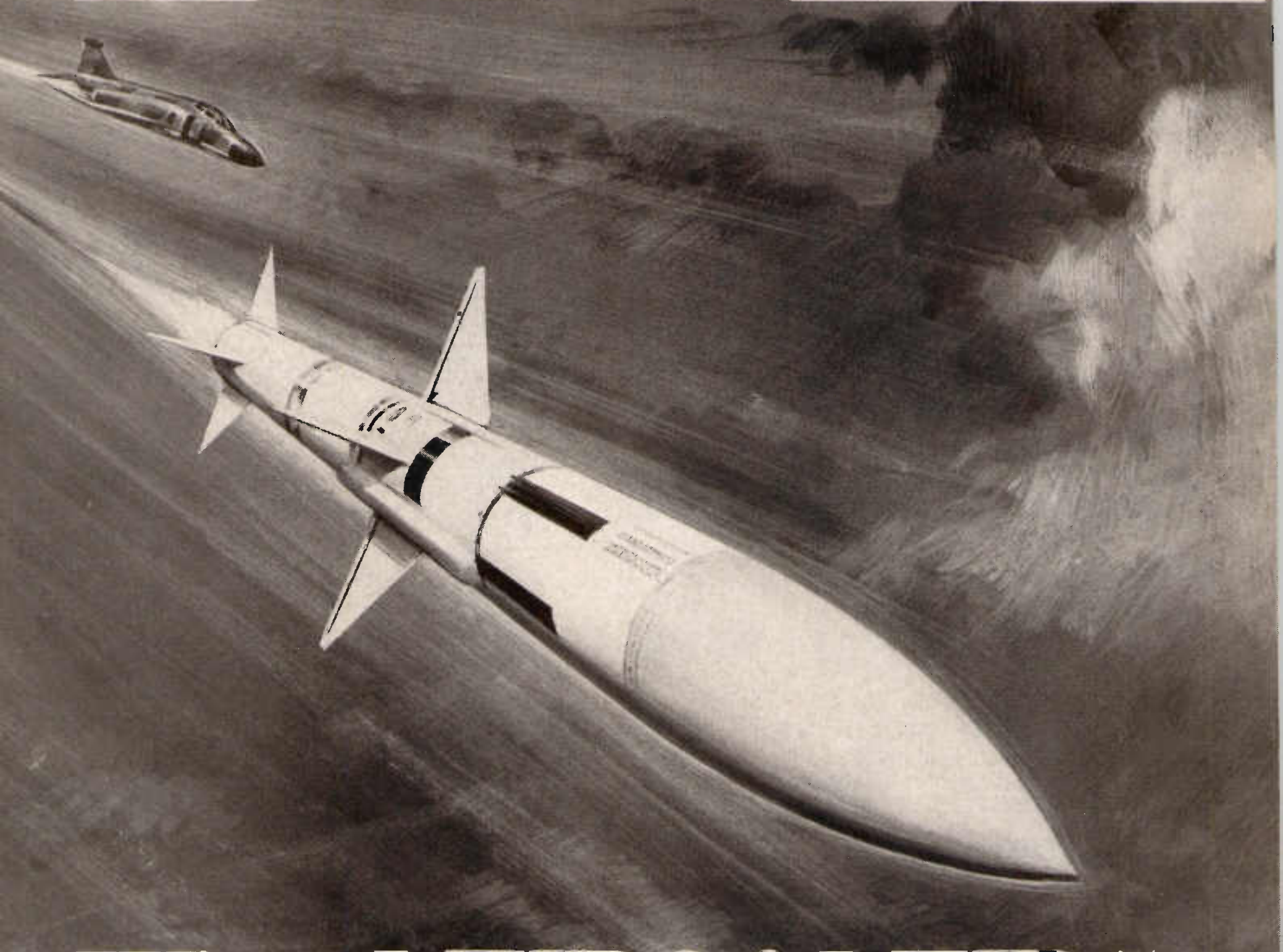

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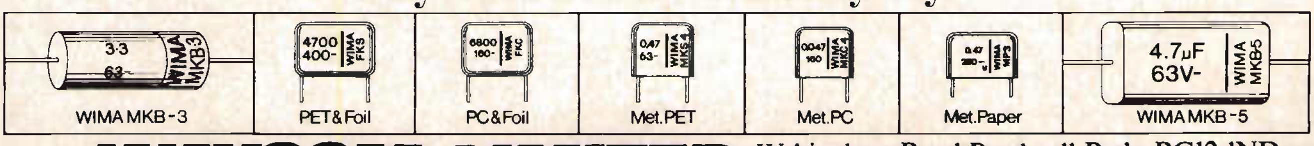

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Magnetic bubble memory systems

Magnetic bubble technology has reached the point of exploitation, writes *A T Gibson*. This article describes a bubble memory system developed in the United Kingdom.

The advent of cheap bulk memory, having a cost/bit approaching that of existing rotating disc memory (i.e. 0,005 c/bit by 1980) even for moderate capacity, will significantly affect the move towards distributed intelligence in systems and will enhance the impact of the microprocessor. Magnetic Bubble memories will also be able to replace electro-mechanical storage in many applications, and give the possibility of improving the cost/performance of memory hierarchies in many mainframe computers.

Numerous articles have been written on the basic technology and method of operation. Briefly, 4-6 micron diameter bubbles are contained in a thin single crystal film of Yttrium Iron Garnet (YIG) which is doped with certain rare earths to give optimum properties. This magnetic film which is grown onto a non-magnetic substrate of Gadolinium Gallium Garnet (GGG) is processed as a multi-chip wafer to include, in a simple two mask process, gold interconnectors for the *write* and *read* functions and the permalloy pattern for bubble propogation and detection. Storage cell size is typically between 16 and 26 microns square giving a storage density 1500-4000 bits per mm^2.

A T Gibson is with Plessey Memories, Towcester

Bubble memory operation

A magnetic bubble memory chip consists essentially of one or more non-volatile, recirculating, static shift registers which operate at a typical clock rate of 100 kHz. Data is represented by the presence or absence of a bubble. Initially production devices will have capacities of between 64 k bits and 128 k bits per chip for a chip size of 5-7 mm^2.

To obtain fast access time, a major/minor loop organisation (Fig. 1) is used. To access data, bubbles in the minor loops are first shifted to the position closest to the major loop. Corresponding bubbles (or absence of bubbles) are then transferred simultaneously from all minor loops to the major loop. Then they are shifted around the major loop, read, annihilated or replicated as required, and transferred back to the minor loops. Access time for this organisation is $\frac{1}{2}\sqrt{N}$ times less than the simple shift register type, where N is the total number of bits per chip,

For simple single register devices, the basic functions required to operate a magnetic bubble memory are propagation, generation, detection and annihilation.

Propagation is accomplished by driving the two clock waveforms, each clock cycle shifting the bubbles one position in the register. A current pulse in conjunction with the clock waveform generates a bubble (i.e. writes a *one*) and the absence of a current pulse generates a *zero*. The pulse amplitude is typically 300 mA with duration of 0,2 µs.

A 'chevron detector' stretches a bubble into a wide strip which causes a change in magneto-resistance of the Permalloy pattern. The resultant change of voltage amounting to several millivolts is compared with a signal from a dummy detector to provide a noise-free signal. A current pulse in conjunction with the clock waveform is also used to a erase a bubble if present. Typical pulse amplitude and width for annihilation are 50 mA and 3 µs. Additional functions for a block organisation. A current pulse in conjunction with the clock waveform transfers a bubble from each minor loop to the major loop, typical pulse amplitude and width being 50 mA and 1,5 µs and for replication another current pulse in conjunction with the clock waveform duplicates information in two divergent paths. Typical pulse amplitude and width for this function

Fig. 2: Single chip package assembly.

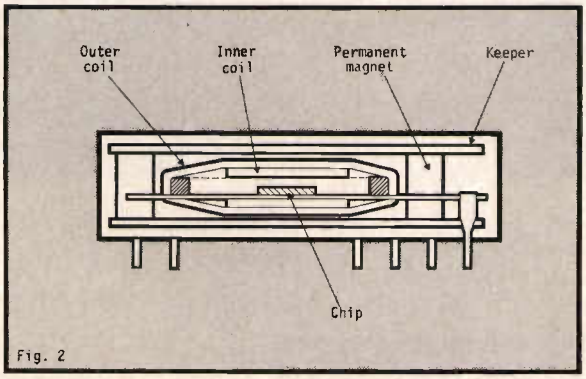


Table 1: Comparison of performance.

	800 BPI Cassette	Floppy Disc	Bubble Memory	
Capacity	2,4	2,0	1,024	Mbits
Bit Rate	10	250	800	kHz
Access Time (Average)	20	0,46	0,08	Seconds
Weight	1,4	4,5	0,5	Kg
Power	35	150	15	W
Volume	2048	8194	410	cm^3
Solid State	No	No	Yes	
Removable Media	Yes	Yes	Possible	
Asynchronous	Yes	No	Yes	
Incremental Facility	Yes	No	Yes	

Fig. 1: Major/minor loop organisation.

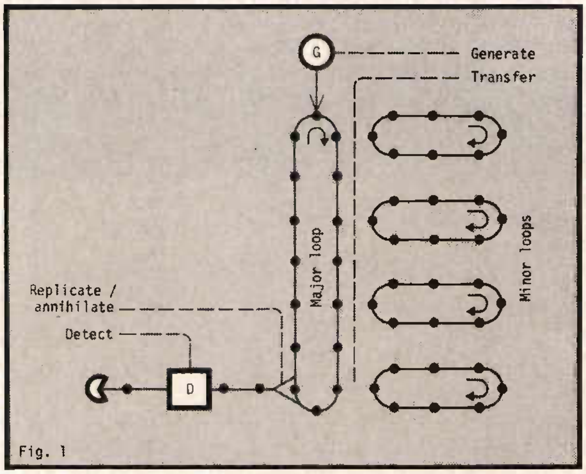


Table 2: Multiloop designs are competitive.

	Fixed Head Discs	Bubble Memory	
Capacity	16	16	Mbit
Data Rate	4,4	7,7	MHz
Access Time	10	1	ms
Weight	32	9	
Volume	0,06	0,03	kgm^3

are 100 mA and 0,25 μs.

The clock waveforms are typically 500 mA amplitude sinewave functions, one clock being 90° out of phase with the other. Stop/Start operation is a very advantageous feature. Stopping the shifting process completely, or restarting it from a standstill, takes only 10-20 μs This allows access to a single bit at a time, groups of bits or continuous operation. Approximations to a sinewave function, such as triangular waveforms, can be used for the clocks.

Up to the stage of wire bonding a chip to a lead frame, the magnetic bubble technology is similar to semiconductor ic technology, except that the structure of the bubble chip is simpler and therefore provides relatively high yield. However, the package must incorporate two orthogonal coils for the two clock waveforms and also a permanent magnet assembly to provide a steady bias field. Fig. 2 shows a single chip package assembly in cross-section. The assemblies are encapsulated to form finished packages.

Some companies are using multichip packages, thus sharing the cost of coils and magnets over 8 or 16 chips. Disadvantages of this approach are lack of user flexibility, lower chip yield inherent in hybrid production, and module rework is difficult at best. However this could be a useful approach where low volume is required.

Memory system

For a single chip package, the clock input impedance consists of an inductance of typically 30 μH in series with a small resistance less than 1 Ω. A coil driver can drive eight of these inputs in series from a 20 V rail. The power dissipation of such an arrangement is predominantly in coil resistance, which amounts to approximately 250 mW per package for both clocks operating at maximum speed.

Sense amplification requires a differential pre-amplifier which can be shared between two packages and multiplexed when used in a large array. The final amplifying stage incorporates ac coupling, dc restoration and a strobing circuit. Resulting superimposed *zero* and *one* signals are shown in Fig. 3 together with a strobe pulse. In future, integrated support chips will certainly be available.

A block diagram of a 32 kbyte bubble memory system card is shown in Fig. 4. One 'X' or 'Y' coil driver will drive eight interconnected coils which, together with tuning capacitors, form a tuned circuit. The natural frequency of the tuned circuit provides the clock for the system and the 'Y' and 'X' circuits are interconnected so that the phases are locked accurately at 90°. Two output synchronising signals are derived from the 'clock' as timing waveforms for the user.

Each coil driver supplies only the incremental current required to replace the resistance losses in the coils during continuous operation and also provides the high energy, short duration pulses needed for start/stop operations. Thus, power requirements are minimised under continuous operation.

Detectors of each pair of bubble chips are connected in a bridge arrangement and the resulting sense signal (≃5 mV) is amplified before being strobed into an 8-bit data register.

The *write* function is performed on eight of the sixteen bubble chips, as determined by the address register. One *erase* driver is pulsed and eight *write* drivers are pulsed, or not, depending on the state of the data register during the cycle.

The control organises the various pulse timings from the basic clock waveform to complete a particular function. By controlling the *run* input, single cycles or blocks of cycles can be performed with the memory being left in a static state ready to perform a function on the next consecutive bit.

Magnetic bubble technology is just at the beginning of its life cycle and advances will be made rapidly over the next few years. The major trend will be towards smaller bubbles, and further advances are predicted to yield 1 Mbit chips by 1980, with no major change in technology.

In spite of the relatively long access time which is a feature of the simple single loop chip organisation, the performance compares favourably with tape cassette and floppy disc memories as shown in Table 1. Multi-loop 64 kbit chip designs will enable the design of bubble memories competitive with fixed head discs (Table 2). Improved materials used in chip fabrication will lead to a wider temperature range and higher operating speed. A 120°C temperature range and 300 kHz operating rate have been demonstrated in the laboratories but this is only the beginning.

Fig. 4: Block diagram of 32 Kbyte system.

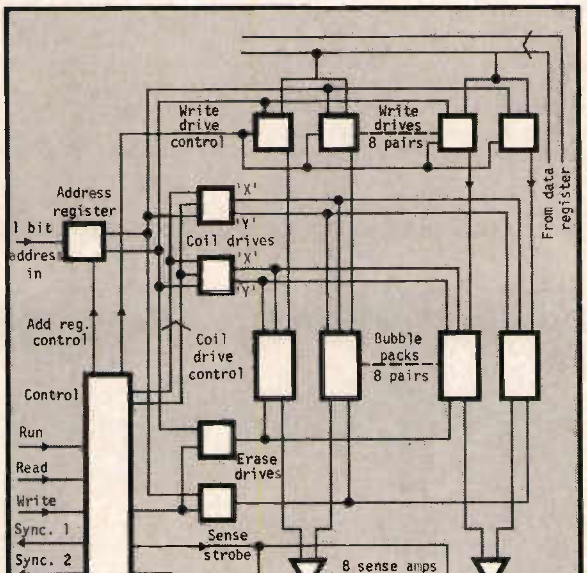
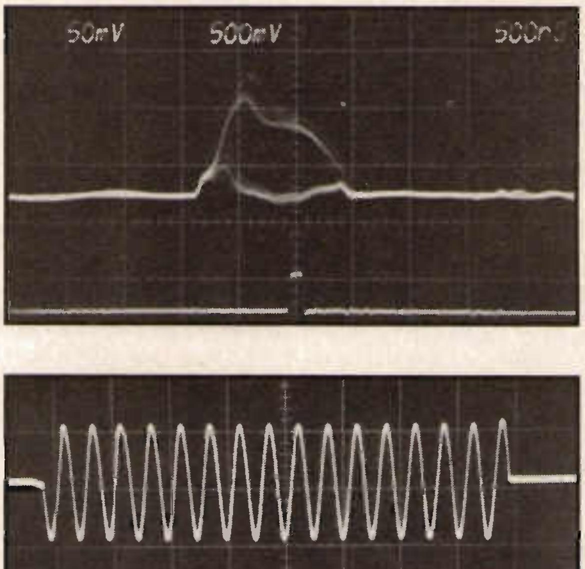


Fig. 3: Superimposed zero and one signals.



Pyroelectric technology in modern thermal imaging systems

In this articie *J R Forman* discusses recent developments in thermal imaging techniques based on the exploitation of the pyro-electric effect.

Objects at temperatures other than absolute zero are known to radiate within the electromagnetic spectrum. In the case of the familiar blackbody (an object whose absorptive power is equal to unity), the total emitted radiation is proportional to the fourth power of absolute temperature, a rule known as Stefan's law. This relationship was inherent in the celebrated Displacement Law due to Wien (1893) and the Planck relation (Fig. 1.) which defines spectral distribution of radiant energy as a function of temperature and frequency within the electromagnetic spectrum.

These ideas are applicable to most graybody objects even though they diverge from black body criteria and form the basis of a remote means of detecting hot bodies. If a 'two-dimensional' detector or a single detection with 'third-party' scanning can be produced with response in a region corresponding to the inherent radiation emitted by an object at a particular temperature and if the detector information can be eventually presented to the eye, thermal imaging will result.

It is generally taken that thermal imaging concerns the viewing of objects at or near room temperature and, in this case, we are dealing with radiation in the common middle infra-red ranges 3-5 or 8-14 microns as dictated by atmospheric absorption (Fig. 2.). Before discussing this, however, it can be added that as bodies heat up, the radiant energy spectrum spreads closer and closer to the familiar visible spectrum to the point where 'thermal' pictures may be taken with conventional suitably filtered silicon vidicon cameras.

J R Foreman is with Thomson CSF

Thermal imaging methods in the regions 3 to 5 or 8 to 14 microns are varied. There is the single detector approach whereby the incident radiation is deflected by means of prisms or the like to fall onto the detector which is usually liquid nitrogen cooled. Cooling is generally necessary as detectors, such as indium antimonide, rely on the ionization of deep-seated donor levels within the forbidden band by incident radiation to give rise to photo-conductivity. Without cooling, these levels would be fully ionized at normal room temperatures alone. This prism approach yields good results and reasonable quality pictures to a spatial resolution of about 0,0025 rad at 50% contrast are obtainable. Good temperature resolution down to 0,1°K/300°K ambient is achieved as might be expected of a cooled system. The disadvantages include flicker presentation to the viewer (as the unit can only be scanned below the limit of minimum eye refresh rate), mechanical size and fragility, the need to supply liquid nitrogen in field applications and, perhaps the main limitation, high cost.

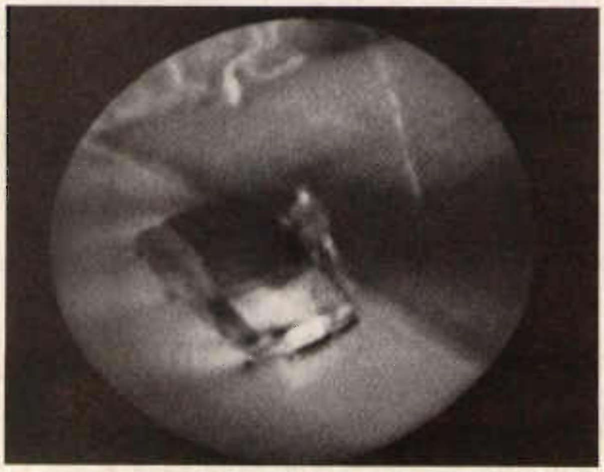
Systems employing electronically scanned (on-chip) liquid nitrogen cooled detectors are under consideration and it seems likely that they will have their day. In this case, an array of detectors replace the prisms but with technology at its present level, the physical size necessary and the difficulty in producing uniform response makes the yield and hence price uneconomic. The advent of sophisticated electronics in the ccd area could hasten progress, but, as most of the development in this area is for the military, it could be some years before this approach is viable.

Pryo-electric effect

The pyro-electric vidicon and its related camera present themselves in recent developments in the thermal imaging field. Certain types of crystals can be spontaneously polarised in a single well-defined direction called the polar axis. As this polarisation is temperature dependent, heating such a crystal creates charges on the faces normal to the polar axis. This is known as the pyro-electric effect. The magnitude of the effect (the quantity of charge produced for a given temperature change) depends on the material and always reaches a maximum at a temperature specific to the material. Triglycine sulphate (TGS) is commonly used as the target material in vidicons of this type and simply replaces the antimony trisulphide deposited layer in conventional vidicons.

TGS targets have a maximum useful pyro-electric effect at about 35°C, the spontaneous polarisation disappearing above a certain temperature known as the Curie Point (49°C). The pyro-electric effect results from electric dipoles inside the crystal lining up along the polar axis and it is a maximum when

Below: Examples of thermal pictures taken with silicon vidicon cameras.



all of the dipoles are orientated in the same sense. This situation can be obtained by a process known as 'poling' which consists of applying a strong dc electric field across the crystal faces.

Electric charges are only produced when the temperature of the pyro-electric material changes. It is for this reason that pyro-electric vidicons cannot produce an image output from an unchanging image. If part of the scene is mobile (for example, a man walking across the field of view) then only the mobile part will be seen. If the whole scene is to be observed then the incoming radiation must be chopped, or the camera panned, in order to produce target temperature variations.

Tube operation

The thermal vidicon (Fig. 3.) consists of a glass envelope, fitted with a germanium faceplate (matching the 8 μm to 14 μm atmospheric window), a pyro-electric target mounted on a metal backing plate that also acts as the video output electrode, an electron gun and beam shaping electrodes like those of a standard vidicon and a gas reservoir headed by a tungsten filament may be incorporated. The tube is surrounded by focusing and deflection coils that are identical to those used with a standard vidicon. When an infra-red image is focused onto the tube, heat energy is absorbed by the target. This creates a temperature distribution which in turn causes charges to appear on the surface of the pyro-electric material. The resulting potential distribution, which faithfully reproduces the thermal image, can then be read by means of an electron beam.

The actual mechanics of the reading depends on the tube operating mode. Stable operation can be obtained in two ways, known as the cathode potential stabilised (cps) mode, which is the more common, and the anode potential stabilised (aps) mode. Unlike a normal vidicon, temperature variations in TGS create positive and negative charges on the target surface. In the cps mode, the electron beam cannot neutralise negative charges once the target has reached equilibrium potential. This problem is overcome by charging the target surface between scans to a pedestal potential which is greater than the potential variations caused by increases or decreases in temperature, so the beam has access to the target at all times. The pedestal potential (which must be constant over the whole target surface) is generated by positive gaseous ions deposited on the surface of the target. The ions are created by the electron beam striking gaseous molecules within the tube which can come from a gas reservoir in the tube or from gas introduced in bulk in the envelope during fabrication. A reservoir is generally preferred as it allows complete control over the tube in all operation modes. The entire active surface of the target

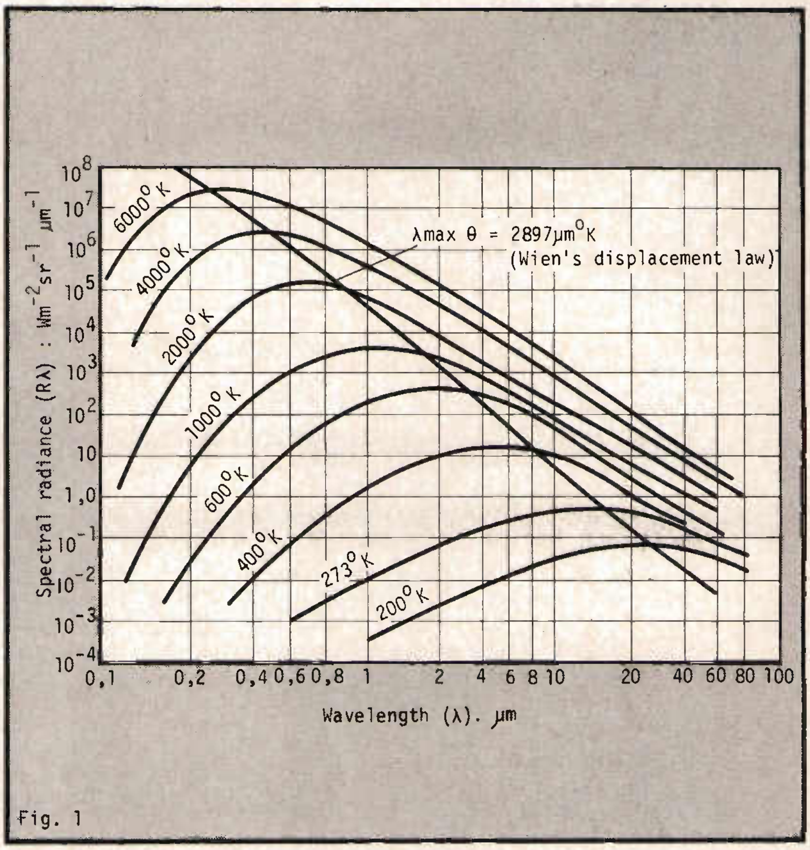
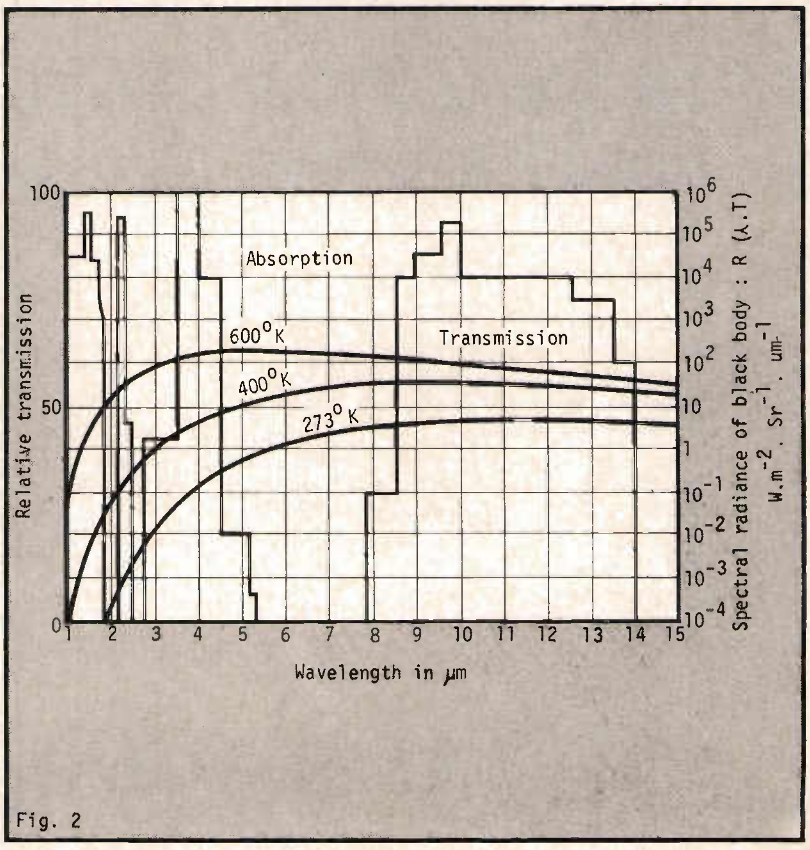
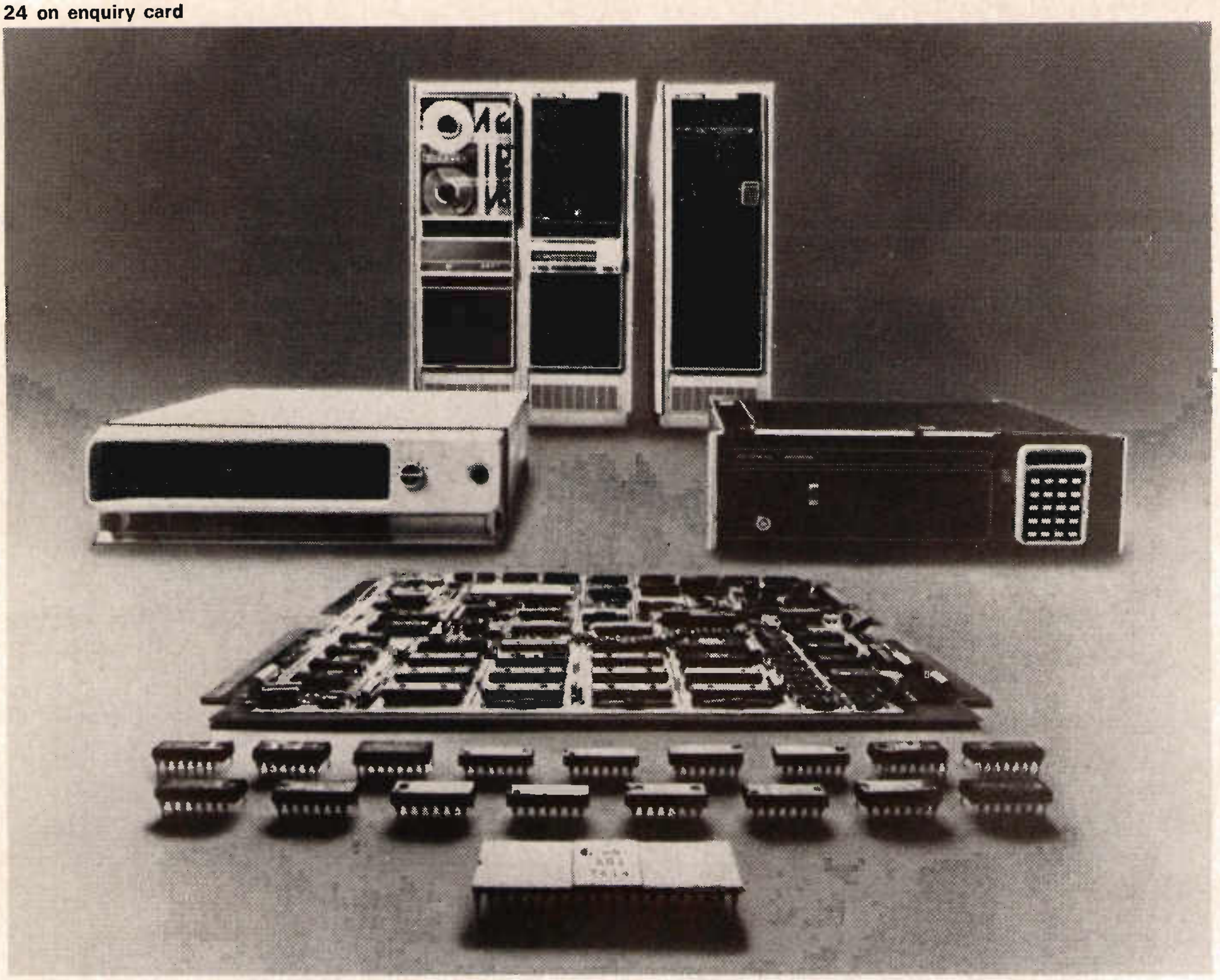


Fig. 1: The total emitted radiation obeys Stefan's Law.

Fig. 2. Radiation in the common middle infra-red ranges.





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must be scanned by the electron beam or else the continuous flow of positive ions would raise the unscanned areas to an excessively high potential causing tube instability. Best results are obtained if the target is overscanned and this accounts for the circular image normally associated with pyro-electric vidicon camera pictures.

Much development effort has been devoted to designing suitable cameras to overcome one of the weaknesses of the pyro-electric vidicon, namely the ability to see only temperature changes and not temperature differences. Two techniques—panning and chopping—have been particularly successful.

The panning mode camera needs only minor circuit modifications to standard cameras. These are concerned with bandwidth reduction and improved pre-amplifier gain and no changes to deflection circuitry are really necessary. The drawback is obviously the need to have a constantly moving camera. Cameras are also available that use specially shaped choppers to modulate the flow of incident radiation to the tube and thereby remove the need for panning. Of particular importance in this type is the need to make best use of the relatively low signal current by combining intricate amplifier circuitry with considerable video image enhancement networks. Performance is such that the image definition is comparable to panning mode cameras but is free of flicker.

The performance of a pyro-electric vidicon in 625 TV line use with 25 Hz interlace is summarised in Table 1. The temperature resolution is always an important parameter and Fig. 4 shows a typical relation between this and spatial resolution.

Target useful diameter	16mm
Signal current - ($E = 10Wm^{-2}$)	15nA
Resolution (20ms after irradiation)	2 line pairs per mm
Limiting resolution 20ms after irradiation	5 line pairs per mm
Average gamma	1
Responsivity (scanned area, $A = 4{,}3cm^2$)	$15\mu AW^{-1}cm^2$
Intrinsic responsivity ($8<\lambda<13$ microns	$3{,}5\ \mu AW^{-1}$

Table 1: Performance of vidicon in 625 TV line use.

These parameters were measured with the camera used in panning mode (image moved over target at $0{,}4cms^{-1}$). The scanned area of target was 18 × 24 mm and the objective was a good quality, coated infra-red lens opened up to F/1. The object was an infra-red test chart consisting of an approximately 300°K background with slightly warmer bars superimposed on it. The assembly has near blackbody characteristics. The minimum resolvable temperature (mrt) was considered as being the temperature difference for which the test chart was just visible on the TV monitor screen. The overload characteristic is good for a pyro-electric vidicon as signal saturation will only occur for object temperatures causing an irradiance exceeding 40 W cm^{-2}. This corresponds, for example to a lens aperture of F1 and an object temperature of 85°C.

In an assessment of performance, specific detectivity is a parameter which permits a comparison of photodetectors of different areas measured in different bandwidths. It is defined by the relationship

$$D^* = \frac{A^{\frac{1}{2}}\Delta F^{\frac{1}{2}}}{(NEP)}$$

Fig. 3: Structure of the thermal vidicon.
Fig. 4: Relationship between temperature and spatial resolution.

where A is the area of the photodetector, (NEP) is its noise equivalent power and F is the bandwidth of the measuring system. Its units are $cmHz^{\frac{1}{2}}W^{-1}$.

The concept of D* is not truly applicable to a pyro-electric vidicon as it is an imaging system, not a simple photodetector. However, for convenience and comparison, an artificial value can be calculated by considering the target as being a whole series of image elements that are sequentially read out.

Specific detectivity is wavelength and frequency dependent for most photodetectors. However, it is wavelength independent over the 8 to 14 micron range for a pyroelectric vidicon a value of $3 \times 10^8\ cmHz^{\frac{1}{2}}W^{-1}$ is typically achieved with a 1MHz bandwidth. In real applications, this level of performance gives useful spatial/temperature resolution relationships. For example, with a good chopper camera giving a completely still picture with a F0,7/50mm gemanium lens looking at a nominal blackbody at room temperature, with full aperture, resolutions of 36, 145 and 180TV lines has been obtained at mrt of 0,2, 1,0 and 3,0°C respectively. Dynamic range was 0,2° to 20°C. For the same lens at F2 aperture, with 2° to 100°C dynamic range, 36, 145 and 180 TV lines resolutions can be obtained at 2°, 10° 30°C mrt.

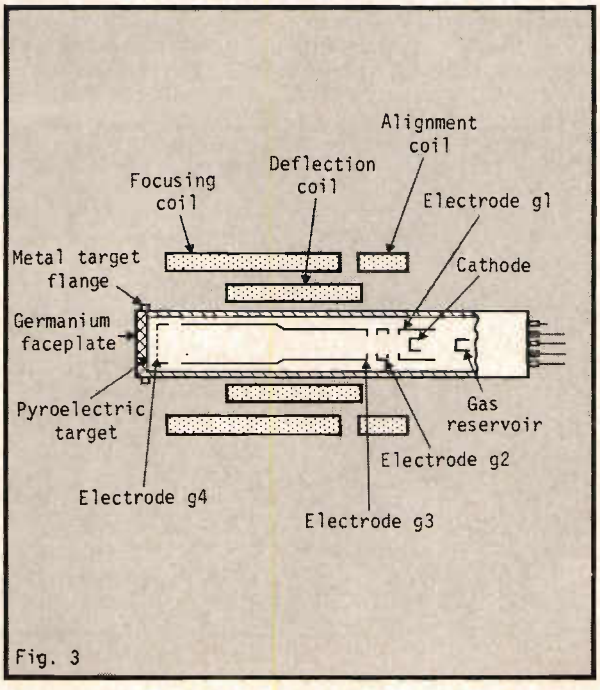

Fig. 3

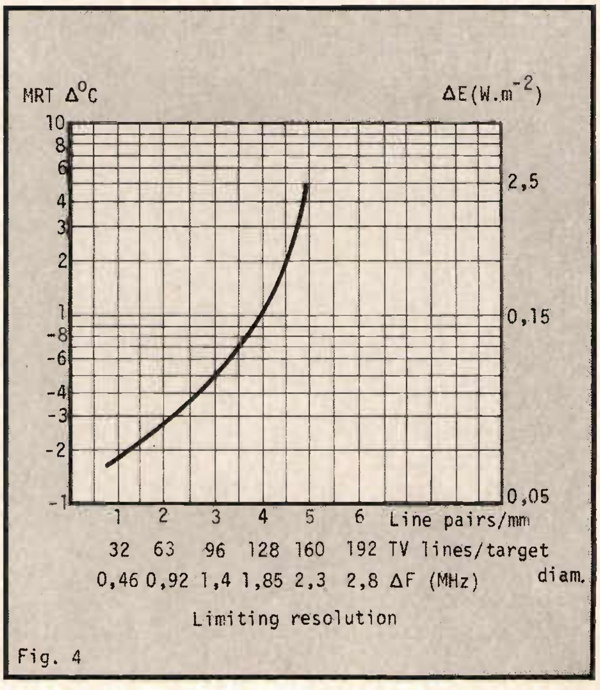

Fig. 4

Software approach to computer displays

The complexity and cost of the hardware for a computer vdu can be greatly reduced by using a software approach, writes *J E M Tyler*.

The usual method of driving a computer visual display unit involves storing the required characters in a coded form (normally ASCII) and to output this code via interfacing to the peripheral. Logic circuits within the peripheral then decode the characters and assemble the data in a format suitable for the display device. The most readily available display is a television monitor. However, owing to its inherent speed of operation, a large character store is normally required, together with decoding and character generating circuitry. In addition, it is necessary to convert the data to serial format and to assemble the horizontally divided sections of each character of a line of text to form the modulation information for the display. The complexity and cost of the hardware can be considerably reduced by using a software approach. In particular, it is possible to store the data for each frame of the display in non-coded format. Thus, using a television display, the data stored represents a series of bits each of which controls the level of modulation at a particular location on the screen. The data is output continuously under program control, with frame synchronisation being incorporated. It would then be possible to write a program to accept characters from an input device or another program, convert the character data to serial form, and store it in the correct sequence for the data output routine.

J E M Tyler is with Leicester Polytechnic.

To minimise display costs, an unmodified uhf television was used, with the output of the display system driving a commercially available uhf modulator designed for use in domestic cctv systems. The standard uhf 625-line broadcast signal consists of 4,7 μs line synchronisation pulses with 64 μs period, with approximately 52 μs of modulation signal between them. The frame synchronisation is achieved with 500 μs of synchronising pulses with a period of 20 ms.

These pulses are simply generated using SN74121 monostables with appropriate timing networks (see Fig. 3). The line and frame synchronising pulses are inverted and added to the modulation signal using an AM301 operational amplifier, the output of which is taken to the uhf modulator.

The modulation pulse demands are derived from the output of what is effectively a 64-bit shift register. The register is clocked continuously during the period between each frame pulse, putting out the data for each line of the display as the data arrives from the output bus of the computer. Because of the difficulty of precisely synchronising the programmed output instructions and the shifting of the register, the four 16-bit words of data are each loaded into a separate register. The outputs of the registers are then gated together to provide a continuous 64-bit data stream. Thus, only one register is being shifted at any instant, allowing the next data word to be safely loaded into another register. This is carried out in a cyclic manner, each register being loaded with new data while the next is being shifted.

The output bus of the computer consists of sixteen lines and data is put on to this bus under program control using the OTA instruction. Clearly the rate at which the modulation monostable can be triggered depends on the time taken for the computer to execute a programmed data transfer loop.

For the Honeywell 316, the number of machine cycles required for the transfer of one data word is eight, assuming the peripheral is ready. This gives a word transfer rate of approximately 78 kHz. (One machine cycle = 1,6 μs). This is equivalent to a bit rate of 1,25 MHz. To allow sufficient time for initialisation and loop count checking of the program loop, a rate of 1 MHz was used. Since the video line frequency is 15,625 kHz, four words of data can be transferred for each line of the display. Thus each line of picture is made up of 64 bits of data.

Fig. 1: Shows the flowchart for a subroutine to demonstrate the data display program (Fig. 2). The routine produces a chequered pattern on the screen and also indicates any lack of synchronisation.

Software

A flowchart for the subroutine to output the four data words for each video line incorporating four of the data output sequence previously described is shown in Fig. 2. The hardware

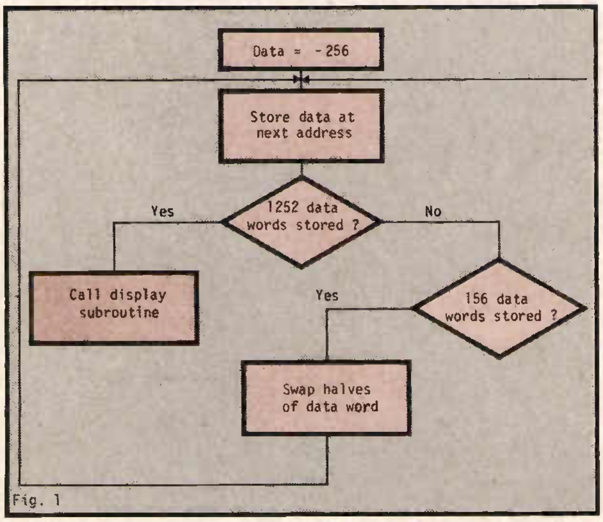

Fig. 1

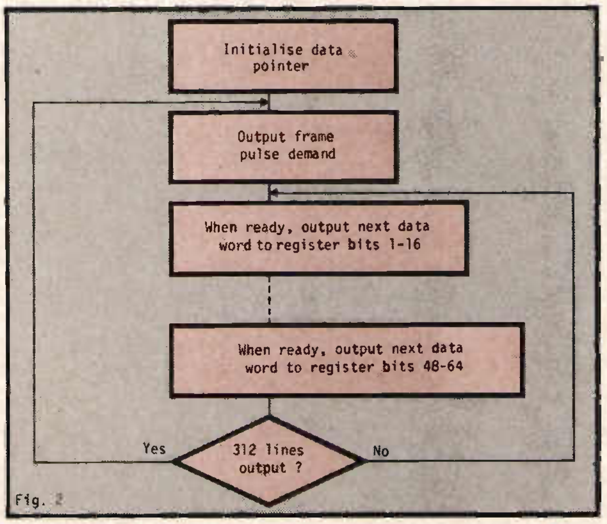

Fig. 2

indicates its readiness to receive data by setting the Device Ready Line (DRLIN) low. If it is not ready, the computer goes into a waiting loop until the DRLIN changes state.

For the display of alpha-numeric characters or graphics, it was not considered necessary to use 625 lines and therefore the system does not use interlacing, and the subroutine puts out data for 313 lines per frame. The subroutine continuously refreshes the display using the same data sequence of 1252 words until the front panel sense switch is set, when control is returned to the calling program.

Hardware

The circuit diagram is shown in Fig. 3. The system was designed around eight SN74165 8-bit parallel-in, serial-out shift registers. These are arranged as four 16-bit registers, the serial data being taken from each of the four outputs in turn during the respective 16 μs period. The system is synchronised by a 1 MHz crystal controlled clock, the counter-decoder supplying the enabling signals to load or shift the registers.

The output of the decoder is also used to drive the DRLIN logic, which ensures that the data is loaded into the four shift registers at the correct point in the sequence. When an OTA instruction is executed, and the DRLIN indicates that the system is ready to accept the data word, the computer sends a pulse on the Reset Ready Line (RRLIN) which is used to clock the data into the particular register.

At the beginning of each 64 μs decoded cycle, the system generates a line pulse. This is independent of the program so that the output of data from the registers is synchronised with the start of each line. However, as already mentioned, the frame pulse command is generated under program control at the start of each frame, since the synchronisation of this pulse is not so critical. During the frame pulse, the frame pulse flip-flop is reset, and the output is gated to the clock inhibit of the registers. The $\bar{Q}$ output of the frame pulse monostable is used to prevent line pulses being generated for the duration of this pulse.

The end of the frame pulse is detected by the sensing of address line '161. The decoded address is gated with the output of the frame flip-flop so that the DRLIN changes state only if the flip-flop is set, denoting the end of the pulse.

External hardware required for the data display routine.

The system as described, has low horizontal resolution but acceptable vertical resolution. It would therefore be suitable for applications where large characters only, or a combination of graphics and characters, are to be displayed. Suitable applications may be the display of data to a large number of viewers.

However, with certain improvements, such as the increase in speed of data transfer, and the reduced cycle time of the more recent microprocessors, a viable system for conventional-sized characters may be possible using the principles described. The required number of bits per line for the representation of, say, 40 characters would be 240, using a 6×7 dot matrix.

This would require a system which transferred the data words at about 5 MHz bit rate or 312 kHz word transfer rate. If this were achieved, the system could be expanded to 16 shift registers, there being 16 words of data for each line of the display. The system could then be used as a conventional vdu.

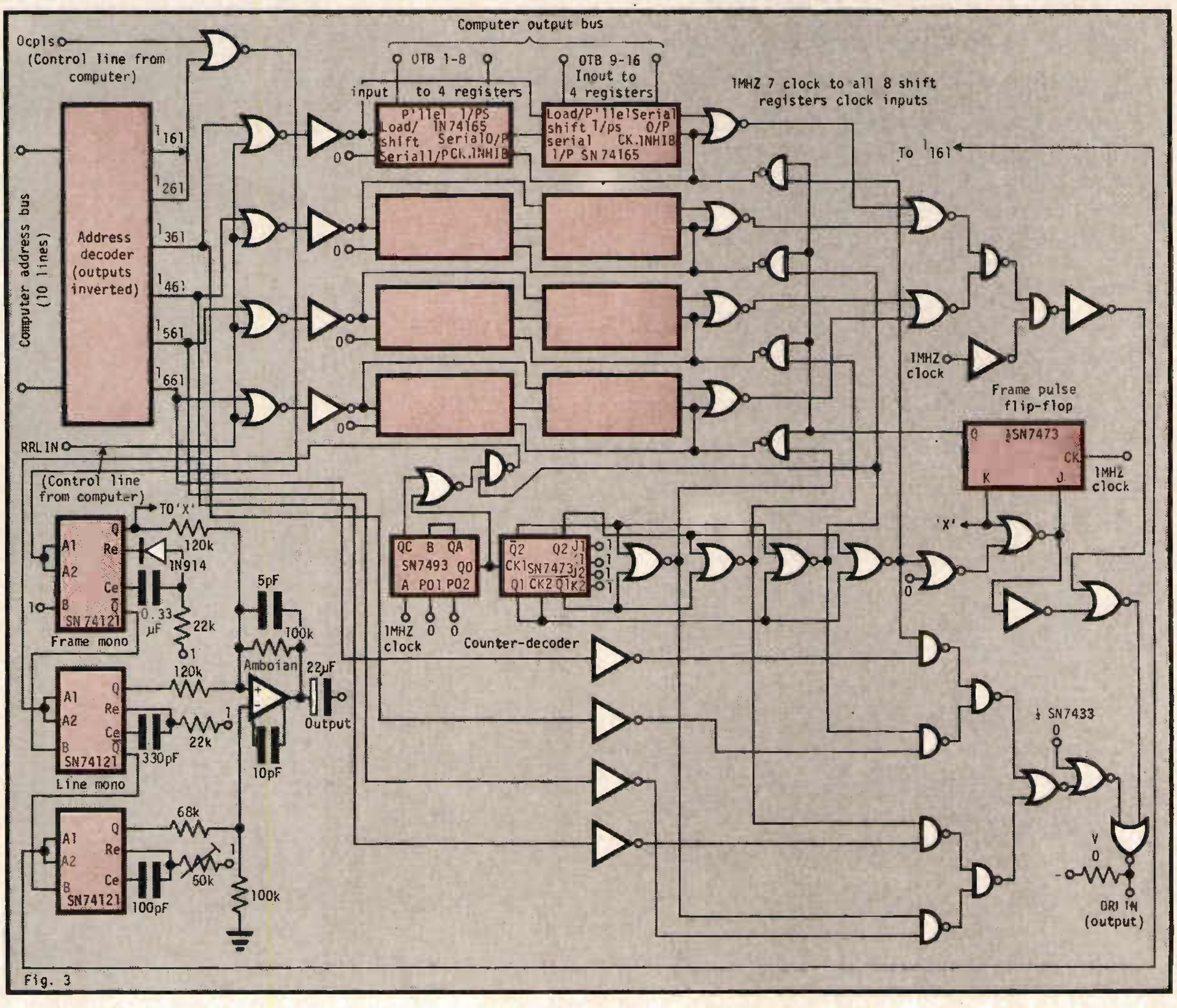

Fig. 3

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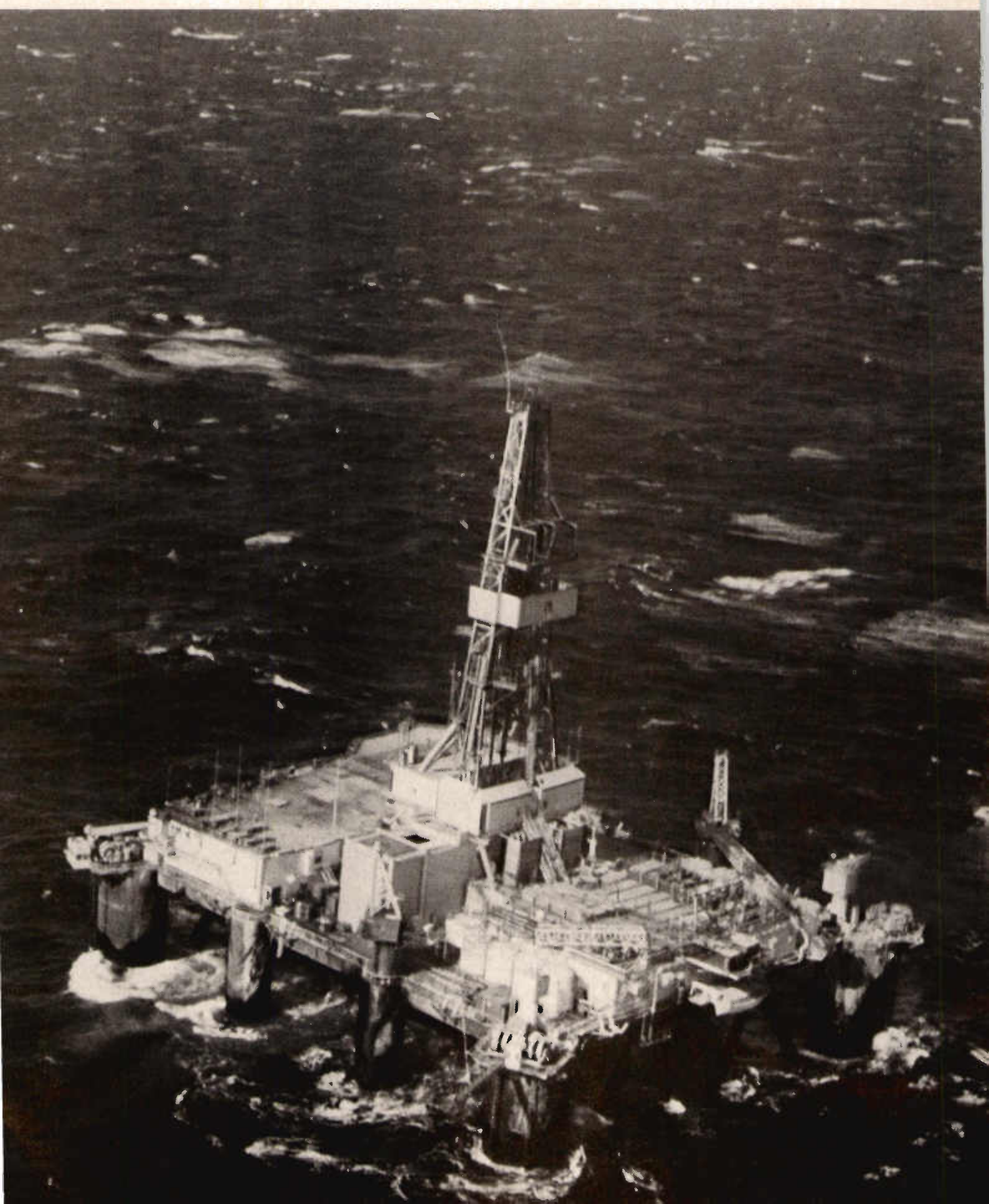

Digital logic board design with test needs in mind

Part 1 of this article dealt with hardware design considerations. In part 2, *David Tose* discusses testability and the impact of ate in a production environment.

The programs for automatic testing normally comprise two types: functional test (go/no-go), and fault isolation files. The functional test program is the basic test program of each pcb assembly and provides an indication as to whether the board is good or bad. It is generated directly from the uut circuit diagram and/or test specification, sometimes with the assistance of a logic simulator. The functional test program can be used in isolation or with the fault isolation tables.

One type of fault isolation (fi) method is the 'footprint' or 'fault signature' technique, in which the fi file contains the effects of all faults on the board as seen at the edge connector. This method of automatic fault isolation (afi) is satisfactory when the logic depth of the board is shallow, and it has the advantage that no operator intervention is required; as a result, test throughput is high. It identifies one or more probable causes of board failure and prints them or displays them on a vdu.

For higher fi resolution on more complex or larger boards, the guided fault isolation (gfi) method is preferable. This method requires that the system stores the inter-nodal connections of the board together with the response of those nodes to the test program—sometimes referred to as the structure and status files. Armed with this information, the ate system can instruct the operator to back track down the circuit path that leads to the source of the fault.

When using this method of fi, the more data about the response of each node that can be sorted, the better will be the accuracy of fault isolation. The seven most common logic states on a board are listed in Table 1. The tester should be capable of differentiating between all these distinct states; in addition, it should have the capability of selectively ignoring the status of those nodes whose condition may be unknown or impossible to determine for part of the test program (e.g. uninitialised circuits).

A test program used in conjunction with afi, gfi or both provides a standard of test performance and fault isolation that is far more reliable than human test engineers, and at the same time allows a much higher board throughput. Furthermore, the quality of the automatic testing remains consistent for as long as the programs and test equipment are maintained. This last point is particularly significant in the application of long-term service testing, because test engineers come and go, but the proven test package is always available.

David Tose is with the Industrial Products Division of Computer Automation.

Test philosophy

The aim of total fault isolation for every board being tested is not always a practical one. Various conditions can interfere with this ideal, not the least of which is circuit design. However, given good circuit design, the user has to decide which application is best for his environment. Due to exceptional production demands, it may sometimes be necessary to operate the ate as go-no/go tester to keep throughput high, and then to fault isolate the failed assemblies later.

If no off-line program generation facility—for example a logic simulation system—is available, then the same tester will have to be employed for program production as well as its normal board testing tole. Because operator intervention slows down board throughput and can introduce false errors, it should be kept to an absolute minimum. This can be achieved by good programming and intelligent board design. For example, where messages are required, they should be kept short and concise, since the experienced operator will not take kindly to having to read long unwieldy text.

Simulation

The use of a computer-based logic simulator during the generation of test and fault isolation programs can greatly reduce test program generation and execution times, improve fault isolation and detection capabilities, help pcb layout and design practice, verify logic design, eliminate logic state confusion and produce prototype pcb wire lists.

A logic simulator takes in circuit diagram data as provided by the design engineer, and with the use of a device library creates a circuit model. This model can be exercised in just the same way as the real circuit, thus enabling a test program to be generated and its efficiency verified prior to the availability of a known good board.

Table 1: Common logic states

1. Floating (between logic O and logic 1 thresholds)
2. Low (below logic 0 threshold)
3. Positive pulse
4. High to low transition
5. Low to high transition
6. Negative pulse
7. High (above logic 1 threshold)

The simulator reduces test execution time by omitting non-productive tests since it can study the effect on each element within the circuit model as the test is executed. It generates automatic and guided fault isolation tables without any increase in effective timescales and can assess the capability of the test program to find any fault on any ic. To do this, the simulator subjects each node to a series of fault conditions, and then monitors the output pins to study the effects of the fault.

Some simulators check that lines are correctly terminated with the right loads and will allow the logic to be laid out more efficiently on the pcb. If the simulator is one that can produce 'all iteration' outputs on demand, it will provide timing analysis data and thus enable the user to check the logic for race conditions and evaluate circuit performance. Since the circuit is only modelled in the computer, it can be readily updated as a result of this analysis and so enable design improvements to be made before the hardware prototype stage is even reached. When the circuit designer is satisfied with the operation of the simulated model, the simulator can then output a wire list for the production of prototype pcbs.

To produce a good test program it is necessary to run the simulation a number of times in order to optimise its fault detection capability. Since each simulation run takes a specific period of time, the benefits to be gained from a high-speed simulator are considerable; for example, if a one-hour run can be reduced to ten minutes (i.e. a reduction ratio of 6:1), then if 20 runs are needed to optimise the final prgramme, a one-week programming exercise can be reduced to one day.

It is important to have a fast simulator and preferably to have a simulator operating in an off-line mode so that it does not interfere with production testing. Simulation employed in this way can complement the operation of logic testers and produce all the programs required to keep the unit price of each ate down to a minimum.

Another item for consideration in automatic testing is the connection to

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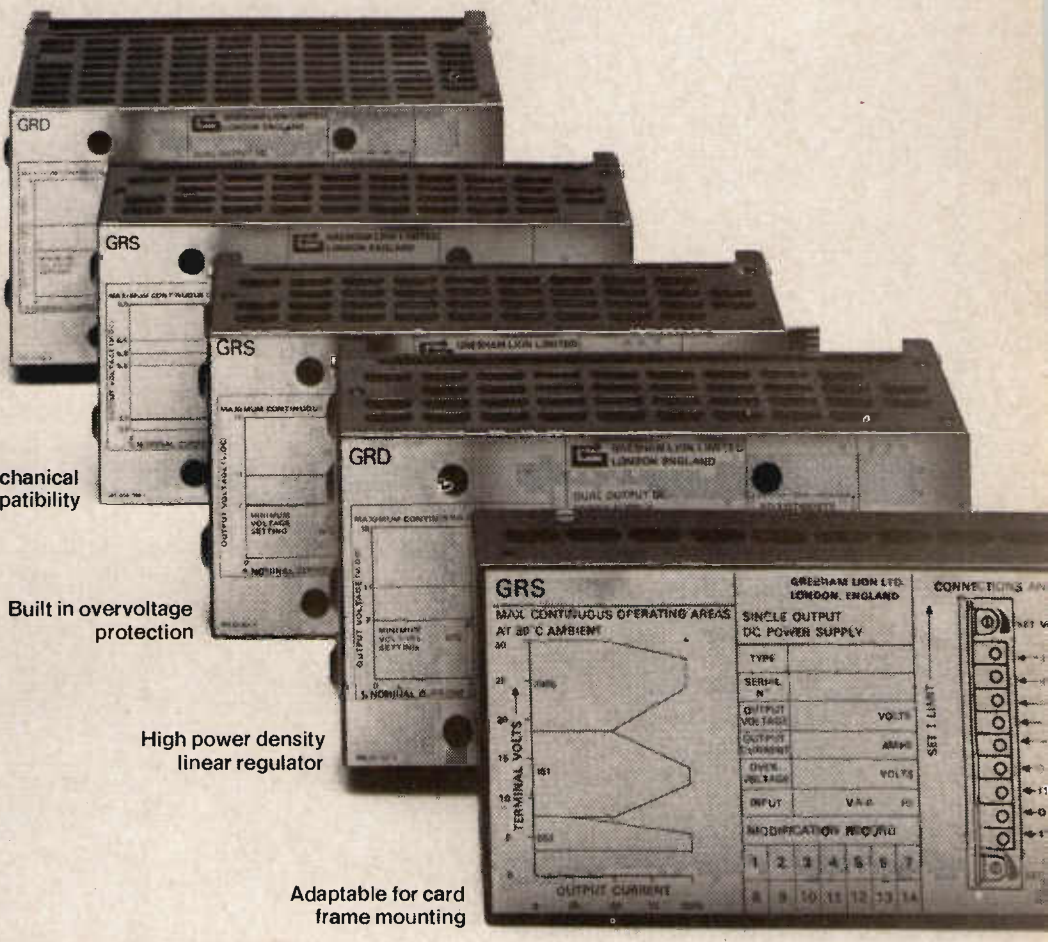

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the unit to be tested. Careful thought needs to be applied to this connection if reliable testing and diagnosis is to take place. For example, consideration of correct earth termination for the uut is one that is often overlooked: it should be located as near to the uut as possible, be as solid as possible, and be the one point where the uut power supply OV line, the OV sense line and the signal-return line all terminate together. The signal harness should employ twisted pair signal lines and its length should be kept to a minimum, uut power supplies should always be remotely sensed at the uut and adequate fast decoupling should be located at the uut interface.

ATE organisation

When an ate system is purchased, it should be borne in mind that for the user to maximise the benefits obtainable from the installation some prior thought should be given to the overall system integration and organisation. First to be decided must be which department should be responsible for the system—Production Test or QA?—since each will have its own particular requirements of an ate system. Production test will wish to supply the system test and/or commissioning department good working boards. QA, on the other hand, will be interested in the quality performance data that is obtainable from the system.

Another aspect of the overall installation will be the physical position of the ate system: for optimum operator comfort and minimum system downtime, the system should be kept in a normal working environment. It is often advantageous, too, to have a small re-work area close to the ate, for quick interactive turnround of faulty boards. A localised store area may also be required (for programme listings, disc files, test harnesses etc) and its size will naturally depend on the number of different types of board in production and being tested on the system.

An equally important decision to make concerns what should be done with faulty boards in the field. Should they be returned to production test for checking on its ate ,or should the servicing department have its own ate facility in the field? If the latter course is adopted, then it must be decided whether or not the field tester should have the same performance as the production tester, or whether it should have only limited testing capabilities. Clearly, a field tester which exercises boards as thoroughly as the production tester, and which uses the same test programs, will be more desirable and economical than any other solution.

The digital ate of the type described here will operate at test rates of up to 100,000 tests per second, and will normally find all but the 'real time' or dynamic faults; these will still require a system test and a commissioning engineer to locate them. On a production unit, faults of this nature tend to be only 1% or 2% of the total, and it can sometimes be more cost effective to discard pcbs exhibiting faults of this nature rather than try to isolate them.

From a well organised ate department, valuable data can be generated and returned to the test programmer to provide him with a means of improving fi techniques. It can also provide invaluable data for the design department, isolating the most common faults and suggesting where tracking could be improved. There is no doubt that ate used correctly in a test environment can reduce the test bottleneck, enable increased production and provide a guarantee of consistent quality that will increase product life, improve service and reduce cost. It ate is introduced properly, the capital investment involved can reap large rewards; but like any change, it requires a disciplined approach to its use.

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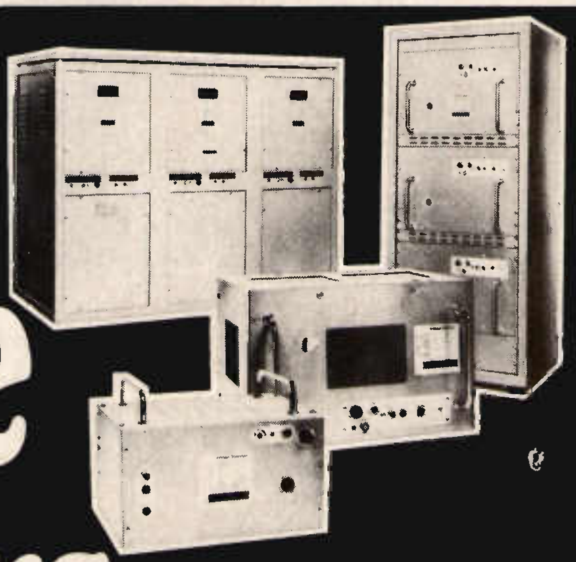

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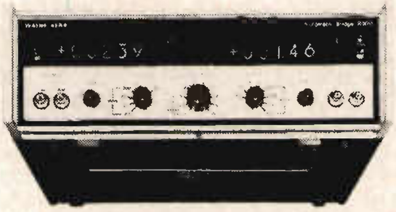

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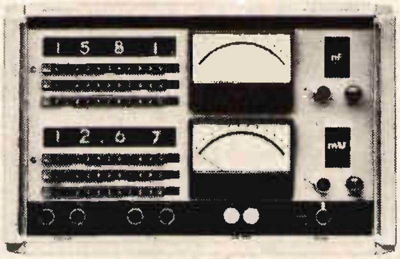

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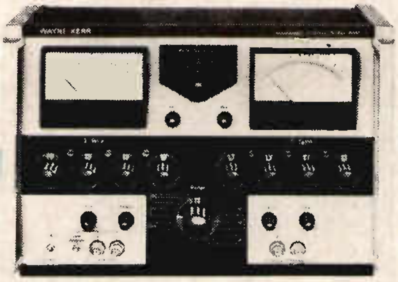

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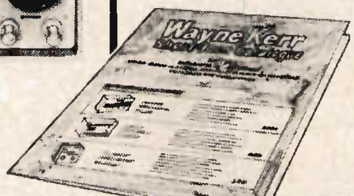

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Linking microprocessors to increase system throughput

Linking several microprocessors can improve system performance and is not as difficult as is commonly believed, writes *Peter Gebler*.

A common reason for using several microprocessors in a system is to improve system throughput. In a single processor system, throughput can only be increased by the use of a more powerful processor. If, for example, a system requires some fast peripherals such as floppy discs, several slower peripherals such as line printers, card readers or adcs and perhaps an interface to a larger computer, the throughput requirements may exceed the capabilities of any single microprocessor. Instead of using a minicomputer, which, two years ago, would have been the only economically viable course, the multiprocessor system shown in Fig. 2 can be used. Apart from the considerations of chip cost, there are other factors which may favour this approach. A designer who has previously used the two types of microprocessor will not have to familiarise himself with a new architecture and instruction set, nor will he have to buy new development tools. The capital investment required to start working with a new microprocessor and the time needed to become familiar with the device's characteristics provide strong incentives for choosing the same microprocessor for different applications. The system shown in Fig. 2 was developed by National Semiconductor to illustrate how the 8080 can be used in an application which demands a greater throughput than the 8080 can by itself deliver.

In the system shown, three or more SC/MP microprocessors are used to control the input/output operations of low-speed peripherals (teletype-writer, crt, line printer etc.) and low-speed interfaces (adcs, sensors). The 8080 controls the I/O operations of high-speed periphals (floppy discs, communications circuits etc.) and may also function as a 'slave' for a remotely located large computer. The basic multiprocessor configuration can be used in two distinct ways. Each SC/MP can perform its own task and use the 8080 as a data reference or as a source of increased execution power or, each SC/MP microprocessor (slave) can perform its own task under the control of the 8080 (master).

In the second scheme, the tasks performed by the slave microprocessors can be regarded as extensions of the master's instruction set and the master will normally execute its own program in addition to controlling the slaves. In the first scheme, the slower microprocessors can 'borrow' the 8080 whenever they are called upon to perform tasks beyond their capabilities.

The multiprocessor system of Fig. 2 features separate address, data and control bus systems for the two types of microprocessor. The master part of the system is straightforward; the 8080 program memory, local ram and peripherals are connected to the buses as if they were part of a single processor system. In the slave part of the system, the program memory, common ram and peripherals are connected to three (or more) slave microprocessors but in this part of the system some memory locations are reserved as data buffers, 'mailboxes' and temporary storage for the individual slaves. Peripherals and memory are treated identically by SC/MPs so that all of the peripherals connected to the slave bus system can be shared by any of the slave microprocessors in the system. However, slave No. 1 is used as a controlling device (responsible for controlling communication between the microprocessors and between the system and the operator) and the operator's peripheral (usually a tele-typewriter) is always connected to this device. By dedicating a slave to the supervision of the interprocessor communication, the software is greatly simplified.

Bus control

At this point, one might ask why SC/MPs have been used instead of additional 8080s. In fact, there is no reason why a multiprocessor system should not use only one type of microprocessor and schemes for a network of interconnected 8080s have been proposed in the USA. The difference in cpu cost between an all-8080 system and a mixed system will normally be unimportant. The use of the SC/MP microprocessors does have other advantages, however, which simplify the system's hardware aspects. The main reason for this is the bus-access logic built into the devices—three pins provide signals specifically designed to simplify multiprocessor system hardware. Before a device can take part in any data transfer it must

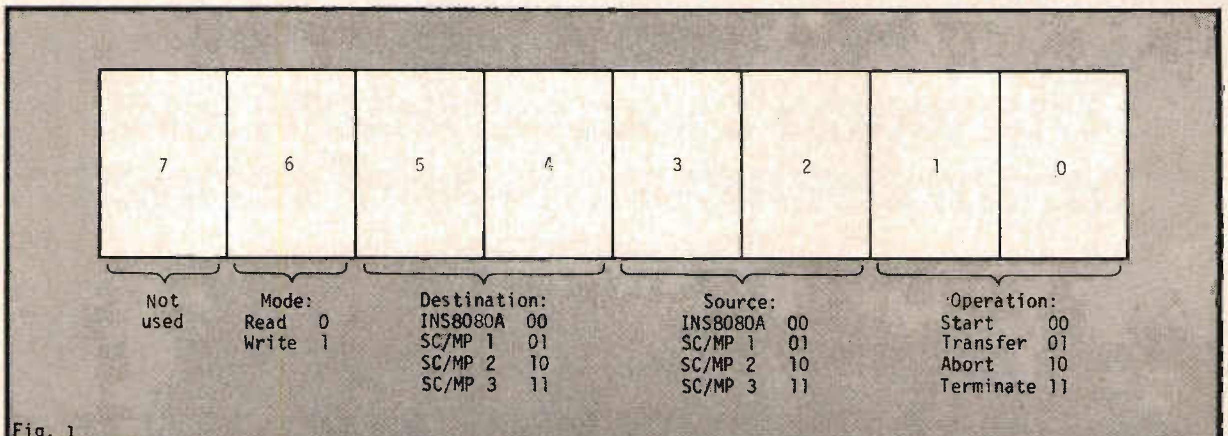

Fig. 1

Fig. 1: A typical format for a Select, Character word.

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have access to the address, data and control buses. Bus access is controlled by Bus Request (BREQ), Enable Input (ENIN) and Enable Output (ENOUT). The microprocessor requests control of the buses by forcing BREQ high. If the request is granted, this is signified by ENIN going high. With BREQ and ENIN both high, SC/MP can use the buses and sets ENOUT low. The ENIN and ENOUT pins therefore allow simple 'daisy-chaining' of processors so that simultaneous requests for bus access are resolved on a priority basis. In the system shown in Fig. 2, slave No. 1 has its ENIN input tied to the wire-*and*ed BREQ pins of all slaves. Thus, whenever slave No. 1 requests bus access by setting its BREQ output high, ENIN goes high. This device, therefore, can access the buses on demand. When access to the buses is no longer required, BREQ is taken low again. ENOUT is low whenever ENIN is low, or when the processor is using the buses. Because the ENOUT pin of slave No 1 is connected to the ENIN pin of slave No. 2 and slave No. 2's ENOUT is connected to slave No. 3's ENIN, slave No. 1 has priority over No. 2 which, in turn, has a higher priority than No. 3.

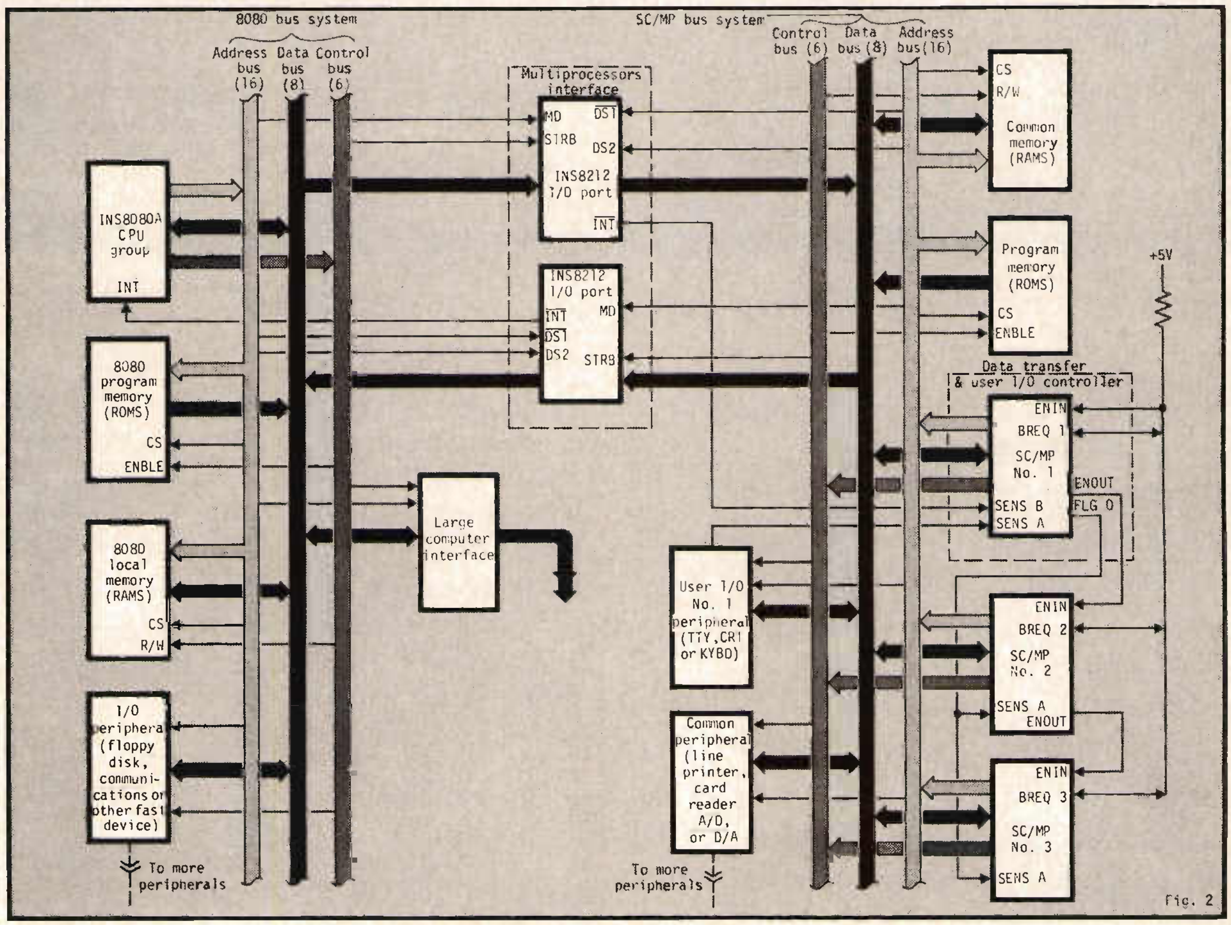
Bidirectional communication between the master and slave No. 1 is effected on an interrupt basis, using a pair of 8212 I/O ports. In the diagram, the upper port is used to transfer data from the master to the slaves while the lower port allows the slaves to pass data to the master. In both cases, the sending microprocessor loads the appropriate I/O port with the required data character and the I/O port activates its Interrupt output line to the receiving microprocessor. If slave No. 1 is the receiving device, it receives the interrupt signal on its sense B line and reads the transmitted data under software control. If the master is in the receiving device, it will also respond to the interrupt request if it has been enabled to do so. Assuming that the master's interrupt line is enabled, the device reads the transmitted data from the lower port. In each case, the I/O ports deactivate the interrupt lines once data is read.

Data transfer

When a particular microprocessor wants to initiate a transfer, it does so by means of a Select Character word. This is an 8-bit word which carries, in encoded form, a description of the nature of the required transfer. A typical format for the select character word is shown in Fig. 1 and it can be seen by inspection that it encompasses all of the possible interprocessor transfers. When the master wants to initate a transfer it places its Select Character in the upper I/O buffer which activates its interrupt line connected to the sense B input of the controlling slave (No. 1). If, for example, the master needed to pass data to slave No. 2, the Select Character sent to the I/O port would be 01100000. The procedure when a slave wants to initiate a transfer is a little different, because both sense inputs of the controlling slave have been used (sense A is connected to the user input peripheral allowing the operator immediate access to the system). When a slave wants to start a transfer, it places its Select Character word in a pre-assigned memory location known as a 'mailbox'. The controlling slave continuously polls this memory location in order to detect transfer initiation requests from the other slaves.

Slave No. 1 has the task of detecting and interpreting Select Character words and this arrangement places a minimum burden on the remaining microprocessors, allowing them to spend as much as possible of their time carrying out other tasks. The controlling slave must be provided with a data transfer routine such as that shown in Fig. 3. This routine causes the controller to continuously poll the 'mailbox' and sense line until either a slave Select

Fig. 2 Basic interconnection scheme for multiprocessor system.



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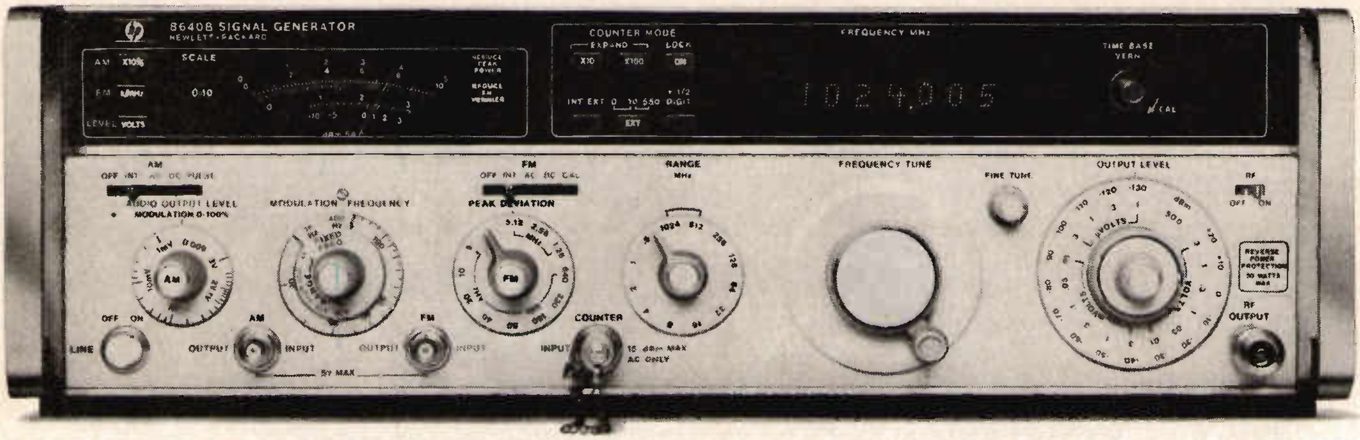

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Character word is found or a sense B transition occurs, indicating that the master has placed a Select Character word in the appropriate I/O port. The rest of the routine decodes the Select Character word and controls the transfer. The poll routine tests the sense B line (which is connected directly to bit 5 of the SC/MP status register) and compares the contents of the 'mailbox' to zero. When the poll routine detects an active input on the sense B line, it exits to the '8080 Select Character Decode' routine and when it detects a non-zero 'mailbox' entry it exits to the 'SC/MP Select Character Decode' routine. In the polling routine, it would normally be more efficient to poll the master Select Character more frequently than those of the slaves; polling sense B before each 'mailbox' polling, for example, enables the master's requests for data transfer to be granted with minimum delay.

In addition to the data transfer routine, the controlling slave is provided with an interrupt service routine which allows the operator to communicate with the system. The user peripheral would normally be a teletypewriter or similar keyboard-driven peripheral but could be as simple as a bank of input switches. The user peripheral is connected to the sense A line of slave No. 1 which, unlike the sense B line, is a true interrupt request line. Provided that slave No. 1 has enabled its interrupt facility, the operator has ready access to the system. The interrupt service routine will then depend on the operator's requirements. These might include writing to a specified location in the SC/MP memory, reading from memory or placing a Select Character word in the 'mailbox'.

The system described can be used as the basis of a wide range of multiprocessor systems, not necessarily employing the devices shown. If other microprocessors are used, the details of both hardware and software will need to be changed, but the conceptual basis remains unaltered. Almost any microprocessor can be used in a multiprocessor configuration and the arrangement of Fig. 1 can be adapted for use with any microprocessor that has bus-isolation capabilities (microprocessors with no bus-isolation facilities can also be used in multiprocessor configuration but an entirely different approach is required). Although the bus-access prioritising logic featured by SC/MP is not usually incorporated, most of the popular microprocessors allow bus isolation. Usually a single input is used to force the microprocessor to relinquish control of the buses by placing its bus output circuits in a high-impedance state and a single output line is provided to indicate when this has been done—the 6800, 8080, CP1600, Z80 and 9900 are examples of microprocessors of this type and the 2650 has similar provisions except that separate bus enable inputs are provided for the data and address buses. It is not necessary for the microprocessors to have interrupt facilities, although these usually simplify the implementation of the system.

Although the technique is rarely employed by microprocessor users today, distributed processing is well established in the minicomputer world and its acceptance by microprocessor users is inevitable. Recent studies by the US Air Force Avionics Laboratory have shown that most avionic processing requirements can be met by this approach. Many of the multi-microprocessor systems developed to date have been military applications, but the technique is well suited to applications such as traffic control, electronic fund transfer and process control in large plants. Previously, the cost of processors precluded the use of distributed processing in all but a small number of applications. With the sharp drop in the cost of microprocessors and their support circuits that has taken place over the past year, this barrier has been removed.

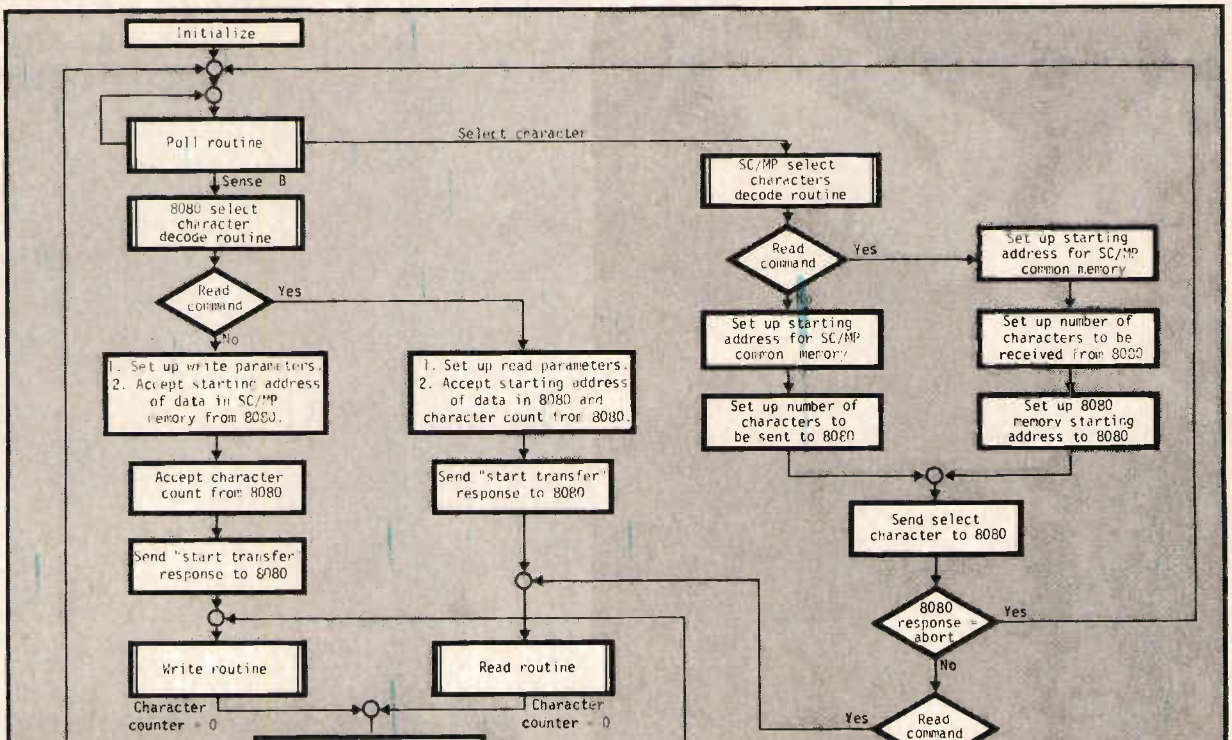

Fig. 3 Flowchart for the interprocessor data transfer routine.

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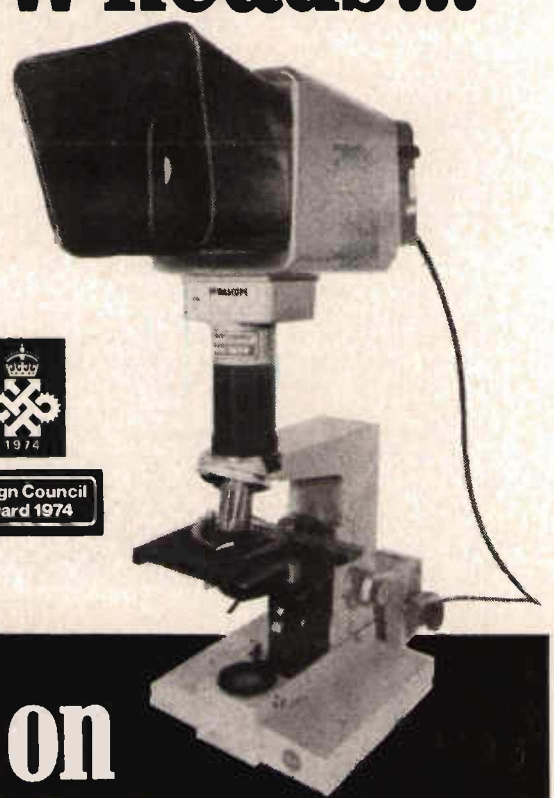

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Assessing polymide film in flexible printed circuit boards

Various types of material have been used in flexible pcb manufacture *Brian Jennings* takes a detailed look at one type and compares it against other available materials.

Flexible circuits proved themselves so well in 'space age' applications that they are now being incorporated into high volume, mass produced products with increasing frequency. These circuits can often solve space and weight problems at lower cost than conventional point-to-point wiring or printed boards.

Flexibles can take many shapes, including coils, bends and twists, conforming to available space and allowing shorter runs to be made. Wiring costs in electronic and electrical equipment can be reduced by as much as 50%. Space savings can be as high as 75% over conventional high density wiring, with weight savings as high as 50%. The high surface area to volume ratio of flexible circuits allows high heat dissipation and higher current ratings than possible with normal round wire. Further, all solder pads are in one plane, making flexible circuits adaptable to automated manufacturing procedures. Also, the etched copper conductors bonded between layers of flexible insulation are completely encapsulated against moisture, gases and foreign materials for increased reliability.

Flexible printed circuits were designed to deliver many positive benefits, but, the flexible circuit design cannot deliver all of these benefits if the insulation used in bonding has serious limitations. Also if the insulation can be soldered only once—the circuit is not repairable. Should the insulation flow during processing, the conductors may become misaligned, affecting circuit quality and if the insulation tends to crack when creased, circuit integrity is compromised.

To this end DuPont developed Kapton. The all-aromatic ring structure polymide film, offers an interesting combination of physical, chemical and electrical properties, previously not available in plastics film materials. The film can be used in applications with temperatures as high as +400°C, or conversely as low as −269°C, without losing its inherent properties. The film will not support combustion, or melt and has no known organic solvent. It is resistant to high energy radiation, has high dielectric strength and it can be used in thinner sections than several other materials.

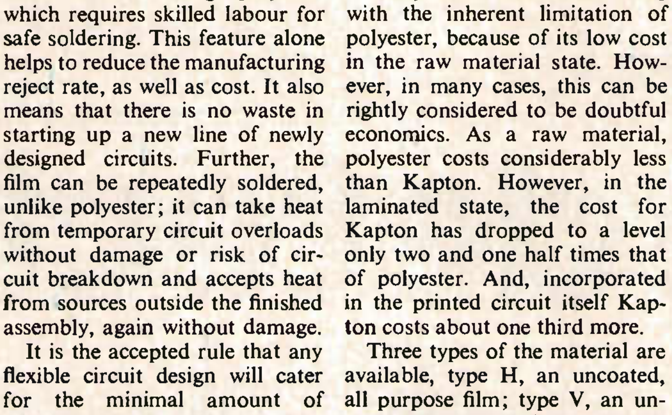
Circuits with Kapton insulation display properties conforming to hand or wave soldering techniques, without damage to the insulation. They can be soldered by unskilled personnel, unlike some circuits using polyester which requires skilled labour for safe soldering. This feature alone helps to reduce the manufacturing reject rate, as well as cost. It also means that there is no waste in starting up a new line of newly designed circuits. Further, the film can be repeatedly soldered, unlike polyester; it can take heat from temporary circuit overloads without damage or risk of circuit breakdown and accepts heat from sources outside the finished assembly, again without damage.

It is the accepted rule that any flexible circuit design will cater for the minimal amount of shrinkage, despite high processing temperatures, and this is true of Kapton. Conductors stay in place during processing, unlike those of thermo-plastics FEP film, where processing heat may cause film flowing and some displacement of the conductors, either increasing the reject rate (and manufacturing costs), or producing circuits of uneven quality. Kapton insulation insures that design distances between conductors are maintained and that all circuits in a production series are identical.

Circuits produced from this insulation film can be bent and flexed repeatedly without breaking, unlike materials such as glass epoxy, where the glass fibre core is inherently susceptible to cracking when creased, giving a subsequently low tear resistance.

Many users have been living with the inherent limitation of polyester, because of its low cost in the raw material state. However, in many cases, this can be rightly considered to be doubtful economics. As a raw material, polyester costs considerably less than Kapton. However, in the laminated state, the cost for Kapton has dropped to a level only two and one half times that of polyester. And, incorporated in the printed circuit itself Kapton costs about one third more.

Three types of the material are available, type H, an uncoated, all purpose film; type V, an uncoated film with high dimensional stability and type F, a base film coated with Teflon FEP flurocarbon resin permitting heat sealing and an enhancement to chemical resistance. Applications for flexible circuits include, electronic digital watches and car radio cassette players, Fig 1. In this instance the circuit connects external push-button controls to all internal working parts. The circuit construction consists of 25 μm of soft rolled copper laminated to 25 μm film; end connectors are hand soldered to the circuit.



It would be unfair to dismiss all other flexible circuit materials without discussing their relative merits and disadvantages. *Polyester:* Although polyester has excellent electrical and mechanical properties, its upper temperature limit restricts its use to mechanical connections rather than soldered joints. Soldering always causes some delamination and flow soldering may cause serious problems. Polyester can seldom be soldered more than once and some success has been achieved using welding techniques. In common with all thermoplastics materials, polyester can be used for all manufacture of retractiles and other heat-set applications, but it is unsuitable for flexible multilayer applications. *Glass epoxy:* In this material, the good electrical properties of epoxy are combined with the mechanical strength of glass fibre. The material has an upper temperature limitation of 150°C and can be hand or wave soldered. It is readily adapted to multilayer processing using conventional techniques. Although the material possesses good flexural properties, the glass fibre core is inherently susceptible to cracking when creased, giving a subsequent low tear resistance. *Fluorinated Ethylene Propylene Systems:* The FEP film may be unsupported or combined with glass fibre or Kapton to give systems with excellent moisture resistance coupled with good electrical properties. However, because FEP is a true thermoplastics material, it tends to flow. This makes it extremely difficult to prevent movement of the conductors during processing. FEP systems are stable up to 250°C and have an operating temperature of 200°C maximum.

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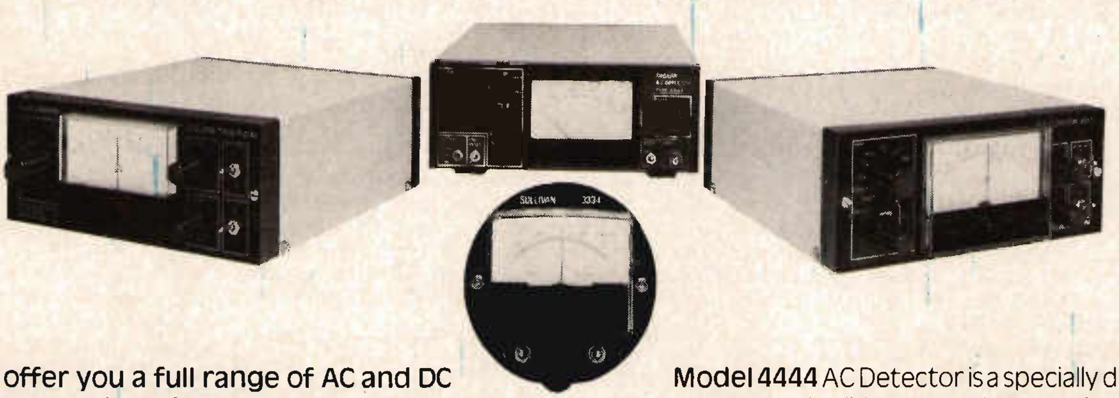

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Developments in pulse code modulation transmission

The appeal of pcm techniques is greatly enhanced by the availability of monolithic companders, writes *Brian Jennings,* who reports on a recent development in this field.

Without question, the technological advancement in cost effective, fast digital switching devices has led to the reality of pulse code modulation (pcm) for telecommunications transmission systems.

Technological achievement in recent months has included the development of the first monolithic integrated circuit containing a complete pcm decoder. This circuit forms the basis for a pcm encoder, making possible an integrated coder and decoder—or *codec,* as it has become known.

The device replaces in excess of two hundred discrete components or the equivalent of two pcb's in the manufacture of pcm terminals.

Precision Monolithics Inc, represented in Europe by Bourns, have not been slow to capitalise on the vast new avenues available for these products, (see p47, New Products, Electronic Engineering, ref:340, August). The standard Comdac (DAC-76) has been upgraded by two military versions, DAC-86 and 96, both adhering to Bell Labs. µ255.

The Comdac or companding d-a converter, provides the telephone industry with a standard off the shelf component, simplifying pcm equipment design, increasing reliability through component count reductions and reducing costs.

Manufacturers, until quite recently, designed and assembled *codec* circuits from discrete devices, but due to the economic considerations involved in this type of equipment it generally prohibited the use of pcm for less than twenty-four channel systems. This restriction has now been removed and this system can be considered for four, eight and even single channel applications. It is possible to apply the pcm advantages to any level of transmission, which is particularly important in the development of pbx and subscriber carrier systems.

Basically, pcm involves the conversion of analogue voice communication into digital pulses for transmission and the re-establishment of that transmission into analogue signals by the equipment at the receiving end.

Fig. 1: The functions of quantising and coding are accomplished at the same time. This process includes companding to reduce the number of quantising steps required.

Coding of signals

To code the analogue amplitude in binary, the axis is divided into a discrete number of equal intervals; 32 levels for a 5-bit number, 64 levels for a 6-bit number etc. At each sampling point the amplitude is measured and the level nearest that value taken as the approximation of the amplitude. Figure 1 shows the stages in obtaining a binary output at the pcm with eight levels. Therefore there will always be an error, the maximum value of which is 0,5 multiplied by the separation in levels (see Fig 2). Most current techniques transmit the binary number serially as indicated in Fig. 1. The bit rate on the line must be much higher than the rate at which the analogue signal is being sampled. For example, sampling an analogue signal eight thousand times per second, coding each sample as a ten bit number and transmitting it serially, results in a bit rate of $10 \times 8000 = 80\,000$/s. For this reason most techniques incorporating pcm are used on high speed (wide bandwidth) lines. There is a

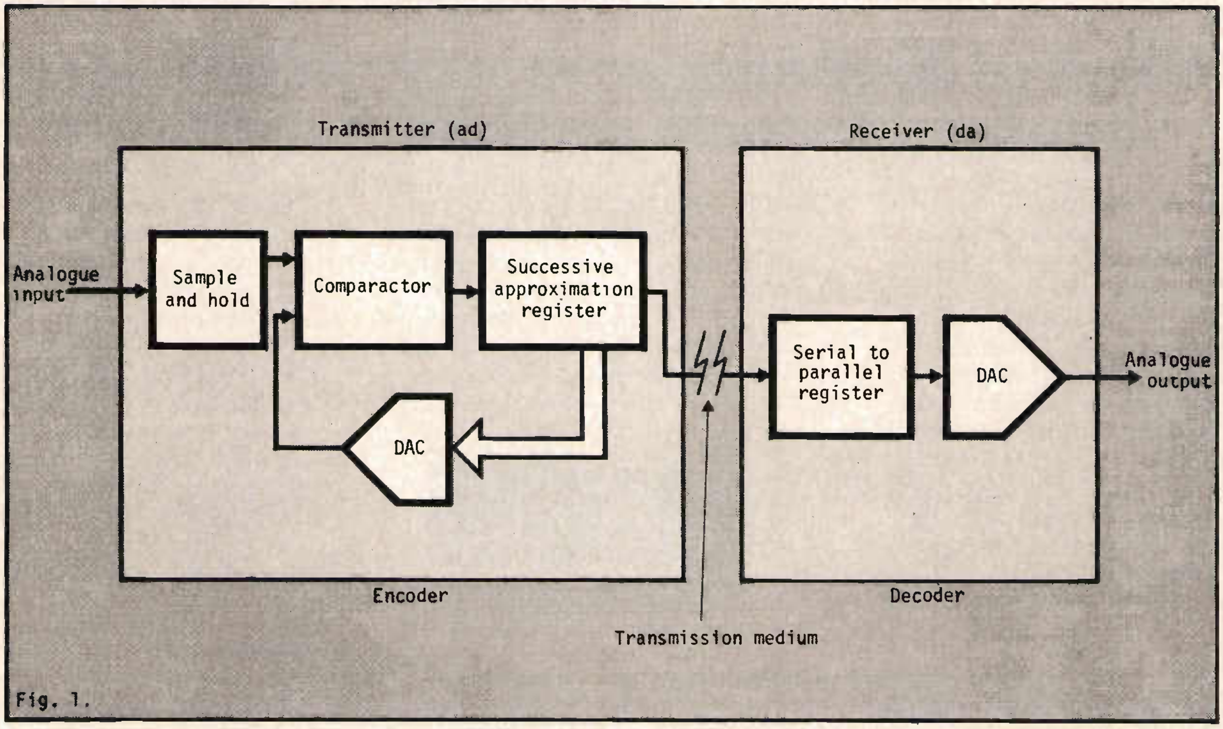

Fig. 1.

STEP SIZE SUMMARY TABLE DECODE OUTPUT (SIGN BIT EXCLUDED)

Chord	Step size normalised to full scale	Step size in μA with 2007·75 μA F.S.	Step size as a % of full scale	Step size in dB at chord endpoints	Step size as a % of reading at chord endpoints	Resolution and accuracy of equivalent binary DAC
0	2	0·5	0·025%	0·60	6·67%	Sign + 12 bits
1	4	1·0	0·05%	0·38	4·30%	Sign + 11 bits
2	8	2·0	0·1%	0·32	3·65%	Sign + 10 bits
3	16	4·0	0·2%	0·31	3·40%	Sign + 9 bits
4	32	8·0	0·4%	0·29	3·28%	Sign + 8 bits
5	64	16	0·8%	0·28	3·23%	Sign + 7 bits
6	128	32	1·6%	0·28	3·20%	Sign + 6 bits
7	256	64	3·2%	0·28	3·19%	Sign + 5 bits

trend, however, towards multilevel transmission; for example, a data transmission system working in ternary, ie a three level system, to increase the data rate. The number of levels refer to the permissible line signal states. The manner in which transmitter and receiver use these states is a first-stage design choice.

The next major step forward will probably be towards a true multilevel transmission system combining the advantages of both binary and analogue transmission.

The sampled amplitude can be coded in many different ways, eg, as a decimal number. One method divides the amplitude axis into a discrete number of unequal intervals, the steps chosen to be on a logarithmic scale. The idea here is that analogue noise which is usually at a fairly low level is then, when on its own, always sampled and coded as zero (or near zero), whilst higher levels of more meaningful signal have correspondingly more weighting.

PCM is a form of quantising in two dimensions; one is the time axis (by sampling), the second by only permitting a finite number of amplitude levels. PCM never allows the analogue signal to be exactly recovered, since the coding allocates a finite number of codes (eg, binary numbers) for an infinite variation in analogue signal level. For example, seven bits could be allocated for a signal level which may be anything in the range zero to 6V. In this case each sample is accurate to 0,5 parts in 2^7, (or 1 in 256). Reforming the analogue signal from this digitised and coded signal reproduces this accuracy of noise, called quantisation noise, discussed in a later paragraph.

Fig. 2: A complete pcm codec comprises a comdac device, an sar, an s/p circuit and associated components. The complete unit will operate as either on encoder or decoder depending on the functional control signals.

Fig. 3: The comdac transfer characteristic is logarithmic in nature resulting in a larger number of divisions or steps around the low amplitude points. The curve actually is made up of sixteen straight segments or chords each containing 16 individual steps.

Without question digital transmission equipment manufacturers have profited by developments in semiconductor componentry, ie reduction in component and assembly costs, faster testing and a significant improvement in reliability. The implementation of a digital pcm transmission system using comdac devices offers the advantages of increased signal to noise ratio. lower system distortion and the facility for computerised switching.

The transformation from analogue to digital signals takes place in three operations; sampling, quantising and coding. An inspection of these functions illustrates how modern ic's will affect performance and cost.

Conversion

The conversion from analogue signals to digital pcm commences with the sampling of speech signals at a suitable rate, following the Nyquist sampling, theorem. (which states that for a given bandwidth or frequency limitation f_0, the sampling interval needed to determine the waveform is $(1/2f_0)$. It gives two samples for each cycle of the

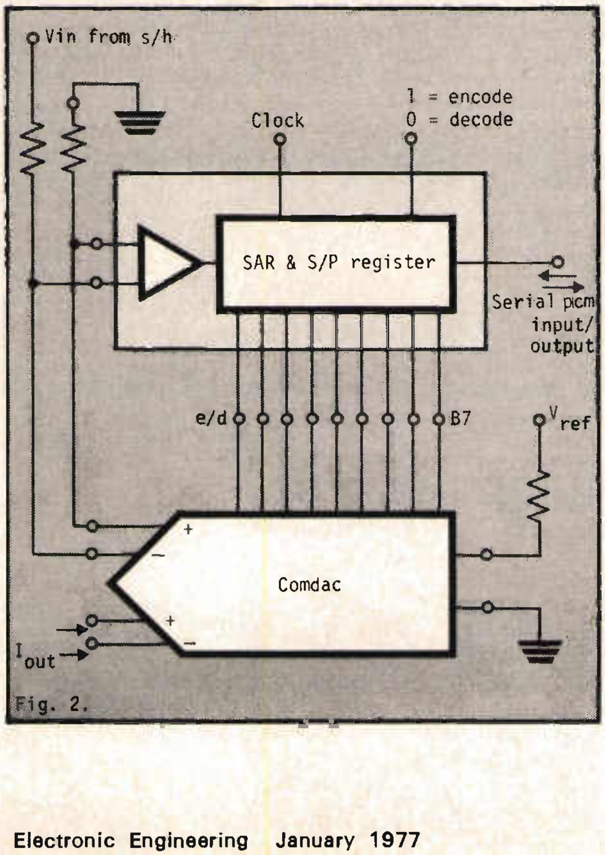

Fig. 2.

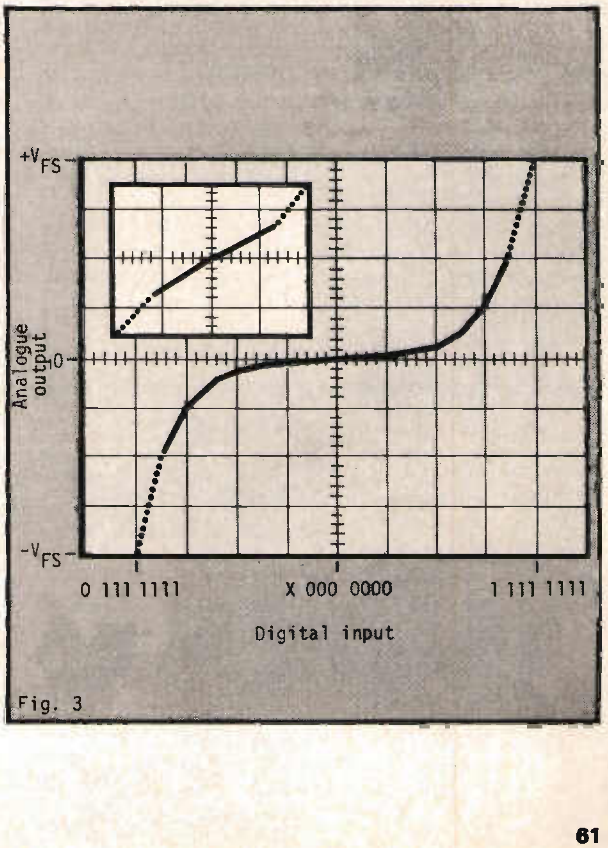

Fig. 3

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cut-off frequency f_0). For a voice channel where the upper limit is no more than 4 kHz, the minimum sampling rate is 8000/s.

The amplitude of each sample is compared to a scale of discrete values and takes on the value to which it is the closest. This operation, as previously stated, is termed quantising.

Finally the amplitude value of the sample must be coded into binary form, represented by a series of digital pulses symbolising the speech information that can be transmitted. It is necessary that this process captures all the levels within the speech range, but since the dynamic range—the variation between the lowest and the loudest signals—is quite large, it would take more than eight thousand consistently spaced steps to sufficiently transmit human speech. To reduce the quantity of operation but maintain quality, non-uniform steps are used to condense the speech information. Very small steps are assigned to lower amplitude levels where the majority of speech information is concentrated. Proportionately larger steps are used as the signal level increases.

A similar result is obtainable by adopting linear, evenly spaced quantising steps and a digital compression process. This method of compression and later expansion of the values, denoted by the terminology companding, is used to identify the non-uniform process whether linear of digital.

Using a companding characteristic variable logarithmically, the number of quantum steps is reduced from in excess of eight thousand to two hundred and fifty six. This subsequently amounts to a reduction in bandwidth required to transmit the information on a pcm system. The non-linear encoding characteristic allows linear 12-bit to be presented in 8-bits (7-bits + sign). Assuming the same transmission channel characteristics, this means you can increase the transmission speed by a factor of 3:2. This method of companding is currently in wide use in pcm systems on both sides of the Atlantic.

Of the three basic functions within the pcm terminal—sampling, quantising and coding—the comdac converter contains most of the required circuits necessary to perform the latter two functions in a single function. All that is required is external digital logic, supplied by another circuit designated a Successive Approximation Register (SAR) and a comparator.

Versatility

In conjunction with the comdac unit, the SAR circuit, an analogue comparator and a series-to-parallel register can perform the complete coding and decoding functions. Depending upon the method of interconnection, the combination can operate as either an encoder or decoder, or since functions can be externally controlled by other logic signals within the terminal, a complete *codec* can be achieved with the same components plus a sample/hold circuit. In this configuration, the unit may be thought of as a two-way transceiver that can either code a voice into pcm pulses or the reverse. Hence, only a single set of componentry is required to establish pcm transmissions in both directions. In twenty four or thirty two channel terminals, however, the functions will remain separate due to the necessary switching times.

In the encoder, the comdac device operates in a feedback loop with the SAR and compataror. Sample signals are quantised through a series of approximations. The Comdac converter and the support circuits when working simultaneously quickly find where the sample is located in the characteristic curve.

Through this process, the binary pcm code is generated for transmission. After serial-to-parallel conversion, the Comdac is used to change received pcm signals back from a digital to an analogue state.

The use of integrated circuits drastically reduces the count in discrete components, some claim by a factor of four, and reduction in the noise figure is also possible. Power savings are significant; the Comdac for instance requires 150 mW for operation, compared to 1,5 W for comparable discretes.

Away from the telecommunications industry, the Comdac finds use in a number of instrumentation applications, ie data acquisition, process control, data recording and in audio presentations. A current example would be the 8-bit code working directly with 8-bit microprocessors, negating the necessity of store and shift functions. The code is also fully compatible with the 8-bit format of current semiconductor memories.

Fig. 4. Functional elements of a pcm encoder consist of sampling, quantising and encoding. The resulting digital pulses is then transmitted over a repeated line or microwave radio system:

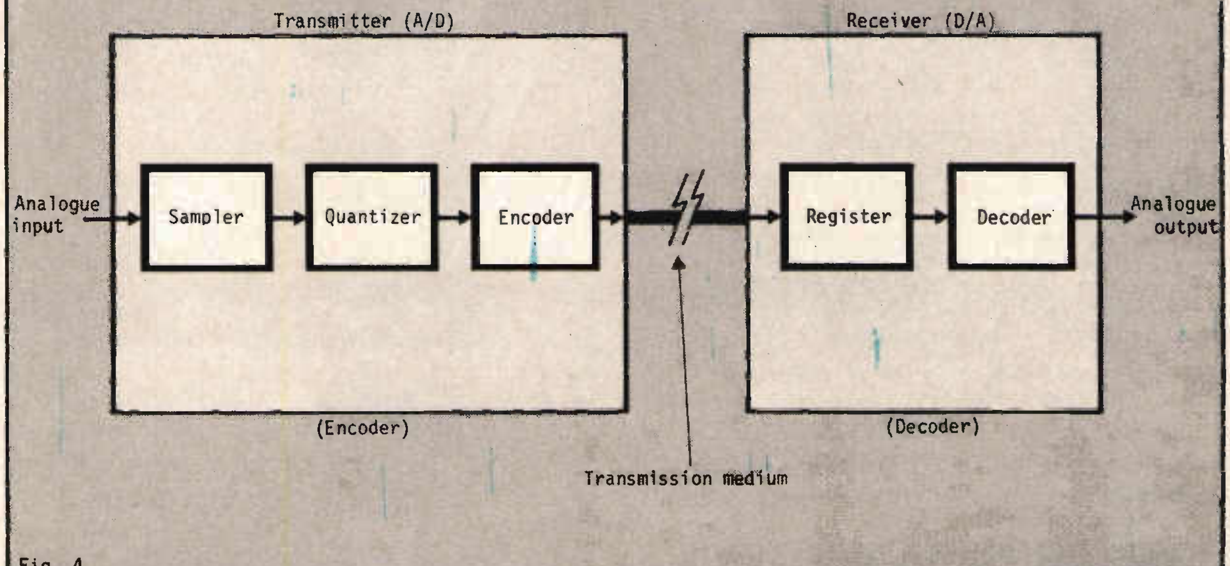

Fig. 4.

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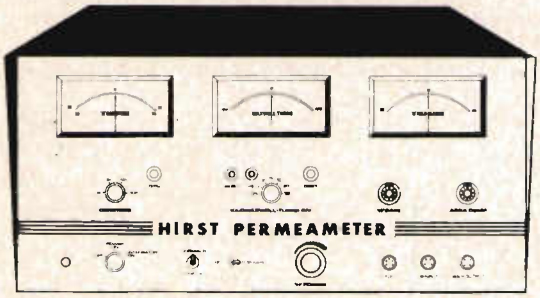

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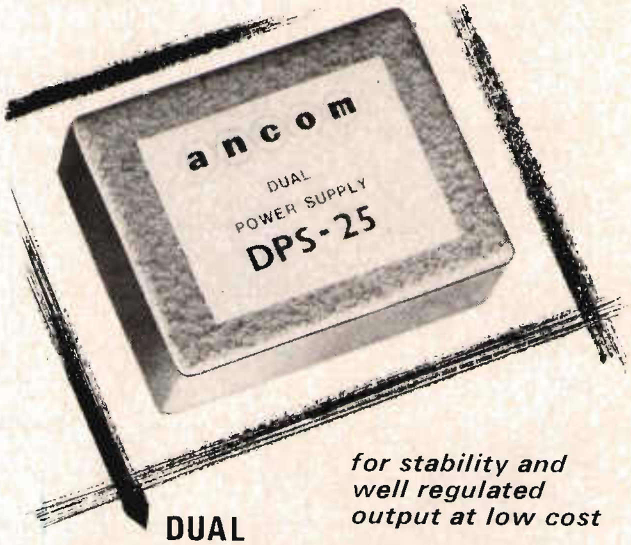

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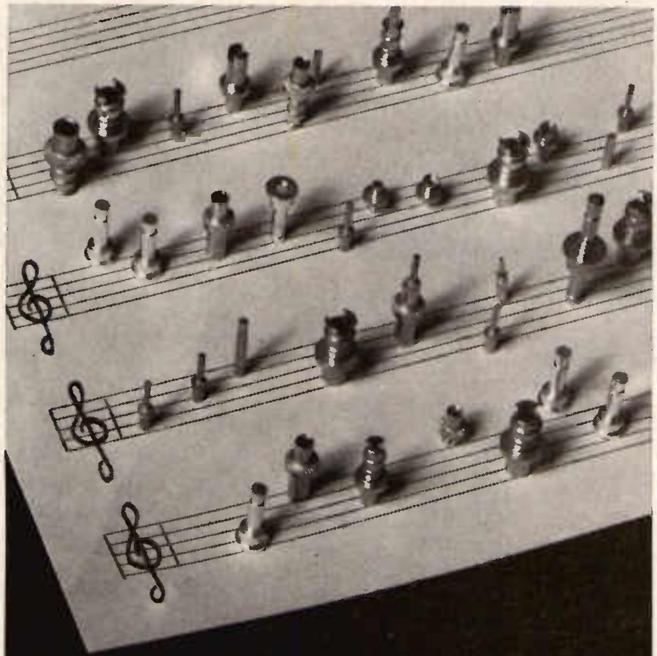

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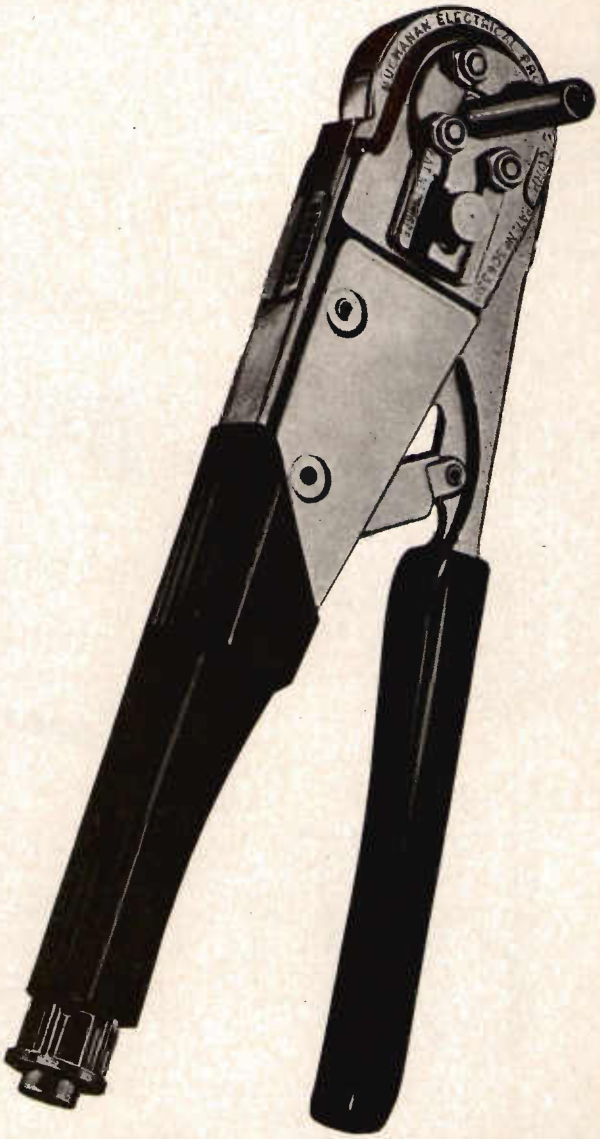

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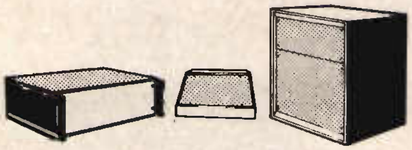

Who else can offer you a choice of over 130 different instrument cases from a standard range? Rectangular cases, sloping front cases, carrying cases, visor front cases, de-luxe cases, economy cases, pack-flat cases, miniboxes, die-cast boxes and, of course, the Series A and B IMcases with easily removable tops.

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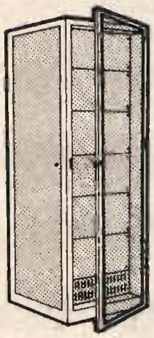
IMRAKS



We offer three comprehensive racking systems – Series 80 IMraks, International Series IMraks and Datum Series IMraks. Over 100 standard models with a whole host of optional variations and accessories such as: deep recessed or adjustable panel mountings, doors, mobile bases, castors, lifting eyes, etc.

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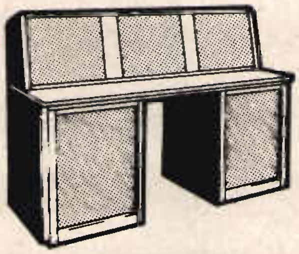
CONTROL CONSOLES



There are some 23 deks/control consoles in our standard range and these may have either single or double pedestals. Superstructures are available to suit all models and non-standard sizes can be built to order.

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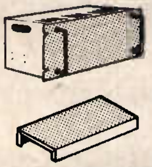
CHASSIS, SECTIONAL CHASSIS, ETC.



All types of chassis are available including both steel and aluminium chassis, bracket chassis and the versatile Datum Sectional Chassis System. A wide variety of chassis brackets and chassis runners are also offered.

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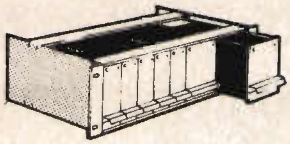
MODULAR SYSTEMS



IMPS InLine is the most advanced of the five systems offered for housing sub-units, printed board units and circuit boards. Not only do these systems include an extensive variety of alternative arrangements, but also many optional accessories.

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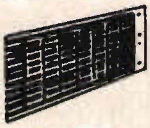
CIRCUIT BOARDS



IMcards are development boards available with two alternative configurations of pads and tracks. In addition, we are able to offer a comprehensive circuit board manufacturing service – including through-hole plating.

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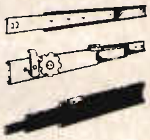
TELESCOPIC MOUNTINGS



Accurides are steel slides of which there are 33 standard designs – each available in a choice of 17 different lengths.

The range of aluminium IMslides includes some 48 standard models to suit most usual applications.

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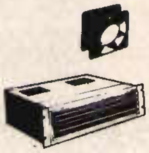
FANS AND BLOWERS



Powerful blowers to cool a whole rak, fan trays that can be positioned at any desired height within a rak or small fans for cooling local hot-spots – all will be found in our 12 page Fans and Blowers catalogue.

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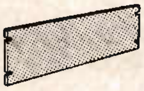
PANELS



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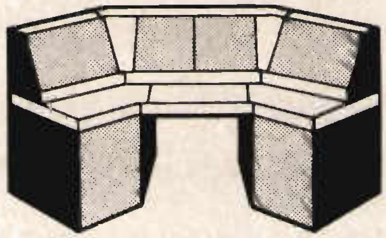
CONSTRUCTION SYSTEMS



Choose from standard IMlok with radiused corners or 901 IMlok with "square" corners to build your own cases and cabinets – of virtually any shape or size. Ideal for prototypes and one-offs but equally suitable for production runs of non-standard size units.

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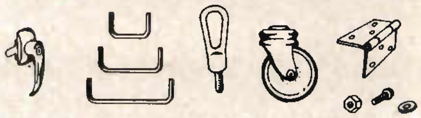
HANDLES AND ACCESSORIES



Our 125 standard handles include simple bar types, elegant die-cast models, lift-up handles, locking handles, etc. Then there are all those difficult-to-find items such as castors, hinges, locks, catches, feet, lifting-eyes, etc.

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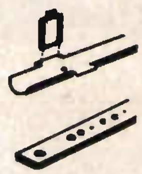
DESKS, DRAWERS, CABLE TRAYS, TAPPED RAK BARS, ETC. ETC.



Our standard range is designed to cater for ALL your packaging requirements and space has only permitted mention of the principal items. So if your specific needs are not mentioned here, please ask – we are almost certain to be able to help.

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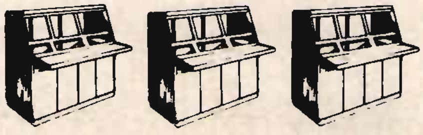
CUSTOM SHEET METALWORK



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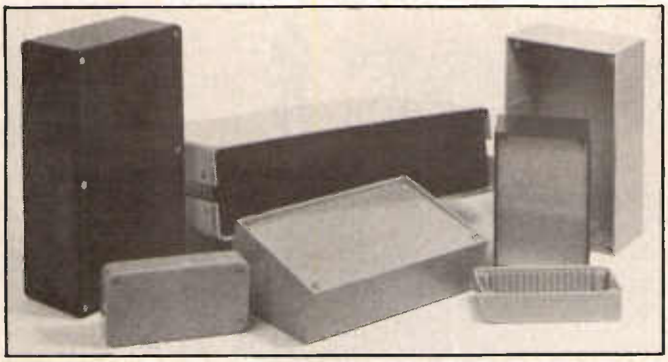
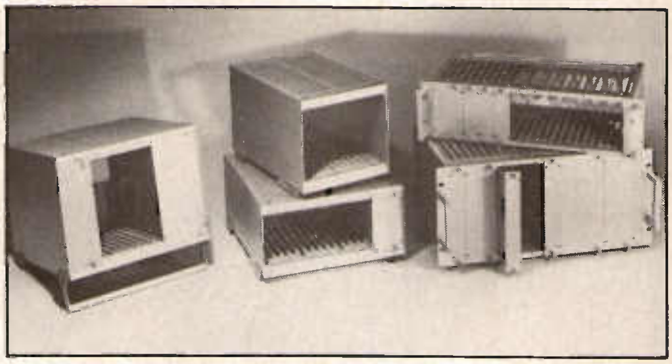




ENCLOSURES AND PACKAGING

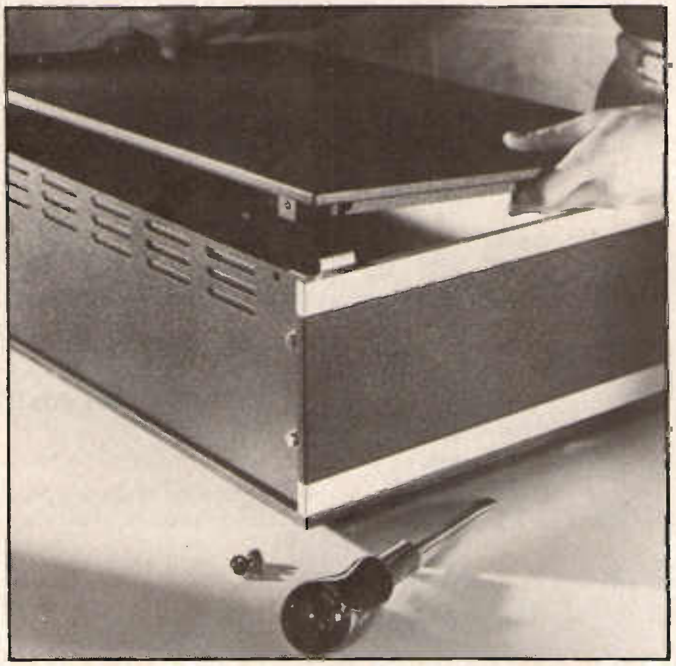
In this month's product focus *Elaine Williams* takes a look into the world of enclosures and packaging, and tries to find out how trends are changing in the design of instruments enclosures.

The importance of instrument enclosure is rarely considered at the design stage of an instrument or system. But it can have a considerable affect on the performance of the equipment it is intended to house and ultimately the success of the product. In some respects a design can fail because the designer has not been aware of the environment in which the instrument has to function or has not made adequate provision for the variety of conditions under which the equipment may be expected to operate. Also equipment must be easily accessible for repair.

Today electronic systems and instruments are being used in relatively hostile environments compared with the sanctity of the laboratory. Communications instrumentation for example, is expected to function equally well in the frozen wastes of Antarctica as in the humid conditions of the jungle. Even though much of the internal circuitry may be capable of versatile operation it has to be aided by good case design.

Portable design

With more and more demands being placed upon manufacturers to provide equipment which can move outside the confined area of the laboratory this requirement becomes even more important. Although portable instrumentation has been around for many years the word *portable* is hardly suitable to some of the cumbersome equipment many field engineers have to heave about. Most of the advances towards lighter instrumentation has come about mainly from contributions from the semiconductor industry such as the elimination of many discrete devices. LSI has undoubtedly removed the necessity for small instrumentation to be encased in heavy boxes just to be able to support the weight of the more bulky components but, the enclosures industry still has an important role to play.



Some of the range of Boss Industrial Mouldings enclosures.
The IMS and NIMS card frame systems by Daturr.
Removing the top of Series B imcase from Imhof Bedco.
The IMS and NIMS card frame system by Daturr. Made in heights of 3U, 4U, and 5U the cassettes can be accommodated in bench cases or rack-mounting frames. Again there is a proliferation of extra features available.

Plastics cases

Lighter instruments have evolved using plastics rather than metal cases. While that makes instruments more portable, provision has to be made for adequate earthing of the circuitry and they may not be so useful for conducting heat away from components which dissipate a large amount of energy such as the power supply. This means that plastics cases are generally confined to low power or battery operation in environments where there is little likelihood of extreme variation in temperature.

The use of plastics is best kept to areas where special consideration of environmental factors is not required such as in laboratory work, although there are plastics coming onto the market which are capable of more robust use. Many manufacturers produce ranges of plastics cases. Vero for example produce a range of polystyrene boxes which have a high impact capability but have a limited operating temperature range of 70°C which is typical of most plastics and is quite adequate for most laboratory activities. Some companies combine both metal and plastics, such as Daturr, so that provision can be made for a control panel and heat sinking.

For a long time the word 'plastics' has been associated with something rather cheap and nasty. The image of plastics has been severely tarnished by the early days when the plastic bucket brigade flooded the consumer market with poor types of plastics. Even though this situation has changed there is still a reluctance which can be observed when equipment manufacturers contemplate us-

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PRODUCT FOCUS

ing it for the first time.

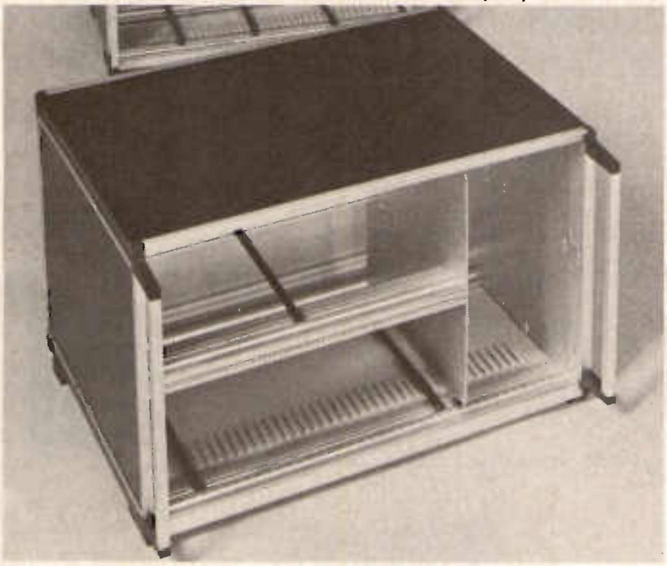
The main advantages of plastics are that they are relatively cheap, readily available and is an easy material with which to work. Also it can be produced in a wide range of colours and shapes which make it an interesting medium in which to design unusual cases.

Ergonomics

Although, often the design engineer is not concerned with the appearance of the final product, the shape of the case should be considered at least. The apparent unconcern of ergonomic factors in case design was illustrated by Mr W R Cheston of Widney Dorlec whose company produces custom consoles. Mr Cheston noted that users did not specify very exciting consoles nor did they think up very exciting colour schemes. He explained "It is easy for people not in the know to think of our custom built consoles as a bit traditional. To combat this the company has arranged a service with leading industrial design consultants for those of our customers who are looking for something a little different".

Widney Dorlec try to consider the human element and some of the company's slimline range of consoles have been used by the Royal Navy for the bridge controls of a frigate. They found that the working surface of a desk should be as thin as possible to be comfortable for a wide range of operators. P and H Engineering also produce a range of desk consoles which can be built up from components.

Consoles and larger equipment housings need only to withstand the knocks and rough treatment of human mishandling or day to day use while smaller enclosures have to undergo a far more rough handling. Manufacturers abound in this area of the market. The most noted case producers are companies such as Foxall Instruments, Imhof Bedco and Boss Industrial Mouldings as well as Vero and Daturr. While Boss has concentrated on producing functional plastics aluminium boxes and cases in large quantities at what they claim as very competitive prices, Imhof Bedco have taken a slightly different approach to the problem. The company believes it is the largest organisation in the world whose production activities are solely devoted to the manufacture of sheet metal enclosures and allied accessories for packaging electronic instruments. The company has a large range of standard products such as the implan series. Where a standard solution does not suffice, the company will undertake custom design or standard products such as the imlok systems which may be suitably modified. Foxall's Hemex range of cases have overall dimension compatible with standard rack mounting equipment so that free standing equipment may be rack mounted by the addition of mounting angles. The cases are made of extruded aluminium while the top and base covers are pvc clad and offer easy accessibility to the instrumen-



ITT's range of standard racking systems.

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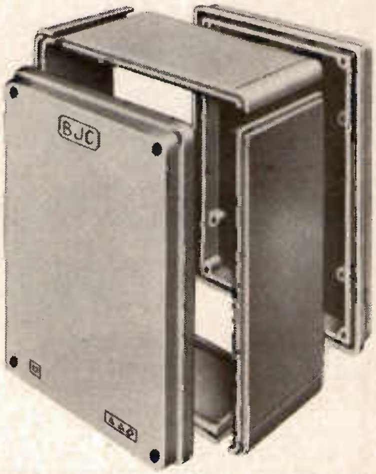

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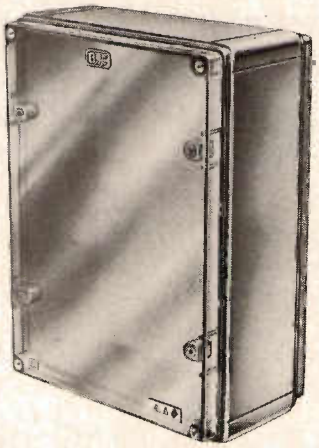

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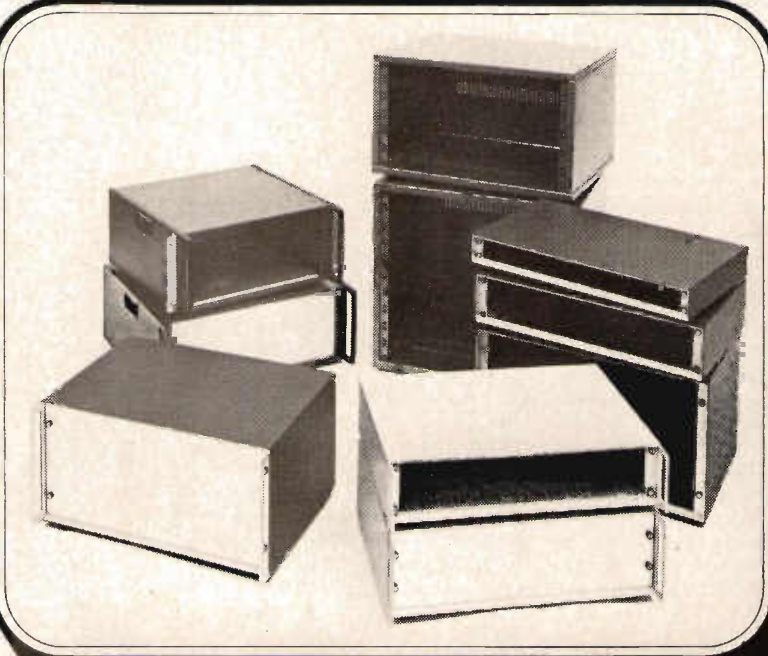

WORLD LEADERS IN PACKAGING TECHNOLOGY

tation inside.

Racking systems

Probably the most flexible type of enclosures are racking systems since while still providing modularity and equipment accessibility within a standard framework, there is still a degree of freedom in the way in which the systems are arranged. Instruments can be made to stand alone or be incorporated within large free-standing racks.

Racking systems have become very popular and most enclosure companies have realised the need to provide ranges of racking systems. ITT's standard product, for example, is based around the nominally 19 inch wide racking system, which was originally associated with Post Office specifications from Europe. David Hawkins of ITT explained that the subracks and enclosures the company manufactures and which make up the total packaging of the systems naturally conform to the basic ground rules of width, height and depth, to be able to offer compatible systems. He could envisage this system becoming more standard especially if European export markets were to be exploited although, he did not think that Britain would lose its individuality.

More flexibility

CSM also realises the demand for more flexibility in enclosure and package design, and the initial problems the engineer has to face in his choice of enclosure design. The first considerations are the price of the enclosure and how quickly the enclosure company can deliver the product. If the engineer has opted for a custom design or special rack design he has to wait even longer for his product whereas if he decides to have one of the standard products he may have had to compromise with the cosmetics of the system he is designing.

CSM explained that additional costs have to be met with custom design for special tooling, especially when section of extruded aluminium is being considered, apart from the expense of hiring the services of specialist consultants.

Compromises

When considering the use of standard enclosures, compromises must be made and the engineer must fit his requirements to the basic standards available. It is recognised that standard enclosures are usually supplied in four heights with a choice of three or four depths. However the international standard is the 19 inch panel width with 1,75 inch increment panel height.

CSM also noted how trends have affected stock standards in that two years ago no manufacturer stocked racks that would accommodate a 30 inch deep chassis depth. With the upsurge of computer peripheral requirements demanding deeper and deeper chassis depths, most leading manufacturers now offer the 30 inch chassis ex-stock.

CSM itself markets the 2000 series racking systems, which conforms to international standards, regarding panel size and unit heights. The range offers 38 standard formats, many variations combine with standard items so that the ex stock range contains over 100 types of enclosure. In addition CSM can modify or adapt the systems to fit specific requirement.

Vero is another company which has understood the trend towards the increasing use of the European standard frame. Its systems was based originally on a printed circuit size of 100 mm by 160 mm. The frame will accept the standard eurocard, the profiled international card, as well as modules in a variety of widths, screened or open, or plug in card units with individual front panels. The company stated that its newest housing systems was designed around the European standard to demonstrate the confidence it has, that this standard will be used increasingly in the future

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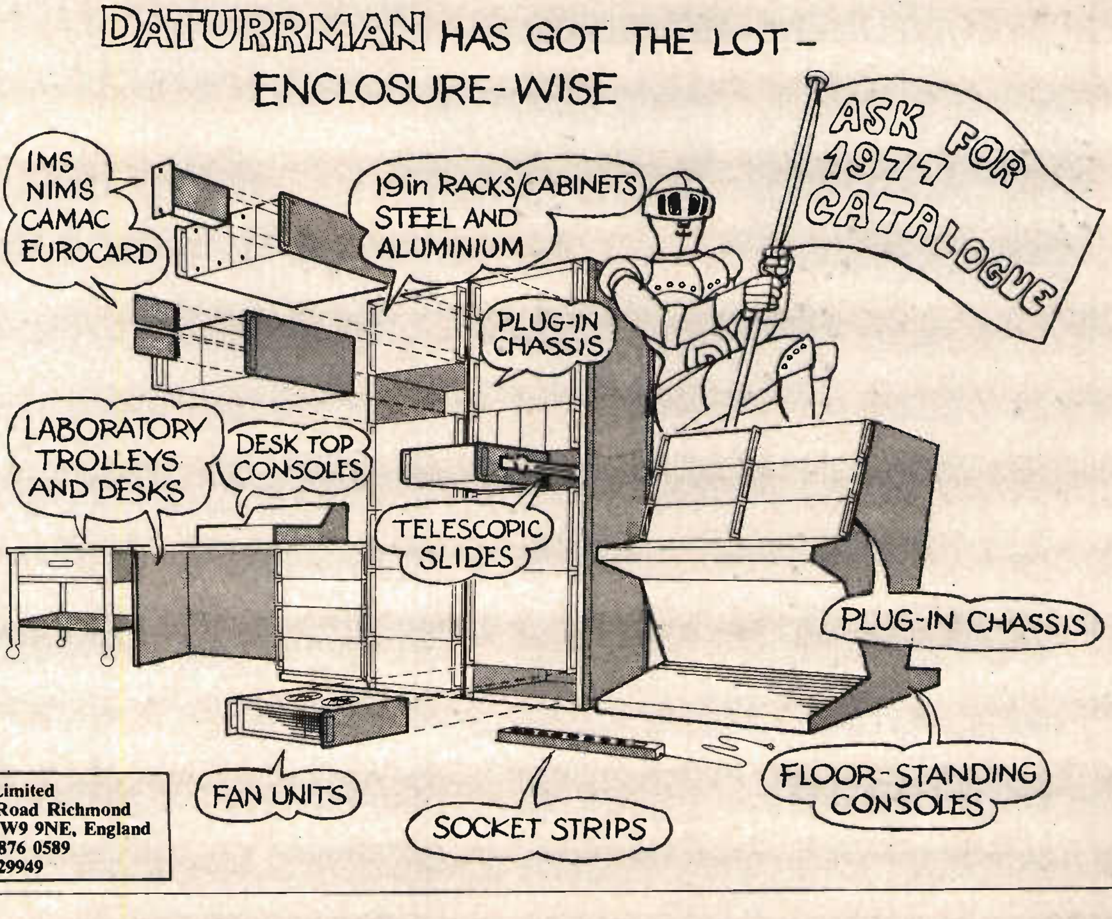

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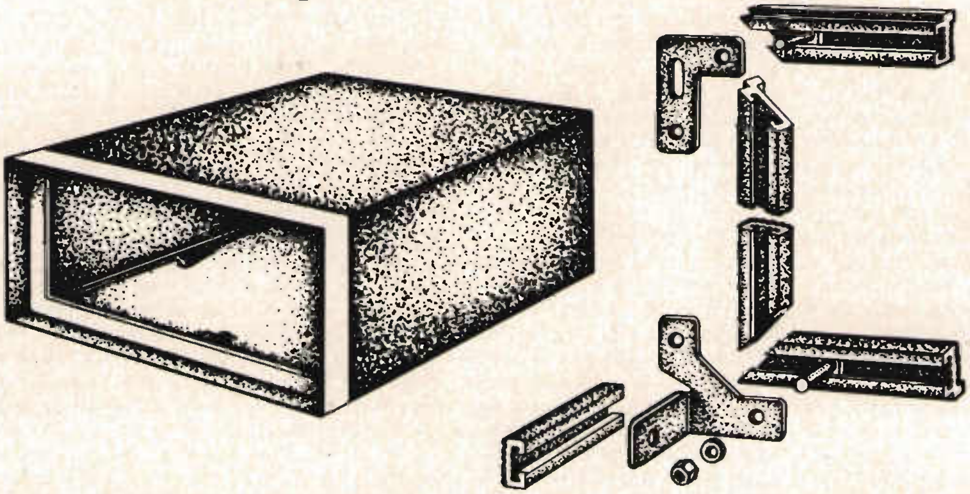
when is a box not a box?

Instrument boxes are often sold in standard sizes – not always the most practical sizes for your needs. When bought they take up a lot of storage space.



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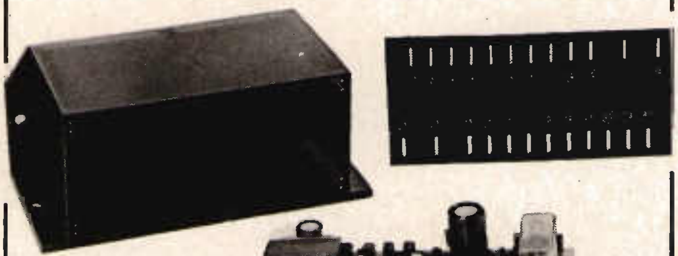
COMPONENT HOUSINGS



These compact component housings are unique, and are specially designed to cut manufacturing costs of electronic circuits. They have facility for 2 printed circuit boards on which miniature mains transformers and relays may be mounted. Printed circuit fast-on connectors and snap-fit lid eliminate the need for a special plug and socket.

Specification	**LK8 & LK16**	**LK12 & LK24**
Material	Polypropylene or Nylon	Polypropylene or Nylon
Size	90 x 50 x 37 mm	130 x 65 x 55 mm
Fixing centre	80 mm	120 mm
Internal volume	100 cc	315 cc
P.C. Board size	65 x 45 mm	105 x 60 mm
Terminals	8·16	12·24

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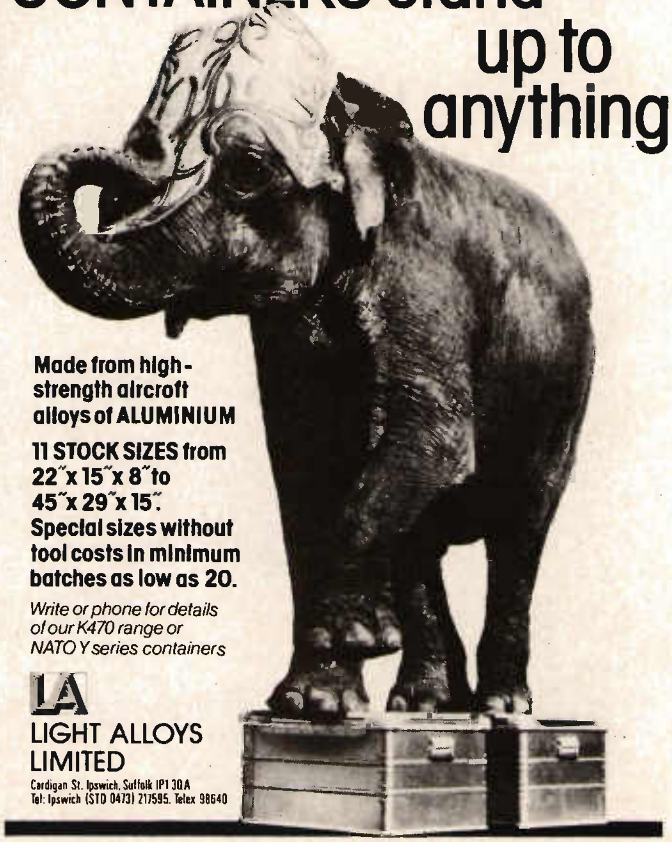

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PRODUCT FOCUS

development of electronic equipment, not only in the United Kingdom, but also in export markets.

Packaging choice

Once the decision has been made on the method of enclosure the next problem to be encountered is the choice of packaging material for shipping and transportation. For certain specialist applications such as in the military area the transportation container has to be a very robust one such as those marketed by Tekdata and manufactured by Zero International. Among the housings they produce are a series of sealed housings which are made from deep drawn aluminium. These are both light in weight and corrosion resistant, also being water tight to a pressure of 0,1 bar.

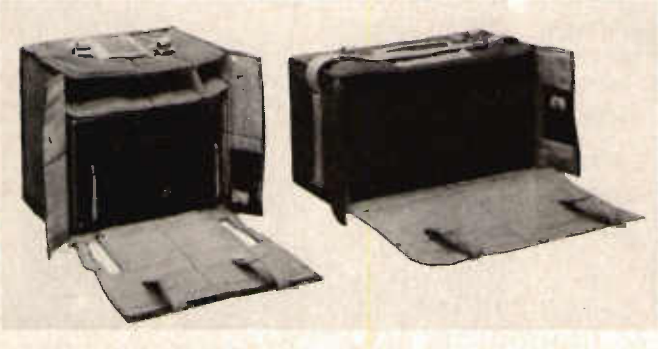
However in the more common applications, other types of packaging is more suitable. The cost of providing adequate protective packaging for equipment whether it be small components or large systems is estimated to be about 1,77 per cent of the manufacturers selling price according to a survey which was undertaken by Information for Industry on protective/transit packaging in the electronics industry. The survey which was undertaken last year covered 600 companies with whose packaging costs were in the region of £47 million. Although the response to the questionnaires was only about 11 per cent it did reveal such information as the types of material used for both outer and inner packages (see Table 1). The report showed that the most popular type of packaging material was polystyrene (both moulded and loose fill) accounting for over 66 per cent of the market. The report stated that polyurethane foam is now the single material in greatest use and has proved itself (together with flexible polyethylene foam) to be the most satisfactory shock cushioning packaging material available. While many companies could report a nil damage rate some had a ten per cent damage rate. In general it was found that those companies using loose fill or wrapping type of packaging suffered the highest damage rate although these materials are quite adequate if the packaging design had been considered correctly.

Material	Percentage use	Material	Percentage use
Polyeurethane foam pads	26	Cardboard liners	2
EPS moulded corners	20	Injected polyester foam	1
Polyethylene film encapsulated air bubbles	15	Shredded cellulose film	1
		Plywood liners	1
Loose EPS chips	12	'Anything to hand'	1
Foam laminated board	8	Woodchip	1
Shredded paper	8	Straw	1
Wood wool	2	Rubberised hair	1

Table 1: Survey of popular infill materials.

Inner and outer packs

Transit packaging can be considered to consist of outer packs and inner packs. Corrugated fibreboard boxes are by far the most popular outer packs accounting for over 40 per cent of the number of outer packs used. Solid board boxes appear to be the next on the list at around 25 per cent. According to the survey other outer cases had the following percentage of



Benjamin Edginton specialises in protectomuffs, soft covers to protect instruments in transit.

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Cabinets, Cases, Housings

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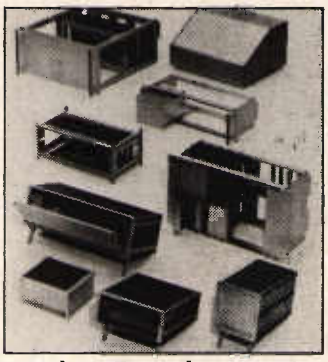

anywhere. Rugged construction in finished aluminum and extremely aesthetic with PVC clad Panels—wide choice of colours. Systems are available for 19in and more recent European Standards.
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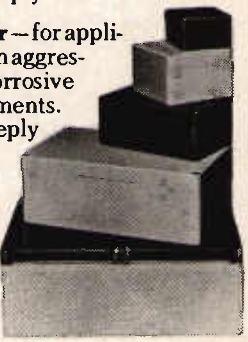

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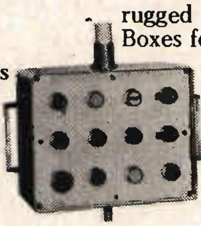

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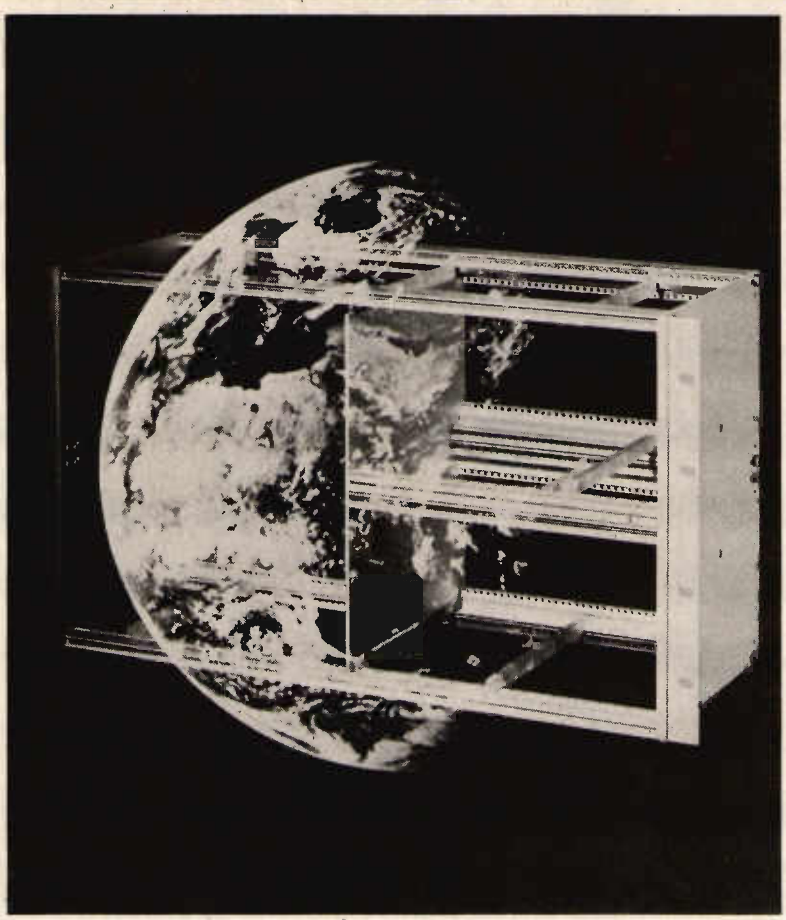

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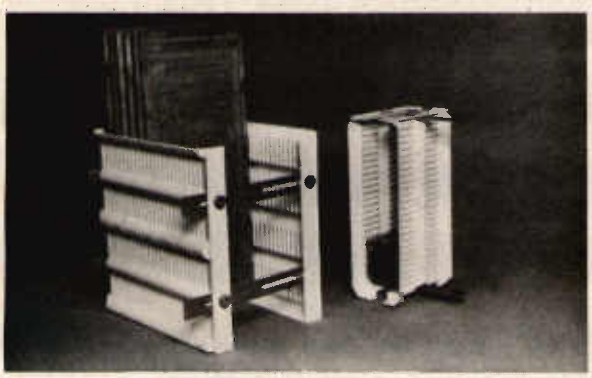

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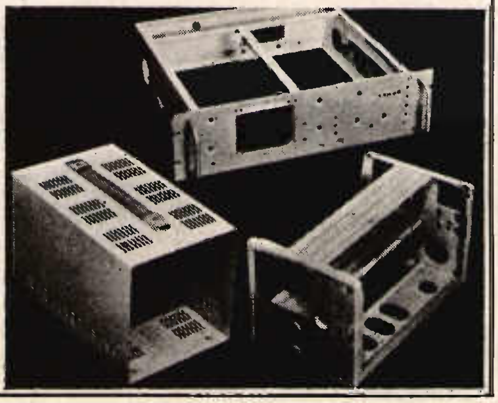
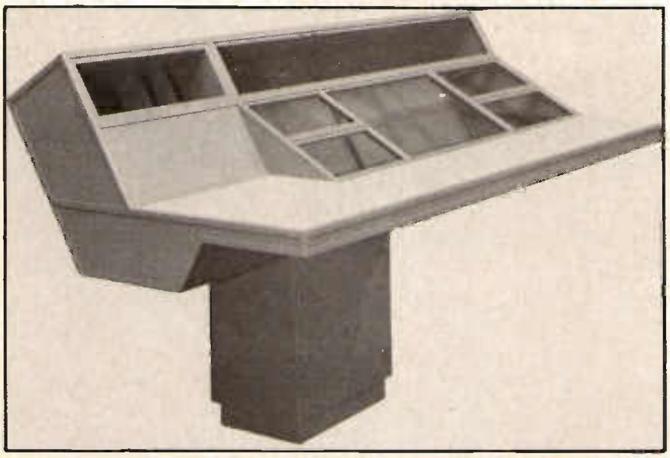


the packaging market, plywood boxes 18 per cent; corrugated paper wrappings seven per cent; padded bags three per cent and aluminium one per cent. Carton Industries, Abbots Packaging and Jiffy Packaging all produce various products from the above.

There was a far greater diversity in the use of the infill materials as Table 1 shows. Since this is one area where the choice of material is important in cushioning the effects of blows, companies seem to experiment with a number of materials. Flo-pak produces a free flow cushioning made of expanded polystyrene pieces in the shape of a figure eight which is used by GEC. Abbots Packaging and Jiffy Packaging both make the padded bags. The Sentinel range from Abbots have the inner surface coated with polythene which means that they can be heat sealed.

Transportation

The decision whether to commit your packaged instrument component to the various hazards of transportation or to provide one's own means of carriage is one which was encountered by Precision Equipment Transport Service. The company noted that there was a lack of specialist electronics transport service and decided to provide a nationwide, fast, highly insured handling service capable of carrying totally unpacked equipment in safety covering the whole spectrum of the electronic equipment market. For this purpose the company acquired two types of vehicles; one type which was capable of carrying smaller items with padding and a safety belt system to protect from shock and chafing; the other type was similar in design but suitable for larger equipment and racking systems. Roger Connel of PETS commented that "In this time of depression the need for a specialist transport service does exist provided it will take equipment of all sizes and shapes and cover the whole of the country rapidly and carefully."



An example of the slimline Widney Dorlec consoles.

Further information

Our reader enquiry service can provide information on the companies mentioned in this article upon request.

Abbott's Packaging	**524**
Benjamin Edginton	**525**
Boss Industrial Mouldings	**526**
Carton Industries	**527**
Daturr	**528**
Flo-pak	**529**
Foxall Instruments	**530**
Imhof-Bedco	**531**
ITT	**532**
Jiffy Packaging	**534**
PETS	**535**
Tekdata	**536**
Vero	**537**
Widney Dorlec	**538**

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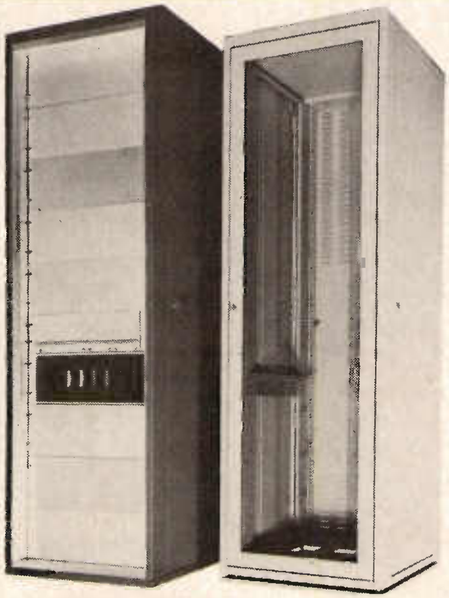

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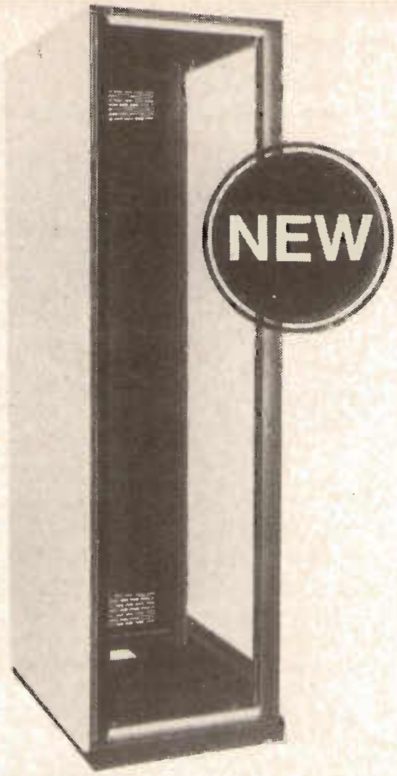
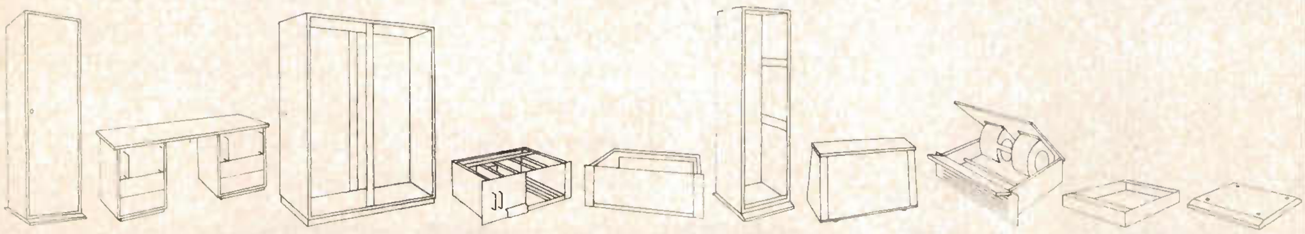


NEW SLIMLINE INSTRUMENT RACK

the latest in a long line of Langley racks for the electronics industry

Featuring fully-welded rigid construction, and a slimline design to prevent excessive build-up of unused space, the new STR rack is built to international standards and incorporates many features usually offered only as optional extras. Among these are panel screw concealment trims, lockable side panels, ventilated rear doors, and a static plinth support with jacking feet.

Standard and enclosed versions are available in 4ft, 5ft, 6ft, and 7ft heights. Overall rack width is 23" to accommodate the standard 19" instrument frame, and depth varies from 17" to 30". Custom-built units may also be supplied.



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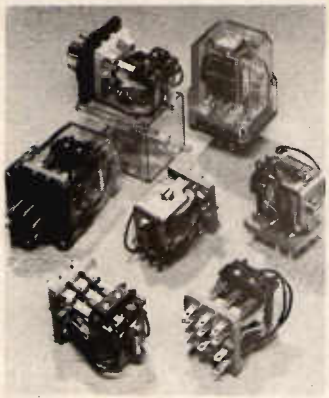
Relays
The R series of medium power relays, rated at five or 10 A, can be supplied in panel-mount,



pcb or octal plug styles and are SEV approved. Relays are available with two or three c/o contacts of pure silver. Switching power, ac, is 1,25 KVA (5 A) and 2,5 KVA (10 A). Insulation resistance is 100 MΩ at 500 V dc. *ITT Comps., Essex.* **301**

UHF dividers
The SP8740 and -/45 are 300 MHz divide by 5/6 counters, with ac/dc coupled i/p respectively. The SP8741 and -/46 types are 300 MHz divide by 6/7 counters with ac/dc coupled i/p. The SP8743 and -/48 versions are 500 MHz dviide by 8/9 counters with ac/dc i/p. The dc coupled devices require PECL III i/p and the ac devices have an i/p range of 400 to 800 mV. The specified supply is 5,2 V but the devices will operate from a 5 V source. *Plessey Semis., Swindon, Wilts.* **302**

Cable harness
A range of heat-shrinkable cable harnesses allow groups of cables to be routed without the need for cable trunking or other conduit systems. The harness is slipped over the cables and then shrunk into position. Shrinking occurs at between 125 and 130°C, allowing the use of a hot air gun or naked flame. *Thomas Ness, Harrow, Middx.* **303**

Solar cells
A solar power module designed for remote power supply applications contains 18 silicon solar cells, each 50,8 mm in diameter, connected in series on a finned aluminium substrate and potted in a silicon compound. Designated MOD-2118, the modules can be connected into arrays to charge 6 V batteries. An optional built-in Schottky blocking diode is available. *Sensor Technology, Chatsworth, California,* **304**

Digital tachometer
The 1000 series of tachometers incorporate a latched digital display fitted with a polarised filter. Speeds of up to one million rpm can be displayed. The instrument is designed to give an accuracy of 0,01% and can be used in conjunction with magnetic, photoelectric or proximity sensors. It is available with bcd printout and analogue setpoint trip controls. *Sapphire, Ferndale, Glams.* **305**

Battery charger
A constant current charger for 501 RS NiCd cells can hold up to four cells. Each cell, 1,2 V, is rated at 500 mAh. The charger has a built-in selector for the number of cells to be charged and is suitable for operation from a 220/240 V mains supply. *Varta (GB), Crewkerne, Somerset.* **306**

Ceramic filters
Type CFM 107S12C piezoelectric ceramic filter has a centre frequency range of 10,62 to 10,78 MHz in 0,04 MHz steps ±35 kHz on each frequency. The −3 dB bandwidth is 220 ±40 kHz and the −20 dB bandwidth is 60 kHz. Maximum insertion loss is 6 dB and minimum spurious response 38 dB (10,7 ±1,5 MHz). Input/output impedance is 470 Ω; ripple 1 dB max: and breakdown 50 V dc. *ITT Comps., Paignton, Devon.* **307**

Signal generators
Two additions to the TF2015 range of signal generators offer alternative deviation ranges. The 2015/1 is a narrow deviation unit with three ranges of 2,5, 5 and 25 kHz fs, whilst the 2015/2 is a wide deviation variant with ranges of 20, 100 and 500 kHz. *Marconi Insts., St Albans, Herts.* **308**

Rotary switches
The C range of rotary, multi-position switches, features up to 30 no/nc contacts for 5 A at 380 V or 10 A at 220 V. Each contact is activated by its own cam and a range of cams can be assembled on a shaft in eight varying positions, allowing a variety of switching sequences. *Entrelec, Felpham, Sussex.* **310**

Opto-isolator
The MCT210 isolator has a specified minimum current transfer ratio of 50% saturated, and 150% unsaturated, over a temperature range of zero to 70°C. The device incorporates a GaAs diode emitter, coupled to an npn silicon planar phototransistor. Isolation between i/p and o/p is 4 kV dc. *Monsanto, London.* **311**

BCD comparator
The 74L 40 comparator accepts up to four decades of bcd i/p information at ttl logic levels. Each o/p, 'high' and 'low', is in the form of a sp c/o contact. The o/p are activated when the i/p exceeds or drops below pre-settable high and low limits respectively. *Orbit Controls, Cheltenham, Glos.* **312**

Field strength meter
Model NM-67 is a programmable microwave receiver with spectrum analyser capability and tracking preselection. Frequency and amplitude o/p are provided for x/y plotting. A digital frequency readout is available simultaneously. Frequency coverage is from one to 18 GHz, expandable to 40 GHz. *REL Equip. & Comps., Hitchin, Herts.* **313**

Resistors
A range of precision resistors conforming to MIL and DIN specifications comprises metal film, carbon film and colloid film types. M/f types have tcr's from ±15 ppm with tolerances down to 0,1%. The c/f range includes high ohmic values up to 100 GΩ. Working voltages up to 30 kV are available in the colloid film range. *Colstar, London.* **314**

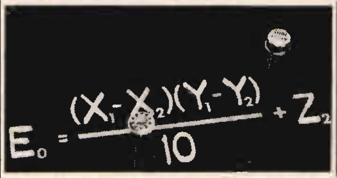
Resistance meter
A battery operated high megohm resistance meter provides direct measurement of resistance values from 0,1 MΩ to 10^6 GΩ. Accuracy is ±5% of fs and the i/p impedance is >10^{14}Ω. *Rofin, Egham Surrey.* **315**

Capacitance meter
The CP570 capacitance meter, includes overload protection and a battery test facility. Five ranges can be selected by means of a rotary switch, from 50 pF to 0,5 μF fs. The meter movement is a Class 1,5 moving coil (3 kΩ) with sprung jewel bearings. *Carlo Gavazzi, Newport Pagnell, Bucks.* **316**

Relays
A low profile, 30 W two-pole c/o relay, designated SC200, is fitted with a dust cover and designed for close space mounting of pcb's such as PO Type 62 EPS. Operate and release times are 20 and 15 ms respectively. The relay can operate over a temperature range spanning −10 to 40°C. *Plessey Aerospace, Titchfield, Hants.* **318**

D/A converters
DAC371-8-LV, is an 8-bit, current o/p model operating from 5 V supplies and drawing 20 mA. Two models are available, one featuring binary i/p, the other a two decade bcd i/p. The binary unit delivers a zero to +1,9 mA. Settling time to 0,2% is 1 μs for both types. *Hybrid Systems, Camberley, Surrey.* **319**

Multiplier/divider
The 4213 differential i/p multiplier/divider is a self-contained, laser trimmed circuit, with an



accuracy of 0,5% and a noise specification of 120 μV rms (10 Hz to 10 kHz). Four quadrant multiplication, division and square rooting can be performed without additional amplifiers. Zener regulated references are included to reduce sensitivity to power source variations. *Burr-Brown Int., Watford, Herts.* **309**

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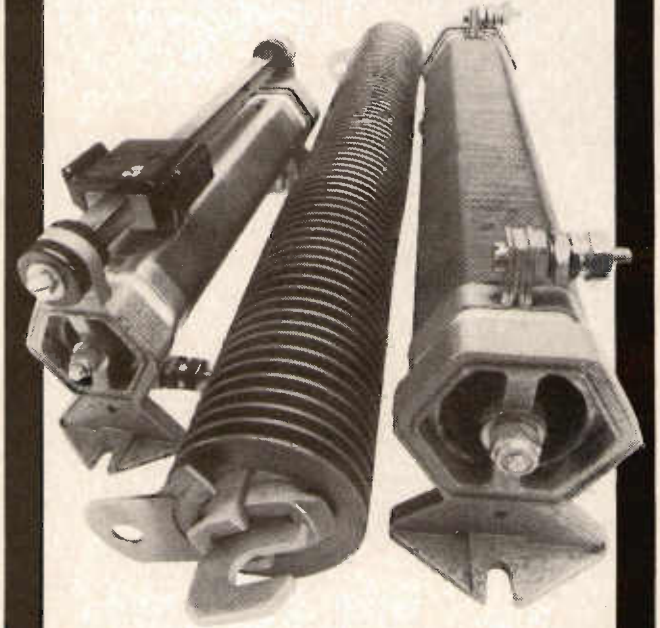

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NEW PRODUCTS

A/D converter

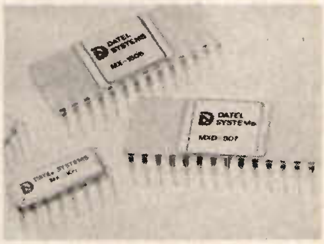
ADC84 contains internal clock, comparator, reference and i/p buffer amplifier and features conversion times of 10 µs for 12-bits and 6 µs for 10-bits. Five analogue i/p ranges are available and gain and offset errors can be externally trimmed to zero. Several o/p codes are available and all digital i/p and o/p are ttl compatible. *Burr-Brown Int. Watford Herts.* **317**

Crystal oscillator

A low profile, tempco: crystal oscillator, TCX08, features 8 mA current consumption, instantaneous turn-on and a frequency range of 4,1 to 20 MHz. The frequency stability depends on the operating temperature range required. Typical specifications are ±1 ppm for zero to 60°C operation and ±1,5 ppm for −10 to 70°C. *ITT Comps., Harlow, Essex.* **320**

Multiplexers

MX series analogue multiplexers, available in four, eight and 16 channel configurations, are manufactured with a dielectrically isolated cmos process.



Break-before-make switching ensures that no two channels are ever momentarily shorted together and no damage results for analogue i/p over-voltages of ±4 V or a loss of power with control and signal i/p applied. *Datel, Basingstoke, Hants.* **321**

Microcomputer kit

The MCS-40 system B kit, comprises a 4040 cpu, a programmable I/O device (4269), providing simultaneous interface with a keyboard and display. An interface circuit provides 16 I/O lines, 256 words of static ram, a combined memory interface and I/O device, 256-bytes of e-prom and a system clock generator. *Intel, Oxford.* **322**

Analogue switches

TL600 analogue switches are fully ttl compatible and will accept ±10 V signals. Operating from five to 30 V supply voltages, these devices have an *ON* and *OFF* resistance of 100 Ω and 10^{11}Ω respectively. Four versions are available providing sp/st sp/dt and dual sp/st configurations controlled by either a single strobe i/p or one, two or three logic i/p. *Mogul Electronics, Harlow, Essex.* **323**

Prescalers

The SP8646 and -/47 are divide-by-10/11 counters identical in performance to the SP8640 and -/41, but with the addition of an open collector o/p stage. The o/p can drive three standard ttl loads. The -/46 is specified to 200 MHz and the -/47 to 250 MHz with dc-coupled i/p. *Plessey Semis., Swindon, Wilts.,* **324**

Power supply

The Triple Powercard is provided with a third o/p line, whilst maintaining the basic Powercard specification. All rails are short-circuited protect and both positive and negative o/p go low when either is short-circuited. The ±12/15 V o/p track together and the 5 V o/p has a fixed over-voltage trip. *ITT Comps., Harlow, Essex.* **325**

Static rams

Three static n-mos rams, organised as 256 × 4, operate from single 5 V supplies and are fully ttl compatible. Each is available in three speed ranges with access times of 1000, 650 or 450 ns. Versions are available with separate and common I/O lines and in plastics or ceramic dil packages. *Texas Insts., Bedford.* **326**

Impedance converters

Model 304 impedance converter includes a fet, a high megohm resistor for biassing and a low value resistor in the power circuit. It effectively converts charge or other high impedance sensor o/p into low impedance voltage signals. Exhibiting near unity gain, the unit will accommodate i/p impedances up to 5 × 10^{11} Ω with an o/p impedance of 6,2 kΩ. *Rofin, Surrey.* **327**

Power drivers

A series of cmos compatible dual peripheral power drivers, includes the DS1631/3631, 1632/3632, 1633/3633 and 1634/3634. These circuits feature pnp i/p which provide high impedance and thresholds that track as a function of V_{cc}. The V_{cc} operating range is 4,5 to 15 V. Output current capability is 300 mA and the o/p transistors are protected in the event of V_{cc} failure. *National Semis., Bedford.* **330**

Orange displays

MAN6660 and -/80 are 15,24 mm high single digit displays in common anode or cathode configurations respectively. Both units emit orange light at a wave length of 630 nm and feature a minimum brightness specification of 510 µcd/segment digit at a forward current of 10 mA. *Monsanto, London.* **328**

RMS converter

A true rms to dc-converter, model 442, features an 8 MHz bandwidth and ±0,5% accuracy for crest factors up to 10, enabling true rms measurements on signals containing both dc and ac components. Power supplies of ±6 to ±18 V dc are required. Input range is zero to 2 V rms and response time to 1% accuracy is 5 ms. *Analog Devices, E. Molesey, Surrey.* **329**

Multimeter

The 1057 is a 5½ digit half-rack multimeter which measures dc-V, true rms ac-V and resistance. Ranges, in five steps, cover 1 µV to 1 kV (dc), 10 µV to 700 V (true rms ac) and 10 mΩ to 20 MΩ. An integration notch and three pole filter provide

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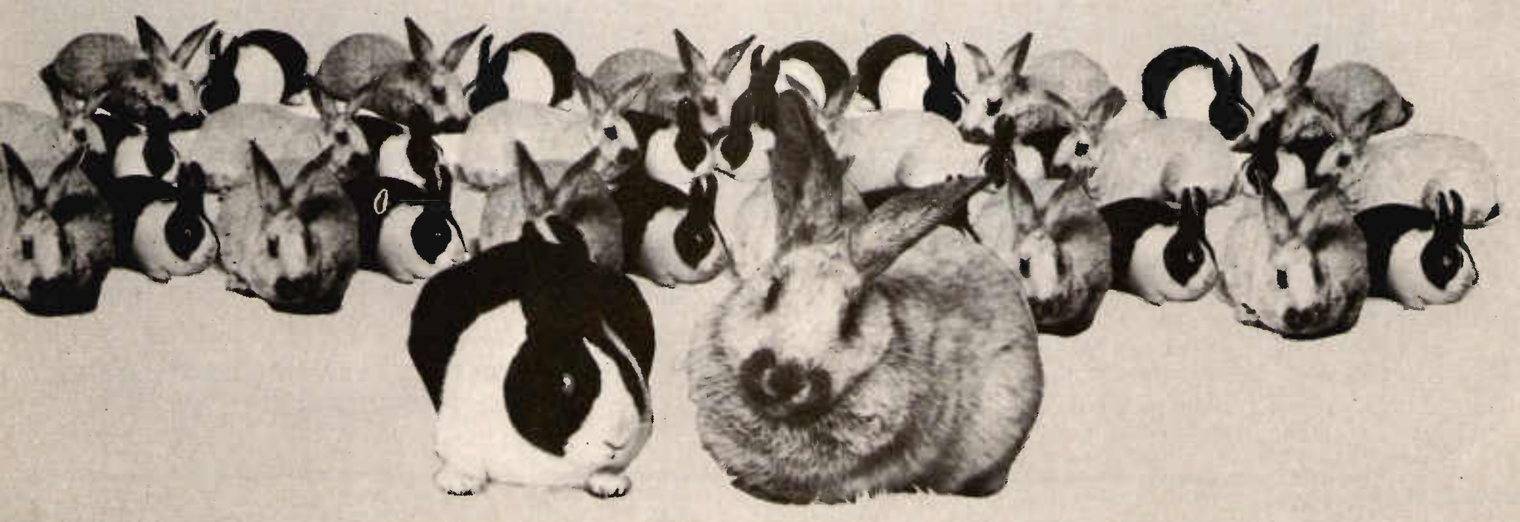


KWP/B124

more than 80 dB of series mode rejection at 50 Hz and a typical dc accuracy of 0,015% ±0,001% fs is claimed. *Datron Electronics, Norwich.* **331**

Diode holder

The TN diode holder, designed for use on pcb's, occupies 40 × 15 mm and offers space for the vertical installation of up to 80 diodes arranged on a 2,54 mm matrix. The diode panel can be enlarged by combining several holders. The holders are made of Ultramid plastics, resistant to temperatures of up to 220°C. *Colstar, London.* **332**

Dynamic ram

The 2104A is a 4k dynamic ram fabricated with an improved n-channel Si-gate process. Average drain current is 30 mA and access time is specified as 200 ns (read or write). The tolerance on the voltage on the power rails is ±10% and the maximum allowable logic low i/p voltage is 800 mV. *Intel, Cowley.* **333**

Power transistors

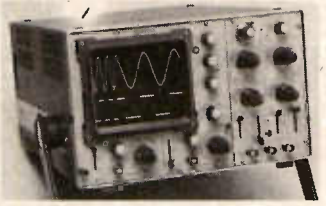
The BU500 power transistor is designed for colour tv horizontal deflection applications where 110° in-line gun crt's are used. The device, rated at 1,5 kV, 6 A, can withstand turn-off transients of up to 16 A at 500 V. The unit is designed to prevent the occurrence of failures due to eht flash-over. *Texas Insts., Bedford.* **335**

Function generator

Model 180 sweep function generator has a frequency capability of 0,1 Hz to 2 MHz with switched range selection and dial tuning. Output signals can be selected as either sine, square, triangle or dc level and separate terminals are provided for ttl pulses and variable ramp o/p. The internal sweep facility allows variable sweep widths and rates to be set by the front panel controls. *Electroplan, Royston, Herts.* **336**

Oscilloscope

The OS3000A is a dual trace 40 MHz 'scope incorporating an 8 × 10 cm rectangular faced crt, running at 10 kV with an illuminated graticule. The sensitivity can be adjusted from 5 mV/cm to 20 V/cm, with a x5 facility giving 1 mV/cm between dc and 10 MHz. Timebase speeds up to 20 ns/cm are provided with independent triggering for each time base. *Gould-Advance, Essex.* **334**



Converters

The 7103 digital processor is used with the 8052 signal conditioner to provide all the logic circuitry necessary for a ±1999 count a/d counter. The device includes auto-zero, auto-polarity switches, converter, latches, multiplexer and associated logic to provide a multiplexed bcd o/p format. *Intersil, Reading.* **340**

Detector

Series 1001 are broadband half-wave detectors claimed to feature a flat frequency response. The vswr is said to be typically >1,1 at 1,2 GHz. The connectors are available with either bnc or n mating faces. *Suhner Electronics, High Wycombe, Bucks.* **342**

Voltmeter

The Ithaco Dynatrac 395 narrow-band voltmeter automatically locks its centre frequency to an external reference signal from 10 Hz to 10 kHz. The user need only set the sensitivity and bandwidth; maximum sensitivity is 100 μV and bandwidth can be set between 0,03 and 300 Hz. A differential i/p is provided, allowing the instrument to be used as a null detector. *Techmation, London.* **337**

Edge connector

The 4338 edge connector incorporates crimp type contacts spaced at 3,97 mm. The Valox 94V-O polyester housing is said to feature dimensional stability, low moisture absorbancy and high dielectric resistance. The terminals are rated at 5 A and are of brass, tin or gold on nickel plate. Versions are available ranging from eight to 30 dual positions. *Molex Electronics, Aldershot, Hants.* **338**

Military fpla

The S82S100 and -/101 are Schottky ttl fpla's with three-state and open collector o/p respectively. Both employ nichrome fuse technology and operate over a temperature range of −55 to 125°C. Key specifications include 600 mW typical power dissipation and 80 ns max. access time. The devices are organised with 16 i/p and eight o/p. *Mullard, London.* **339**

Pressure transducer

The sensing element of the 8507 series of pressure transducers consists of a shaped silicon chip on which is diffused a four-arm piezo-resistive Wheatstone Bridge. The chip is 3 mm in diameter. Full-scale o/p is 300 mV and an integrated temperature compensation circuit keeps sensitivities within ±2% of fs. Four models are available, with pressure ranges up to 50 psi. *Endevco UK, Royston, Herts.* **341**

Connectors

A range of two-part connectors, designated the KS 1000 series incorporates conventional tuning fork contacts. The contacts are produced from beryllium copper with gold over nickel plating. The contacts are designed to handle currents up to 3 A with contact-to-contact voltages of up to 1 kV ac (rms) at 60 Hz. *Teradyne Comps., Cambs.* **343**

Insulation tester

A 10 kV insulation tester, measuring 203 × 139,7 × 76,2 mm can be operated from the mains or from internal batteries. Nominally rated at 7 kV the unit delivers o/p voltages up to a

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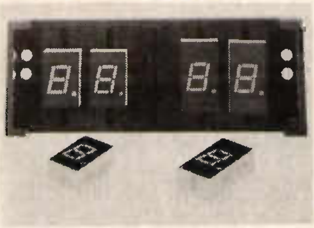
maximum of 10 kV at 250 μA controlled by a 10-turn potentiometer. Push-button switches provide four metering modes. An auto-trip facility operates at 130% of the fs setting. *Hunting-Hivolt, Shoreham, Sussex.* **345**

Photoconductive cells

The NSL312 and -/412 series of Cd-sulphide photoconductive cells operate over a temperature range of −60 to 65°C and 75°C respectively. Both types have a 50 mW power rating at 25°C a choice of seven photocell resistances and typical dark capacitance figures of between 1,2 and 4 pF. The devices have peak spectral response figures of 720 and 560 mn respectively. *National Semis., Altrincham, Cheshire.* **346**

LED displays

Series 1775 and -/76 led displays are 7,62 mm high with deep red characters providing zero to nine and right-hand decimal point. Series 1775 is the



common cathode version, whilst the -/76is common anode. Other features include single plane, wide angle (160°) viewing and 350 μcd/segment luminous intensity at 20 mA drive current. *IEE, Van Nuys, California.* **344**

Oscillograph

The 45000 uv-oscillograph recorder provides 18 fixed speeds from 10 mm/m to 5000 mm/m. An alpha-numeric indicator panel presents the status of the main controls. A variable speed vernier control is also provided and the display warns when this control is engaged. A choice of six, 12 or 25 channel magnet blocks are available and both heated and hv blocks can be provided as options. *Electroplan, Royston, Herts.* **347**

Slide switch

Series 24 slide switches are designed to escape contamination during pcb assembly. Measuring 14,5 × 3,8 × 12,7 mm the switches can be supplied either fully assembled or in two-parts. The upper half contains the actuator button and sliding contacts, whilst the lower section contains the fixed contacts and the pcb pin base. *Roxburgh Electronics, Rye, Sussex.* **348**

Regulators

A pair of three terminal voltage regulators with preset o/p of +5 and −5 V have load driving capability of 3 A. The LM323 (+5 V) is a 3 A version of the LM309 with internal current and thermal limiting. Typical o/p impedance is 0,01 Ω and power dissipation is 30 W. The LM345, the −5 V device, can dissipate 25 W and requires one external component. Both devices come in hermetically sealed TO-3 cans. *Jermyn, Sevenoaks, Kent.* **349**

Oscillators

Model CO-238A-2S-2 clock oscillator drives 10 ttl loads at any specified frequency in the four to 100 MHz range with a stability of ±50 ppm over the −55 to 125°C temperature range. The device is sealed in a metal can and ruggedised for shock to 100 g and vibration of 20 g to 2 kHz. *Lyons Insts., Hoddesdon, Herts.* **350**

Rotary switches

A family of rotary switches provides eight positions within a TO-5 package. The switches have gold contacts and each contact is rated at 0,5 A at 125 V ac with a break-down voltage of 500 V at 60 Hz. Switches are available for direct pcb mounting or can be supplied for panel mounting. *Quiller Comps., Bournemouth, Dorset.* **351**

Microwave amplifier

Models 600L and /P microwave amplifiers provide 24 dB of gain with an o/p of 150 mW (min) of linear Class A power, or 300 mW of saturated power over the frequency range of 0,8 to 1020 MHz. Model 600L is designed for use as a laboratory amplifier, whilst the 600P finds use as an oem product. *ENI Power Systems, Hitchin, Herts.* **352**

Audio amplifier

The TDA2002 is a Class B audio amplifier with typical o/p powers of 5,2 W into 4 Ω load and 8 W into 2 Ω. The minimum guaranteed figures are 4,8 W and 7 W respectively. In addition to its intrinsic reliability it can withstand $>7{,}5 \times 10^3$ thermal fatigue cycles with $\Delta T_{case} =$ 100°C. *SGS-Ates, Aylesbury, Bucks.* **353**

Microprocessor system

Two new μP systems forming complete 8-bit micro computers on two chips, claim to cut the cost of equipment systems. Designated the PPS-8/2 family, both systems provide two-chip micro computers with cpu, one auto-serial and 17 parallel I/O ports, 16-bit interval timer, three level interrupt, clock circuit, 64 × 8 ram and either 1024×8 or 2048 × 8 rom. Both use 109 instructions. *Pelco (Electronics), Hove, Sussex.* **354**

Integrated drivers

This comprehensive family of integrated monolithic circuits has been designed to work as interfaces between logic circuits and inductive loads, ie, relays, motors, lamps, etc. The PBD3510 is a single driver for positive earth systems with a fast switch-off. Driving capability is 125 mA. The 3511 is identical, but for negative systems. The PBD3513 is a dual 12 V driver with two 3 i/p *and* gates plus dual expandable i/p. The 3520 is a driver with open collector/emitter o/p and the 3523 is a Darlington Septette, designed for 7-segment printers, 500 mA driving capability/channel. *Rifa, Sweden.* **355**

16k cmos ram

The HMM1600 is the first of a series of static silicon gate hybrid ram's designed to optimise the capabilities of 1k cmos ram's. It is organised as 2k × 8-bit words, but can be optionally connected as 4k × 4-bit words by bussing relevant i/p and outputs. Access time is 150 ns typically with a standby current of 120 nA. It is ttl i/p and o/p compatible and includes on-chip registers. *National Semis., Bedford, Beds.* **356**

Electrolytics

Aluminium electrolytic capacitors have now been designed for use in rc-timing circuits. The family consists of six devices, with capacitance ranges from 10 to 500 μF at working voltages of 25 V dc. Capacitance tolerance of the type 603D is 10%. *Sprague Electric, W. Drayton, Middx.* **357**

16k rom

The MCM68316E, 16384-bit static rom is organised as 2048 bytes of 8-bits and offers a maximum access time of 450 ns. The rom offers tri-state o/p and ttl compatible i/p. *Motorola Semis., Wembley, Middx.* **359**

5½-digit dmm

Known as the 8500A this instrument is really a modular measuring system rather than a

dedicated instrument. Operation of the unit is based on a μP, which controls all the unit's modules. All these modules reside on a computer-type bus structure and each module has a discrete address. The basic device incorporates five dc-V ranges as standard, additional modules permit true ac-V, average responding ac-V, dc/ac current and resistance measurements. *Fluke Int., Watford.* **358**

Voltage regulators

With an o/p voltage adjustable between three and 30 V and o/p current adjustable from zero to >1,8 A, the L200 has considerable advantages over existing regulators. The maximum reference voltage is 40 V, ripple rejection is (>70 dB) and the adjusted current has low thermal drift (100 ppm/°C). Stability is >0,2% of I_{out}/V during load variations. *SGS-Ates, Aylesbury, Bucks.* **360**

Dual-gate mos/fet

The MFE140 dual-gate mos/fet is characterised for frequency modulation amplifiers and mixer applications. This n-channel device functions in the depletion mode and silicon nitride passivation has been utilised. Both gates have been diode protected. The device features a low reverse transfer capacitance of 0,05 pF, high gain of 20 dB and high conversion gain of 15 dB. *Motorola, Semis., Wembley, Middx.* **361**

Opto-isolators

A uniquely designed internal shield for high common mode rejection guarantees common-

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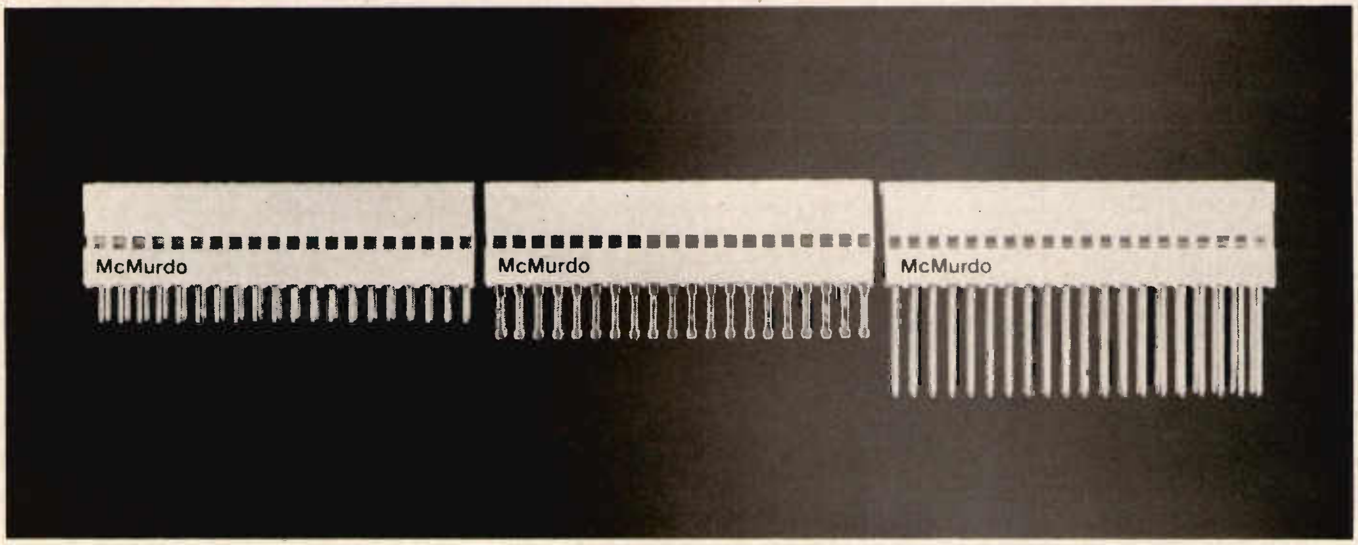

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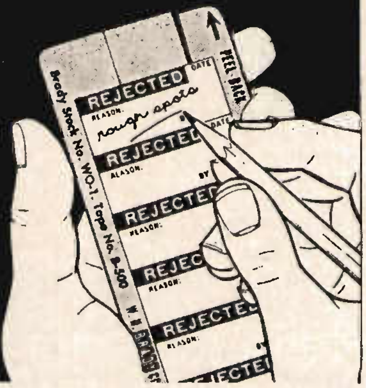

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mode transient immunity of 1000 μV/s. Designated the 5082-4361, these isolators have the ability to reject an increase of 100 times more common-mode noise. Input current required is 5 mA with a propagation delay time to high or low o/p level is 35 ns. *Hewlett-Packard, Winnersh, Berks.* **362**

Chart recorder

A new thermal writing multipoint recorder, type 816 can record up to eight channels of analogue information on fanfold chart paper at sampling rates of up to 17 points/s. Three operating modes are available; multipoint, intensified and continuous. The maximum channel span of 11,4 cm provides high display resolution. *Gould-Advance, Bishop's Stortford, Herts.* **363**

Frequency synthesiser

The model 6595 frequency synthesiser module is designed for use in the range 962 to 1213 MHz. The device provides 10 mW o/p over the band and is tunable in 1 MHz steps with 250 μs switching time. Spurious o/p are 80 dB below the carrier. *Dale Electronics, Camberley, Surrey.* **364**

Differential amplifier

The 3627 unity-gain differential amplifier is a self contained amp. including resistor network and laser trimmed offset circuitry. Accuracy is $<\pm 0{,}015\%$ at 25°C. The cmr offered ranges from dc to 60 Hz of 80 dB and offset voltage drift of 40 μV/°C. Offset voltage of <250 μV; small signal ±3 dB response >0,8 MHz; slew rate of 0,6 V/μs and settling time of 20 μs are all major specifications. *Burr-Brown, Int. Watford, Herts.* **365**

Voltage reference

The REF-02 precision voltage reference provides a stable +5 V o/p adjustable over a ±6% range with minimal effect on temperature stability. Single supply operation over an i/p voltage range of seven to 40 V, low current drain of 1 mA and excellent temperature stability have been achieved with an improved bandgap design. Noise is low, typically 10 μV pk-pk and the load driving capability is 20 mA. *Bourns (Trimpot), Hounslow, Middx.* **366**

Solid state relay

The 613 series is claimed to be the industries first dc solid state relay with a current rating of 20 A at 50 V dc. Two versions are available with ttl or HiNIL compatible i/p, to cover a control range of four to 32 V dc. Transformer isolation provides 1,5 kV rms isolation together with a low 5 mA off-state leakage. Response time is <200 μs. *Teledyne Relays, Hounslow, Middx.* **367**

Joysticks

The model 101-2, two axis miniature force joystick has been designed to meet stringent military and industrial environments. The overall size is 31,7 mm mounting flange with body diameter 25,4 × 50,8 mm long. Analogue voltage o/p is standard and infinite resolution is offered. *DACO Scientific, Basingstoke, Hants.* **368**

Isolators

These three ranges of optically coupled isolators utilise GaAs ir-led's, together with silicon phototransistors. Type 520 is avaiable in a 14-pin dil and type 521 in a 24-pin package. Both types have minimum isolation voltages of 5 kV and insulation resistances of $>10^{11}\Omega$. Type 525 offers a minimum isolation voltage of 10 kV and an insulation resistance of typically $10^{14}\Omega$. Operating temperature range is −40 to 85°C. *GE Electronics, London.* **369**

Receiver

The CM8824, single digit receiver is a high performance, low cost module for applications where single dtmf receivers are required. A low power requirement and excellent talk-off protection affords use in control systems, dial transfer applications or precise dial tone detection. *Mitel, Shannon, Eire.* **370**

Strip-switch

The 2500 series, is a low profile strip-switch, having a maximum height above the pcb of 7,62 mm. Operation may be either thumbwheel or screw driver slot and the setting of the switch is clearly shown in a window. Six 10-way switching codes are available, including single pole decimal and the commonly used bcd codes. *Waycom, Bracknell.* **371**

Miniature meter

The Minipilot is a miniaturised moving coil meter designed for radios, tape recorders and other portable equipments. Its applications are as a battery checker, turning meter, sound level meter, etc. The meter has an 11 mm barrel, 12,6 mm flange and is 16,3 mm deep. The range spans zero to 1 mA or 0,5-0-0,5 mA. *Europa Comps & Equip., Elstree, Herts.* **373**

Slider pots

The Seimart series C and F slider potentiometers, include single and tandem slider devices with both 40 and 58 mm travel.

The resistive element consists of carbon composition film bonded, at high temperature, to a flat base made of paper impregnated with phenolic resin and housed in a moulded plastics case. Metal screened types are available where the elimination of external interference is important. *Distronic, Harlow.* **372**

W/W resistors

Five nprf radial tag series precision w/w resistors are available in resistance ranges covering 1 Ω

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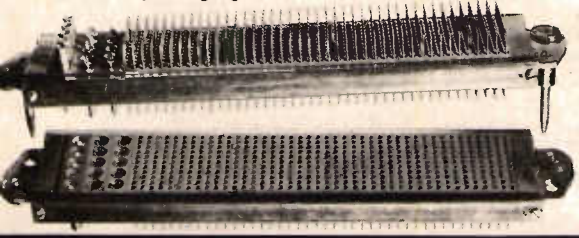

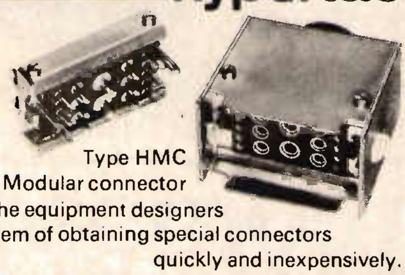

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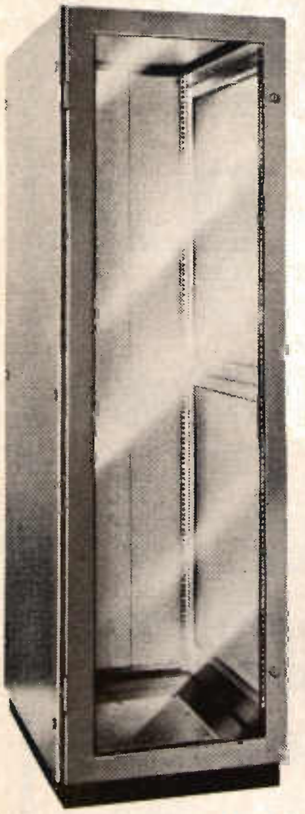

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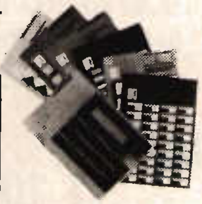

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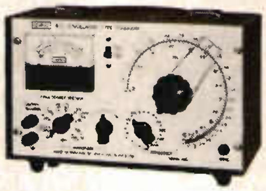

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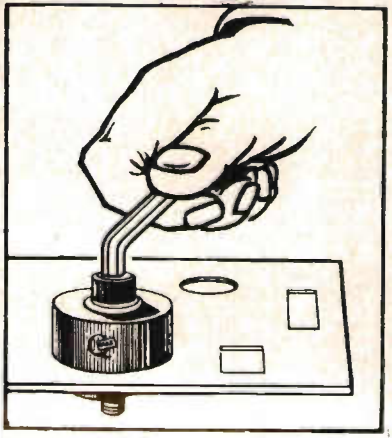

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NEW DATA

Physical properties of materials by Lovell Avery and Vernon, £5,95 paperback version, contains basic ideas of **modern physics** and concepts required by materials scientists. *Van Nostrand Reinhold Company, Wokingham, Berks.* **421**

The series 050 flat cable **connectors** and jumpers are the subjects of a leaflet from Kings. The leaflet reference no. 47-755 can be obtained from *AWP, Horley, Surrey.* **422**

A catalogue of **optoelectronic** devices has been produced by Telefunken listing their complete range of devices with technical data. Information on the handbook can be obtained from *AEG Telefunken, Manchester.* **423**

The EVA brochure have details of the offerings of principal British manufacturers of electrical **vehicles** and trucks. *EVA, London.* **424**

The Intronics Technical wallchart is available from REL and contains information for engineers who design **analogue** circuitry for computing, signal conditioning and function generation. *REL, Hitchin, Herts.* **425**

Understanding **microprocessors,** £2,75 comprises 120 pages and 24 chapters taking the novice in ups up to a standard of being able to specify and use systems. *Motorola, Wembley, Middx.* **426**

The 1977 Fluke Instrument catalogue contains data on the company's wide range of instrumentation from digital **voltmeters,** counters, signal sources to digital thermometers and data loggers. *Fluke, Watford, Herts.* **427**

Electronics by Close and Yarwood, £4 (paperback) is aimed at students studying for a degree and the emphasis is on semiconductor devices, circuits and systems. *University Tutorial Press, London.* **428**

Data sheets are available which give details of the 50 secondary **windings** available in Avel-Lindberg's standard range of low noise, loss toroidal transformers. *Avel-Lindberg, Ockendon, Essex.* **429**

The 1976/77 condensed general catalogue is now available from Bourns giving details of components such as **potentiometers,** resistor networks, converters, comparators and silicon rectifiers. *Bourns, Hounslow, Middx.* **430**

Designing surge suppression circuits to protect **thyristors** from load induced faults is the topic of a new application data sheet produced by the *Westinghouse, Le Mans, France.* **431**

John Matthey Metals has just revised its electrical engineering **catalogue.** Also included is a 20 page colour booklet illustrations of the products available. *John Matthey Metals, London.* **432**

The SC/MP **microprocessor** applications handbook is now available from *National Semiconductors, Bedford.* **433**

A six page brochure has been produced by Kistler on **transducers** and amplifiers which have been designed for the plastics injection moulding industry. *Kistler, Farnborough, Hants.* **434**

Du Pont has information available on the Hytrel range of polyester **elastomers** which have electrical properties which are relatively insensitive to moisture. *Du Pont, Hemel Hempstead, Herts.* **435**

The latest publication from Computer Automation discusses the various extra costs that an oem can incur when he buys a **minicomputer.** *CAI, Rickmansworth, Herts.* **436**

Intel Electronics has published a combined pack of three leaflets containing information on **relays,** resistors and switches. *Intel Electronics, Henlow, Beds.* **437**

The **book** Discrete Time Signal Processing by S A Tretter, £18,25, is intended as an introduction to discrete time signal processing. *John Wiley & Sons, Chichester, Sussex.* **438**

A four page brochure is available from Radiatron which describes the latest version of the ptw diamentor, diagnostic **dosemeter** for measuring x ray exposure. *Radiatron, Twickenham, Middx.* **439**

Worked examples in Engineering Field Theory £5,00, by A J Baden Fuller provides a summary of engineering **field theory.** *Pergammon Press, Oxford.* **440**

The PEM International condensed catalogue contains information of the company's range of **fasteners** from standoff spacers to earth terminals for pcbs. *PEM International, Doncaster.* **441**

A wallchart giving details of all the commonly used **graphic symbols** for electronic diagrams is available from *Belling Lee, Enfield, Middx.* **442**

Handbook of Instruments and instrumentation £15, is intended to give the engineers a quick means of reference to the type of method and measurement required. *Trade and Technical Press, Morden, Surrey.* **443**

The latest catalogue of information on broadband power **amplifiers** and power generators is now available from *ENI, Hitchin, Herts.* **444**

The latest edition of the **data book** of discontinued integrated circuits is available from *London Information, Ascot, Berks.* **445**

The fifth edition of the book **Problems in Electronics** with solutions by F A Benson £3,95 is intended for undergraduate engineers. *Chapman and Hall, London.* **446**

A new brochure has been released by Advanced Water Services on its range of packaged modular design fully automatic **pressure filters.** *AWS, Penn, Bucks.* **447**

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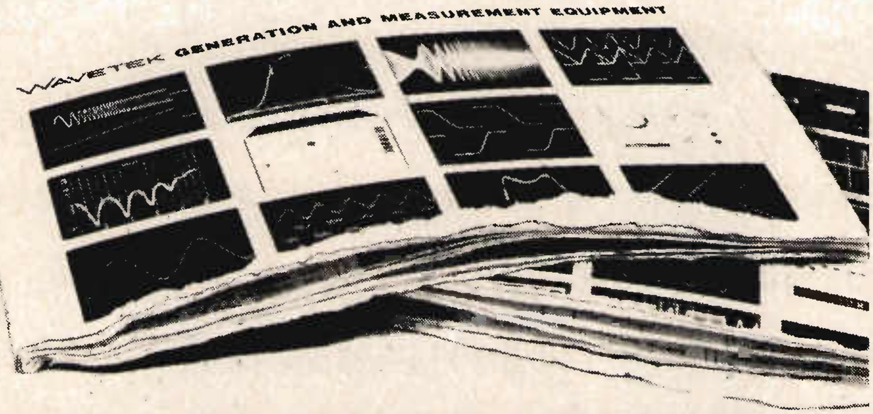

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The latest edition of the George Kent Review No 17, contains technical articles on the group's **measuring**, analytical and process control instrumentation. *George Kent, Luton, Beds.* **448**

The Gould Advance OS3300B, a portable 50 MHz dual trace **oscilloscope**, is described in a new four page data sheet. *Gould Advance, Hainault, Essex.* **449**

Morlock Industries has produced a two colour catalogue and specification list on its **helical** spring lock washers. *Morlock, Wolverhampton.* **450**

ITT's Electron Device Division has recently issued a new data summary covering a wide range of **microwave** tubes. *ITT Paignton, Devon.* **451**

The P/rel 700 a four page brochure introduces the Standard Grisgby programmable rotary encoded **logic switch.** *Standard Grigsby, USA.* **452**

A new wallchart showing Sprague's range of **wirewound resistors** is now available. *Sprague, W. Drayton, Middx.* **453**

A sonic tide and liquid level **indicator** is the subject of a brochure from *Vacuum Reflex, London.* **454**

Power testing methods and reliability by A Simpson is intended for students £3,95. *Macmillan, London.* **455**

A brochure is available from Rikadenki detailing a range of 250 mm chart width **potentiometric** recorders, *Mitsui Machinery Sales, Chessington, Surrey.* **456**

Penny and Giles has published a brochure describing its range of linear motion **faders** and joystick quadraphonic pan potentiometers. Full data and circuits are included. *Penny and Giles, Blackwood, Gwent.* **457**

Information is available on Matthey silvered mica **capacitors** in the company's new catalogue, *Matthey, Stokeon Trent.* **458**

A four page shortform catalogue from Nolton Communication describes the daneman range of **switching modules**, instrumentation and monitoring equipment for the control of data networks. *Nolton, Waltham Cross, Herts.* **459**

A wallchart from Rayleigh describes the range of products the company produces from **paper tapes** of programme cards. *Rayleigh Instruments, Rayleigh, Essex.* **460**

Fifteen pages of application notes are available in a brochure on media and disc **cartridge** requirements for Pertec D36XX disc drives. *Pertec, Reading.* **461**

Digital Engineering, £19,45, by G K Kostopoulos presents techniques, methods and algorithms as well as practical information. *John Wiley & Sons, Chichester, Sussex.* **462**

The Jordon Dataquest financial survey of 175 British component distributors has been published and contains details such as sales **pretax profits** and assets and liabilities. *Jordon Dataquest, London.* **463**

A brochure has been produced on the range of **meters** such as the 900 and 440 series manufactured by *Ernest Turner, Northampton.* **464**

Another London Information data book in the guise of **power semiconductors** can now be obtained at a price of £45,15 a subscription (two issues). *London Information, Ascot, Berks.* **465**

The engineering properties of Viton **Fluoroelastomer** is described in a publication from Du Pont and has applications in many industries. *Du Pont, Hemel Hempstead, Herts.* **466**

A new product summary booklet is available from Marler Haley exposystems illustrating the complete range of **portable display** and exhibition systems. *Marler Haley, Barnet, Herts.* **467**

A 14 page short form catalogue covering the range of Toshiba semiconductors including **transistors,** diodes, thermistors and microwave devices can be obtained from *Eire Electronics, Gt Yarmouth, Norfolk.* **469**

This 16 page periodical includes an introduction to **microprocessor** and technical articles on broadcasting and personal call systems. *Telephone Rentals Milton Keynes.* **470**

Three more DATA Books cover the subject matter, MSI/LSI **memories, transistors** and **thyristors.** The first of these covers some 4500 devices, broken down to subject area and costing £30,25 for two issues, **471.** The second in the series is the 41st edition of the transistor book, priced at £39,85 for two issues and covers in excess of 20 000 devices **472.** The last in the trio dealing with thyristors lists some 2950 new types and 1688 deleted products **473.** *London Information, Ascot, Berks.*

REL has published some information on the latest of the company's products in the programmable switched mode **power supplies.** *REL Hitchin, Herts.* **474**

A colour brochure on the cat 2 **logic tester** which has a low cost microprocessor controlled memory system has been produced by *Columbia Automation, Slough, Berks,* **475**

The book, Instrumentation, measurement and feedback by BE Jones, £5,95 provides a degree level treatment of the basic principles of **measurement** and feedback. *McGraw Hill Maidenhead, Berks.* **476**

The IBA technical review no 8 and 9 cover the fields of digital **video processing** and digital television developments. *IBA, London.* **477**

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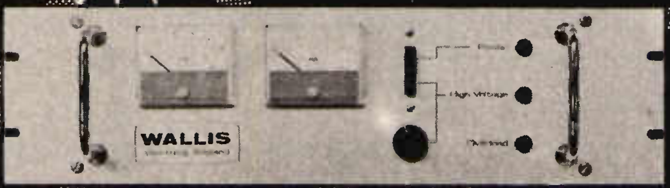

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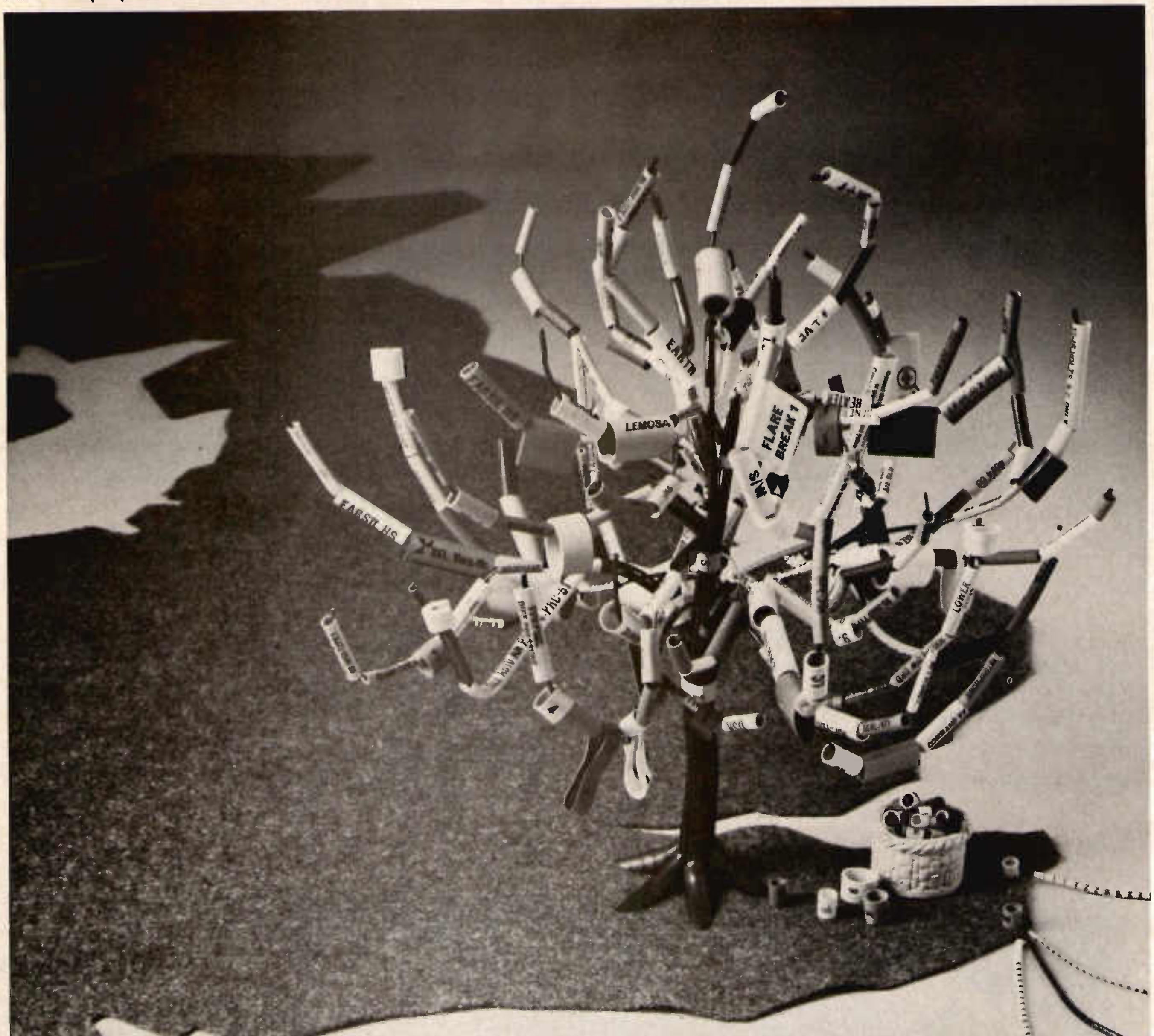

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Information is available on courses and publications in the **microprocessor** and microcomputer field published by *Integrated Computer Systems, Brussels.* **478**

Linear **transducers** are the subjects of a brochure from Penny and Giles and cover rectilinear transducers, and LVDTs for various applications. *Penny and Giles, Christchurch, Dorset.* **479**

The annual report and accounts for the 75-76 period has now been released by the IBA, £1.50. *HMSO, London.* **480**

Another annual **report** this time from Sira has also been recently prepared and is now available from *Sira Institute, Chislehurst, Kent.* **481**

Details are available on the range of **multimeters** and panel meters which are marketed by *Carlo Gavissio, Newport Pagnel, Bucks.* **482**

The services offered by BXL are described in a brochure entitled products and services and gives all the **plastics** products the company has. *BXL, London.* **483**

Pluggable accessories and **assemblies** for packaging are contained in a catalogue from *Garry Manufacturing Co, New Jersey, USA.* **484**

The MP range of regulated **static inverters**, which provides 110/220/240V ac at 50, 60 or 400 Hz from dc supplies of 24, 32, 48, 100 or 220V, is described in a leaflet. *Avel-Lindberg Ltd., South Ockendon, Essex.* **485**

ITT Instrument Services has produced a supplement to its catalogue. The supplement describes the recently added Fluke 8030A and 8040A **dmms.** *ITT Instrument Services, Harlow, Essex.* **486**

Enclosures and accessories for the electronics industry are described in a catalogue produced by *Daturr Ltd., Richmond, Surrey.* **487**

Quality Assurance assessment by multiple purchasing agencies is the subject of a review published by the *Institute of Quality Assurance, London.* **488**

The latest issue of Farnell News includes information about new **power supplies oscillators** and **computer peripherals.** *Farnell Instruments, Wetherby, West Yorks.* **489**

The papers presented at the sixth **International Broadcasting Convention** held in London in September, have been published by the *Institute of Electrical Engineers, Stevenage, Herts.* **490**

Erie Electronics has produced a catalogue providing technical information on its range of **ceramic capacitors.** *Erie Electronics, Great Yarmouth, Norfolk.* **491**

The basic requirements of **shielded facilities** are described in a leaflet produced by *REL Equipment and Components, Hitchin, Herts.* **492**

A brochure summarising the company's range of **coaxial connectors** has been produced by *Plessey Connectors, Northampton.* **493**

The latest edition of the **Landis and Gyr Review** is now available. *Landis and Gyr, London.* **494**

Specification details of seventy-nine **fire resistant fluids** are included in a publication prepared by the *Association of Hydraulic Equipment Manufacturers London.* **495**

The **Science Research Council's** report for the year 1975/1976 is available for £1.75 from *HMSO.* **496**

Tri-Data Corporation has published a leaflet describing the CartriFile 10 **magnetic tape subsystem.** *Tri-Data Corporation, USA.* **497**

NRDC has published its **report** for the year 1975-1976. *National Research Development Corporation, London.* **498**

"Incandescent readouts in Avionics", a paper presented in October at the European Electro-Optics Conference, is now available from *Chicago Miniature Lamp, Bury St Edmunds, Suffolk.* **499**

"Multivariable control theory" by JM Layton presents the theory of deterministic multivariable control systems. Part of the IEE Control Engineering series, the book is available at £11 from *Peter Peregrinus, Stevenage, Herts.* **500**

Video instrumentation manufactured by Colorado Video, Inc. is described in a short form catalogue produced by *KGM Vidiaids, Isleworth, Middx.* **501**

Bin units, conveyors and other production and storage aids are described in a catalogue available from *Kaiser and Kraft, Watford, Herts.* **332**

A list of **unclassified documents** by the staff of the Materials Development Division, AERE Harwell, has been published by *HMSO.* **503**

A 12-page applications guide to the HDSP-2000 four-character **display** includes drive and interface circuits, mounting techniques and contrast enhancement. *Hewlett-Packard, Winnersh, Berks.* **504**

The latest **stock information** on the range of components and instruments handled by REL is now available. *REL, Hitchin, Herts.* **505**

Electro-Optic deflection of laser beams is among the topics included in the latest issue of the Philips Technical Review. *Philips Research, Eindhoven, The Netherlands.* **506**

A brochure describing the Acculin range of machine-tool **digital read-out systems** has been prepared by *Ferranti Dalkeith, Midlothian.* **507**

A four-page application note describes how **optical isolators** can be used in a variety of linear applications. *Hewlett-Packard, Winnersh, Berks.* **508**

Another Hewlett-Parckard application note gives details of the **design** procedure for waveguide and coaxial amplifiers using **IMPATT diodes.** *Hewlett-Packard, Winnersh, Berks.* **509**

A leaflet describing the Lyssy **multi-channel water vapour permeation test system** is available from *Richard R. Leader, Chertsey, Surrey.* **510**

A 16-page brochure describing the RCA range of **memory products** gives basic parameters of six cmos memories, static and dynamic mos rams and three static 1k sos rams, *RCA Solid State-Europe, Sunbury-on-Thames, Middx.* **511**

A range of **switched-mode power supplies** is the subject of a leaflet produced by *REL, Hitchin, Herts.* **512**

The latest edition of **"The World of Learning"** contains more than 2000 pages and lists educational and scientific personnel and institutions throughout the world. *Europa Publications, London,* **513**

A brochure describing the range of **design and production services** offered by the company is available from *Electronic Engineering, Ipswich.* **514**

The latest Heathkit **catalogue** is available from *Heath (Gloucester), Gloucester.* **515**

Service planning end propagation is the topic matter featured in the latest IBA Technical Review. *IBA, Winchester, Hants.* **516**

A 36-page **distributor catalogue** and distributor list published by Elco Corporation lists all the interconnection products available directly from Elco distributors. *Elco Corporation, USA.* **517**

A range of conversational mode crt **terminals** manufactured by the data systems division of Research Incorporated is described in a leaflet available from *Technitron, Camberley, Surrey.* **518**

All forms of **joining and fastening processes** are the subject of the PERA Industrial Joining Digest available at an annual subscription of £25. *PERA Melton Mowbray, Leics.* **519**

Model 7575 **smoke and heat detector** is described in a leaflet produced by *Nu-Swift International, Elland, Yorks.* **520**

A **tone-to-pulse converter** for telephone equipment is described in a brochure available from *Mitel, Ontario Canada.* **521**

Techniques for the measurement of mechanical, electrical and fluid parameters are described in **"The Handbook of Instruments and Instrumentation"**, £15, available from *Trade and Technical Press, Morden Surrey.* **523**

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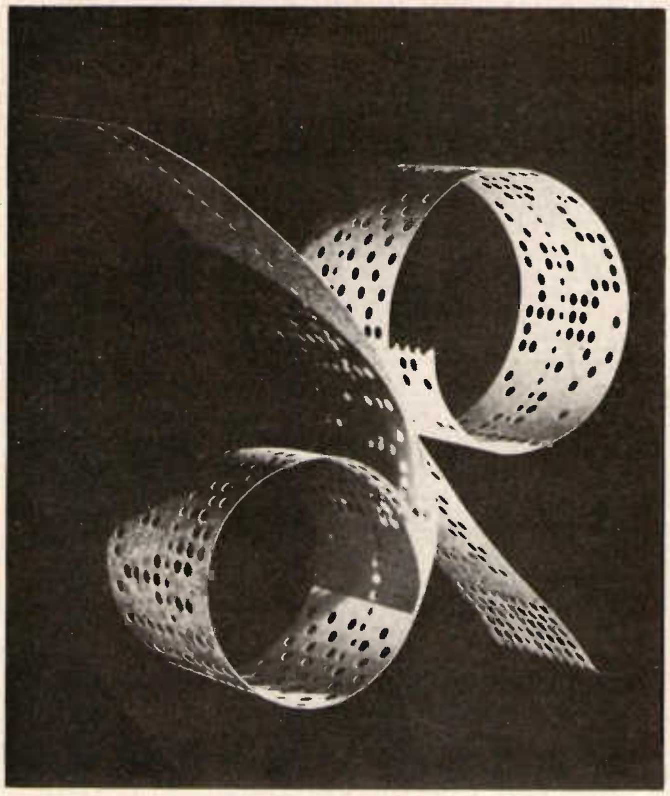

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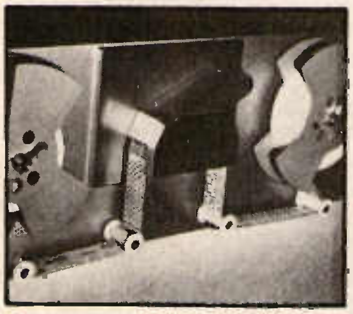

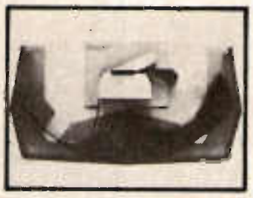

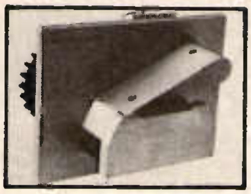

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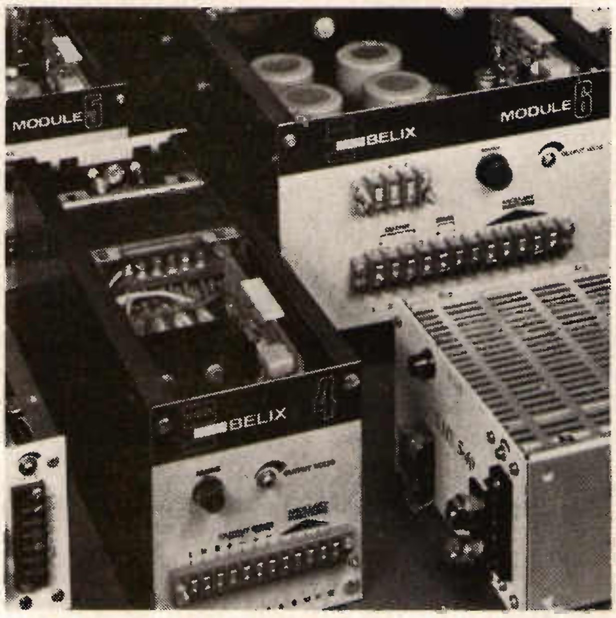

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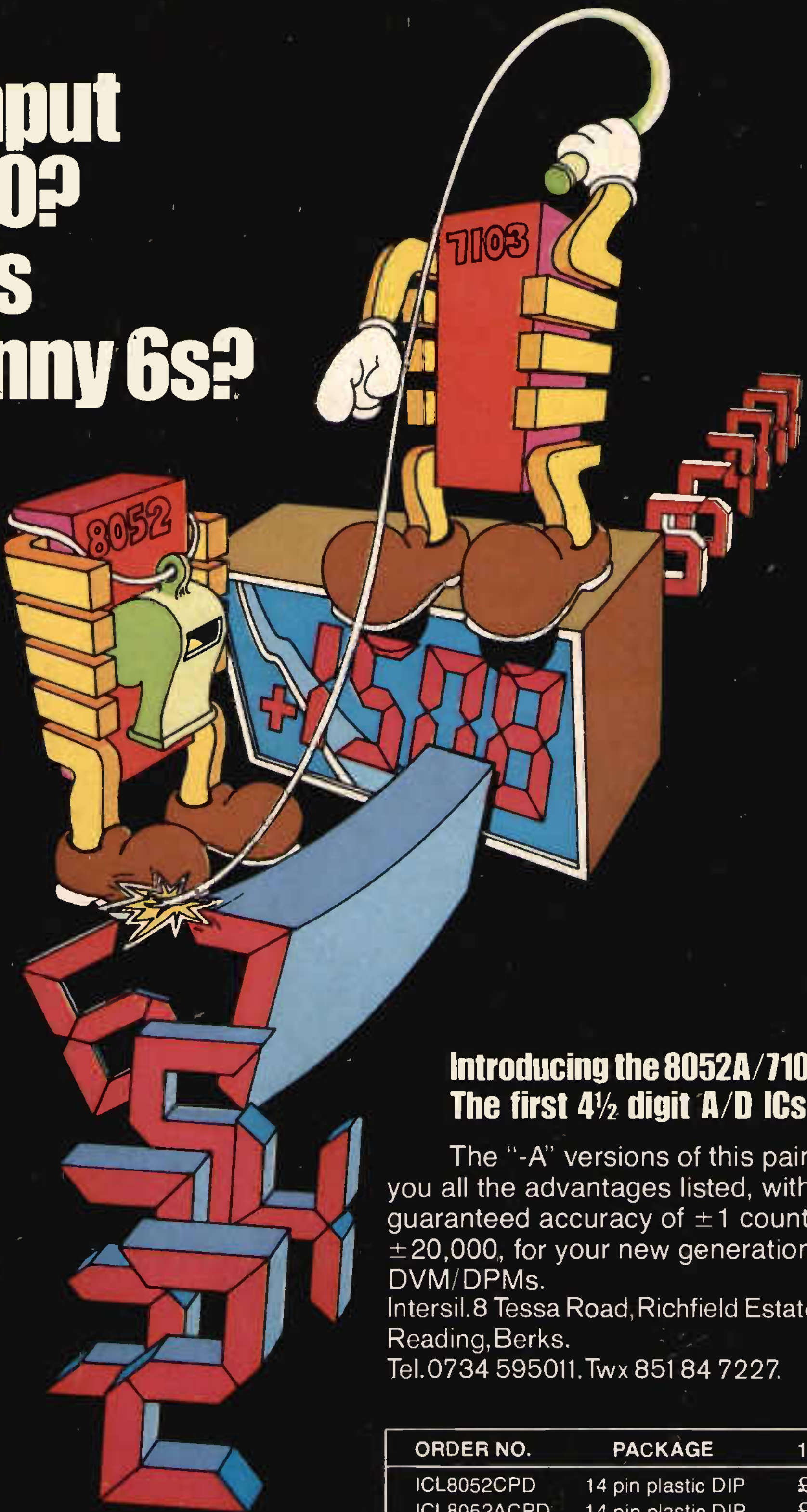

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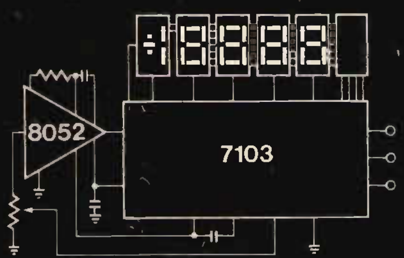

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