ELECTRONICS &

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May 1985 85p

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ELECTRONICS &
Wireless world
over 70 years in independent electronics publishing

May 1985

Volume 91 number 1591

FEATURES

REGULARS

Front cover shows John Linsley Hood's automatic enlarger timer, featured on page 45. Cover design by Phil Brooker; photography by Kenneth Crook.

NEXT MONTH

David Stonebanks shows how to improve performance of cassette recorders with the BBC micro and details an alternative method.

Design for a video camera and computer interface stores eight picture elements from each scan line at a time, reducing the time for storing a picture by a factor of eight.

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It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. **£59 + £2 p&p.**
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Cable set £30.

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I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Recep-'acle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	—
St Hood	90	95	100	120
Screw Lock	130	150	175	—

TEXTOOL ZIF

SOCKETS
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EDGE CONNECTORS

	0.1"	0.156
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12-way (vic 20)	—	350p
2 × 18-way	—	140p
2 × 23-way (ZX81)	175p	220p
2 × 25-way	225p	220p
2 × 28-way (Spectrum)	200p	—
2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22 way	190p	—
2 × 43-way	395p	—
1 × 77 way	400p	500p
2 × 50-way(S100conn)	600p	—

EURO CONNECTORS

DIN 41612

2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B	425p	
IDC Skt A + C	425p	

For 2 × 32 way please specify spacing (A + B, A + C).

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36 way plug Centronics (solder **500p** (IDC) **475p**
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PCB Mtg Skt Ang Pin
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8-way	120p	10-way	150p

TELEPHONE CONNECTORS

4-way plug	110p
6-way plug	180p
6-way rt ang skt	160p
Flexible cable	
4-way	50p/m
6-way	72p/m

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	—
20 pin	75p	—
24 pin	100p	150p
28 pin	200p	—
40 pin	200p	225p

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8 pin Video Connector	200p

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Alice through the cash nexus

Money is extremely useful as a measure of market value in the exchange of goods and services but becomes tyrannical when used to exert power over people. The present UK government has raised the power of money to a new height, both in their technical use of monetarist economics and in the way they seem to attribute an almost mystical essence to that rationale of human greed known as market forces.

Two recent proposals illustrate the fact that almost anything can be sold. In the past men have traded their wives, their children and their honour. Now, in the field of radio communication we are facing the prospect of two new commodities being brought out of the grocer's store-cupboard to be added to the list of things available over the counter. One is a natural resource, the electromagnetic spectrum; the other a mass-medium, public service broadcasting.

Recent debates on financing the BBC have made it quite clear that a good many politicians are willing to abandon the central principle of public service broadcasting. They are saying it would make good sense for the BBC to obtain at least some of its income be taking advertising.

Most of the discussion around this possibility seems only to have considered matters of expediency. It has largely ignored a central point about public service broadcasting. If we agree that sound and television broadcasting in the UK has reached a level of proficiency in all departments (news, entertainment, arts, education etc.) that makes it a really valuable contributor to our culture, then we should do it the honour of being ready to pay for a substantial part of it directly — like books, music, theatre, films — either through licence fees or equivalent methods.

Commercial broadcasting, though capable of producing excellent programmes, is vitiated by its dual function. It cannot escape the fact that advertisers are only interested in it as a medium for selling. And unquestionably this pressure distorts its general character. Ask Michael Grade, for example, the new Controller of BBC 1, who used to work in commercial television.

As for the electromagnetic spectrum, the Government has commissioned a firm of management consultants to do a feasibility study of pricing the spectrum. They have made no policy decision yet, but want a technical and economic analysis of what would be the effects of pricing if used as a means of assigning frequencies when demand exceeds supply.

The mere fact that the Government is even considering such a measure must be thoroughly condemned, on two counts. Both are matters of principle. First, the e-m spectrum is a free natural resource, not a property owned by anybody, even the state, and is therefore not available for sale. To commandeer this resource would be an offensive and dictatorial action, not worthy of a government which is always prating about freedom.

Secondly, the expedient of leaving the distribution of spectrum space to the mechanism of market forces is a cop-out. It avoids the responsibility of having to make difficult political decisions on the relative social worth of different claims for frequencies. One cannot respect a government which even entertains the notion that technical expediency could be a substitute for political responsibility.

British lan agreement

A number of British computer manufacturers have agreed on a standard for local area networks and many others seem likely to follow suit. This follows a feasibility study commissioned by the British Microcomputer Manufacturing Group in conjunction with the DTI and in consultation with the BSI.

Concerned about the existence of a great number of micro network designs in the market, the BMMG were afraid that the lack of common standards and the resulting confusion of incompatible systems would discourage potential users and undermine their own credibility. Another danger was the possibility of one major manufacturer (IBM) producing a design which would dominate the market to the disadvantage of both users and other manufacturers. A year ago they set out a programme to identify, design, specify and encourage the adoption of a local area network standard that would be accepted by UK manufacturers and users, and promoted as a British and International Standard.

The report was undertaken by Dr Chris Shelton, a member of BMMG, acting as consultant and involved interviewing all the manufacturing members of BMMG as well as a number of users to identify their needs. He needed to define a 'local area network' and define its functional parameters and their compatibility with the Open System Interconnection (OSI) protocol standard of the ISO.

The report, which took ten months in preparation, has now been published. The recommendations are presented in an ordered sequence for implementation. The main point is the adoption of a low-cost scheme that would lead to the final goal of a full OSI environment. The implementation of each phase "creates the opportunity to advance to the next."

Phase one is concerned with the hardware and is the easiest part of the scheme to implement. Existing l.a.ns were varied chiefly because there was no standard when their development started and off the shelf systems were too expensive. One system Arcnet was preferred by many because of its high degree of integration; just two i.cs and a hybrid that includes medium access control (m.a.c.) firmware. However the report rejects all existing l.a.ns because of the high licence fees associated with proprietary designs; the components may not be multi-sourced; may not be readily applied to different microprocessor bus systems; the proprietary interest may preclude the adoption of a system as a standard and the originator may not be prepared to publish sufficient detail to enable the l.a.n. to be specified as a standard.

The hardware recommendations derived from a study of existing systems and the needs of users are: compatible speed options of 250, 500, 1000, and 2000Kb/s; operation over a distance of 1km. To be connected through low-cost 75Ω coaxial cable. Connectors should be BNC (or DIN for the slowest speed); interconnection should be bus based though this could be arranged in a star; no repeaters or active elements in the cable which is to be isolated through transformers. RS422 signal level. The signal can be modulated using m.f.m. or Manchester to take advantage of new l.s.i. devices such as the AMD 7960. Various options are presented for the implementation of the interface hardware.

The cheapest, at £10-worth of semiconductors consists of an h.d.l.c. device within the clock, modem and driver receiver circuits. This puts the l.a.n. with the budget of the low-cost microcomputers but the software responses of such devices may limit the line speed to 250Kb/s. For a silicon price of about £25, it would be possible to offload the l.a.n. support onto a co-processor and the l.a.n. could operate at up to 1Mb/s. For £10 more, a direct memory access chip could be added and the performance could be extended to 2Mb/s. At the conclusion of phase 1 manufacturers would have plug-compatible hardware. The report recommends the adoption of these hardware standards or find an existing system, such as V-Net or Strathnet, neither of which are adequately documented, which are potentially available for unrestricted use.

Phase two is the adoption of an interim software standard so that a useful product can be achieved as soon as possible. The report suggests that the Digital Research DR-Net which will communicate with concurrent DOS is suitable because of its wide use, this incorporates a m.a.c. layer, though for the low-cost micros the m.a.c. layer could be implemented through their own schemes. It is hoped that at the conclusion of this phase different manufacturers' equipment will operate together as a multi-user computer.

Phase three recommends that DR-Net be replaced by OSI protocol to enable different operating systems to be used. Dr Shelton admits that the remaining three phases are more tentative and should be taken as suggestions. They are: 4 — To extend the system to a number of other operating systems to ensure its widest use, while also providing the widest scope for software developments to adhere to the standards. 5 — To organize, within this compatible environment, a gateway for connecting this standard of l.a.n. to other standards that may exist, and a gateway to the package switched network. 6 — To cover the longer term of ensuring that application software is developed which can work under this l.a.n. standard.

The BMMG has accepted the report wholeheartedly and at least ten manufacturers have agreed to implement its recommendations. It is thought that with such a kernel many other manufacturers will join the bandwaggon to make it a de facto British standard and ultimately a world standard.

A telephone designed for use in the third world. It is solar powered and communicates by radio, with battery back-up. The equipment can also act as a relay to act as a local link so that remote villages can communicate with each other. Designed by Plessey Radio Systems.

Cable news

Geoffrey Pattie, the IT Minister was full of praise for Swindon Cable at a recent visit. Swindon Cable is the first cable operator to offer new services on a wideband system and they have just scored another first with the introduction of a French tv channel, TVS, to their choice of programmes.

"There have of course been setbacks but this system has demonstrated that they can be overcome. I believe that the cable industry can make a very positive contribution to the prosperity of the country. Cable means investment in new technology and new jobs. It will give this country an advanced broadband infrastructure offering not only entertainment bus also new interactive services for bisinesses and domestic customers.

"We have always taken the view that cable is an industry which should be privately financed but that the Government still has an active role to play in the future of the industry. We have created the right legal framework and the Cable Authority has announced the first five areas for which it is seeking new applications."

Swindon Cable is a wholly owned subsidiary of Thorn EMI and was one of the eleven initial pilot projects. The five new areas under consideration are Bolton, Cheltenham and Gloucester, West Surrey, and Wandsworth and Tower Hamlets, both in London.

● BT has announced that it has clinched a deal that will allow the direct reception of the American cable tv channel, Cable News Network. The channel will be available to British broadcasting companies from September. Cable news network will be beamed from the headquarters of Turner Broadcasting Systems, in Atlanta to an Intelsat V satellite which is also used to disttribute cable tv channels to networks within the UK. British Telecom International also hope to be able to distribute the network to other European countries.

Electronic co-pilot for cars

An electronic system is being developed to provide cars with automatic route planning it knows the position of the car and can specify it at any moment, and can also provide a number of details about the environment or the destination of the journey. The Carin (car information and navigation) project is the brainchild of the Geldrop Project Centre of Philips Research Laboratories. It is planned that the system is coupled to dashboard functions and a speech synthesiser to inform the driver of any problems, such as low petrol or oil, battery faults or high engine temperature. The system could also be linked to traffic warnings received over the car radio and thus avoid areas of heavy congestion, or road works.

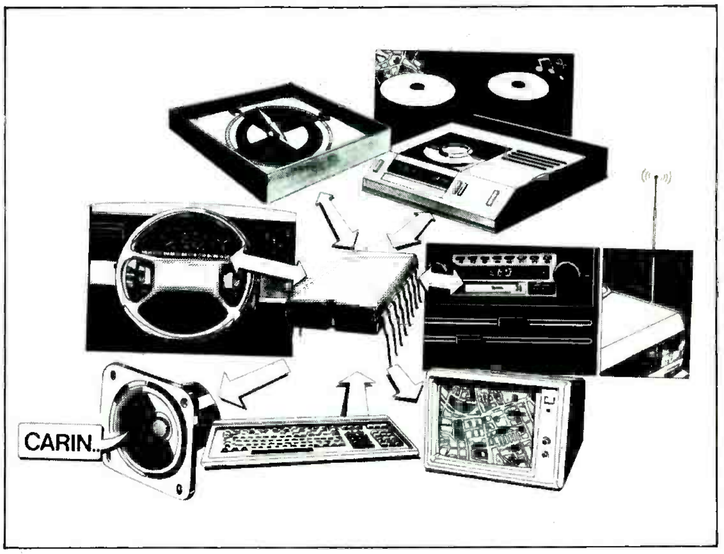
At the heart of the computerized system is a modified compact disc player which could not only play compact discs but also read road information stored on discs, for example a complete road map of the country, street maps of a town etc. A compact disc is a read-only memory with a capacity of about 5Gbit. The CD system was modified to extend its error correction so that the chance of an error on an undamaged disc was better then 1 in 10^{18}. If the capacity is increased to the equivalent of a playing time of 66 minutes, then the capacity of the disc excluding any redundant information required by the error correcting algorithm, is 600Mbytes. As an example of the capacity a 1:15000 coloured map of the area around Eindhoven and Geldorp in Holland (where the research is being carried out) would require a memory of about 375Mbits, or 8% of the capacity of the disc. However by a system of identifying and coding intersections in a road by node points and angles, adding the road name information, a road map of the same area would only require 1.5Mbits, or 0.03%

of the disc capacity.

The system also needs to know where the car is. The first solution is the inclusion of an electronic compass linked to the odometer that will use the car's computer to correct any errors caused by magnetic disturbance such as other vehicles and the massive ironwork in reinforced concrete. Error correction can be carried out by constant reference to the map held in memory. A longer-term solution is the possibility of satellite navigation using the Navstar global positioning system. The 18 American satellites will provide signals that enable a ground receiver to locate itself to within 10m, Including height, and provide the time, accurate to that of an atomic clock.

The system requires a video screen, but from the safety point of view it is deemed to be important that the screen can only be consulted when the car is standing still. A typical journey could have the driver insert the disc for the local area, indicate the cars present position and the destination. The computer will store the information and the disc player can then be used for playing music. The system will guide the driver through the speech module. In future the necessary keyboard may be replaced by a touch screen.

Philips emphasize that the system is not a dream of the future but that all the technology already exists and a practical system will be available quite soon.



The elements, CD player, dashboard data, electronic compass and computer, that go together to make the Carin route information system, under development by Philips.

Fears about tape levy

BREMA, the Radio and Electronic Manufacturers Association, has deplored the Government's support for some sort of levy on blank video and audio tapes as expressed in the Green Paper (Cmnd 9445). The Green Paper accepts that the proposals will involve some element of rough justice but it is unable to think of any realistic alternative.

The Association is particularly worried because the levy implies that at some future date it could be extended to recording equipment and to any future recording medium that may be developed. Any such levy would be disccriminatory as it could not apply to the millions of pieces of recording equipment already in use. The Association is further apprehensive that once the idea of a levy is accepted, then future Governments could increase the levy over the years, just like any other tax. The one redeeming feature they see in the paper is that it admits that the levy could not be used to compensate for lost revenue by copyright holders.

Finally the Association voiced its fears that once having paid a levy, users could feel licensed to copy freely and that this could lead to more piracy, rather than less.

In brief

• The UK f.m. Group (western) of the RSGB has put its thirteenth amateur radio repeater station on the air. In contrast to the other repeaters, this one is a data and r.t.t.y. unit. It operates on the 432MHz band on Channel RB12 from Winter Hill, near Bolton, Lancs. Slant aerial polarization is used. Operation is on 50baud Murray code but ASCII operation at 1200baud is to be implemented. With RSGB approval, the Group hope to attach a 'mailbox' service to allow radio amateurs to leave messages for each other; similar to the telephone bulletin boards.

• BT is to make and sell a 16-bit microcomputer. An agreement has been signed with Bleasdale Computers to produce the Bleasedale 68000 Unix computer. The computers are to be assembled at BT's own plant in Birmingham. Intended chiefly for BT's own use, the computer is also to be marketed outside the company. Unix is an 'open' operating system developed at Bell Labs, and offers multi-user, multi-tasking facilities.

• STC Components are now making development quantities of a range of GaAs i.cs. Employing one-micron geometry gates, and using ion implantation techniques, the range will include standard products as well as custom and semi-custom designs. Full production of Gbit/s logic circuits is to start later in the year. Typical of the range is variable modules prescaler and a 4bit synchronous counter, both of which can operate at 900MHz.

• BBC External Services is to install a massive computer which will act as a news source of reports picked up by the monitoring service at Caversham. It needs to have a storage capacity of about 28bn characters to hold the teleprinter material emanating from international new agencies and monitoring units abroad. It will have 174 v.d.u. input stations and be connected to 100 printers. Monitors will be able to key their transcripts straight into the computer. Journalist who prepare the External Service's news file and daily summary will be able to draw directly on this information and feed their own stories into the system. Bids for contracts to install the computer have been invited from 40 computer companies.

Anti-piracy law

The Government has expressed its support for William Powell's Private Member's Bill to extend the copyright laws to include computer programs. John Butcher, Secretary for Industry, said: "The Government is anxious that this important measure should become law as soon as possible to help the UK software industry combat the growing threat of software piracy." It is hoped that penalties imposed by the act will deter software pirates as successfully as the reduction of the level of video piracy since similar Bills were passed in 1982 and 83.

Transputer on the way

Inmos are now producing their super microprocessor, the Transputer in test quantities and hope to have evaluation samples available for customers by the middle of the year. Volume production of the fast 64K static ram and of the 256K dynamic ram is also expected during the year. Static rams manufactured in Colorado Springs, California and dynamic rams from Newport, Gwent are now being produced in millions and the company, after many years of Government investment is now making a profit. It was sold to Thorn-EMI last September.

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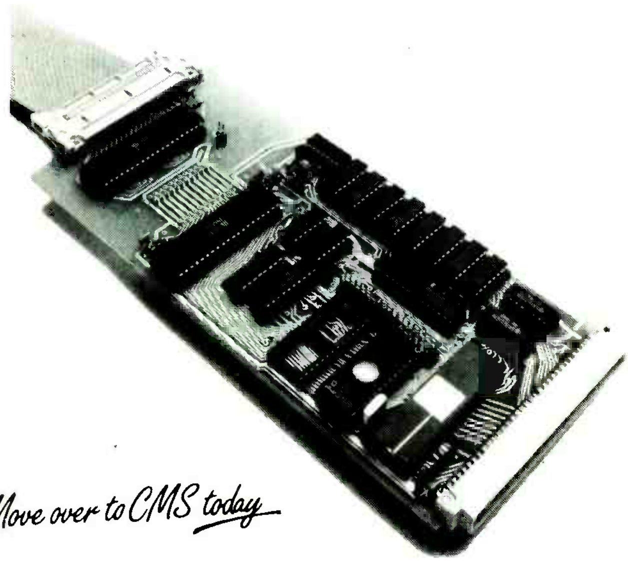

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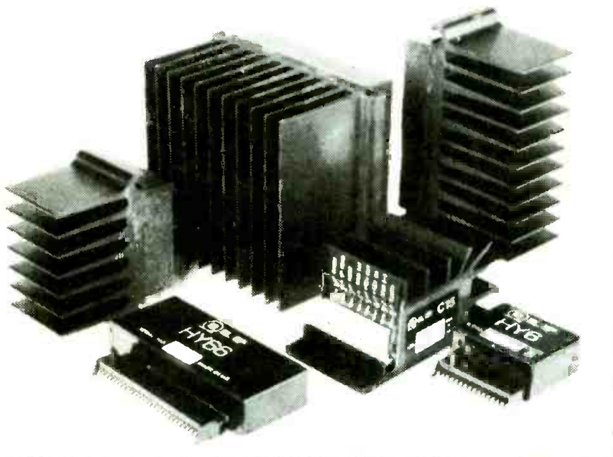

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HY6060	30 + 30	4-8	£19.45
HY124	60	4	£20.95
HY128	60	8	£20.95
HY244	120	4	£26.95
HY248	120	8	£26.95
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Ideal for Disco's, public address and applications with complex loads (line transformers etc.). Integral Heatsink slew rate 20v/µs distortion less than 0.01%

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MOS248	120	4-8	£39.95
MOS364	180	4	£45.95

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All modules are supplied with in line connectors but require potentiometers, switches etc. If used with our power amps they are powered from the appropriate Power Supply.

Type	Application	Functions	Price
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PSU522	2 HY124	£17.45
PSU532	2 MOS128	£17.95
PSU542	1 HY248	£17.95
PSU552	1 MOS248	£19.95
PSU712	2 HY244	£21.95
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Woofer	12	8	80	HI-FI	£25
Auditorium	15	8-16	60	Bass	£37
Disco/Group	12	4-8-16	45	PA	£16
Disco/Group	12	4-8-16	75	PA	£20
Disco/Group	12	8-16	100	PA	£26
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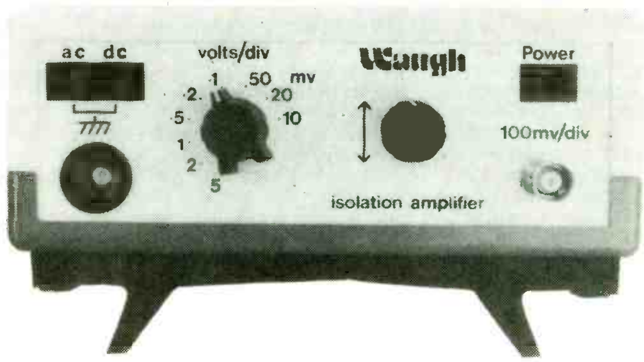

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CIRCLE 58 FOR FURTHER DETAILS.

SSB LINEARITY

At least one idea that could reduce some of the spurious emissions that tend to be increased by broadband systems is the work that has been going on for several years at Bath University on the application of cartesian (polar) feedback. V. Petrovic described a 100-watt p.e.p. transmitter with cartesian-loop phasing-type s.s.b. generation having third-order intermodulation products some 67dB below the tones of a two-tone test, with image sidebands suppressed by 68dB.

A coordinated presentation of five papers from the US Naval Research Laboratory described a new wide-band h.f. system with frequency-hopping capability being developed for the US Navy and resulting in studies similar to those that led some 15 years ago to the development of the ICS-3 system for the Royal Navy. The Americans, however, plan to use v.mos field effect devices for power amplification, with negative feedback and feedforward linearizing techniques. In all complex shipborne installations the major problem is the proximity of several transmmitters and receivers. NRL are developing fast-tuned narrow-band filters for both antenna couplers and for preselection filters for receiver protection, together with the use of adaptive interference cancellation by phasing techniques. They are also developing new broadband h.f. antennas for ship installations.

It was interesting to note that some professional systems designers are at last recognizing that conventional receiver a.g.c. systems designed for analogue s.s.b. voice signals tend to degrade performance on morse and narrow-band data transmission, due to the finite attack time which means that the instantaneous dynamic range of a receiver is significantly less than the claimed 140dB or so available when the a.g.c. range is added. There is also the problem that the a.g.c. bandwidth may be considerably greater than that of a narrowband transmission, particularly where a receiver depends on audio filtering for r.t.t.y. or data reception. The problem arose when "hang a.g.c." systems were introduced and the ability to switch out the a.g.c. circuits dropped from most h.f. communication receivers.

HF RESURGENT?

A three-day international conference at Savoy Place "HF communications systems and techniques" underlined the resurgence of interest in the application of advanced technology to h.f. Less happily it emphasised that this interest, although spilling over into university and commercial research projects, is primarily centred on Defence communications. For these the trend is firmly towards fast frequency hopping at rates between several hundred and several thousand per second yet capable of providing secure digital speech and data at rates of about 2400bits/second. For other users such technology, unfortunately, offers the prospect of ever increasing spectrum pollution.

The current sunspot-minimum is already leading, particularly after dark in Europe, to excessive overcrowding of h.f. with some users employing spectrum analysers to seek out the few relatively clear channels and then to occupy these whether or not registered with the International Frequency Registration Board. At the conference a number of papers were presented on built-in systems of real-time channel-evaluation which could formalise this type of operation.

Of the 235 delegates from almost 20 countries the vast majority were connected with, funded by or manufacturing for Defence with few from traditional h.f. user organizations such as British Telecom and Cable & Wireless. In the often lively discussion periods it was left to J. Clarke of British Airways and radio amateurs to question the effect of the spread-spectrum techniques on frequencies still required for civilian communications.

Frequency-hopping on h.f. poses state-of-the-art challenges to designers if the problems of multipath, fast switched antenna couplers and digital synthesizers are to be oversome.

ENERGY-SAVING ON U.H.F. TV

For the past decade the major klystron and transmitter manufacturers have been striving to out-do each other in reducing the appalling waste of power in high-power u.h.f. television transmitters. Pulsers, variable couplers, depressed collectors, annular gridded cathode techniques have all been developed with the aim of improving the conversion efficiency of kylstron amplifiers that conventionally require constant power, set by the peak sync pulses. Even when referenced to peak sync, conversion efficiency has often been only of the order of 20-25 per cent. When defined in relation to the vision waveform, efficiency drops to just a few per cent. About half a megawatt of electricity is consumed for the 110kW transmitters commonly used in the USA and some broadcasters have complained that electric power costs them more than off-peak programming.

A promising development is the Varian "klystrode" that combines the efficiency of a tetrode with gain and long-life of a klystron and will be capable of true Class B operation — but there will first need to be a new generation of transmitters for this device.

Meanwhile klystron manufacturers are continuing their development of techniques that enable u.h.f. klystrons to match the efficiency of v.h.f. tetrodes. Marconi, with their new American associates Comark, are claiming to have achieved at WITE-TV, Channel 28, Columbus, Ohio a klystron beam efficiency of no less than 77 per cent, with an Amperex (Philips/Valvo) YK1265 klystron vision amplifier, a Comark high energy CTM-20 pulser and the new Marconi B7500 modulator unit.

DIGITAL TRANSCEIVERS

The opening address at the h.f. conference was given by Dr Ulrich Rohde who for many years was the representative of Rohde & Schwarz in the USA but is now a consultant to RCA Government Communications Division and part of a design team seeking advanced technological solutions for US military communication. He emphasised that "in order to meet communication goals for 1984 and beyond, modern h.f. equipment has to be adaptive, frequency agile and capable of supporting secure, digital voice communication, operating on a point-to-point, and a networked basis as well". His keynote paper explored solutions aimed at an all-digital h.f. transceiver for which there is currently an American defence requirement. For voice encryption, the Americans have chosen linear predictive coding, a technique not unlike that used in children's "speaking toys" and capable of compressing 3kHz analogue speech into an encrypted 2.4Kb/s data stream. He also surveyed work on direct digital synthesizers, PIN-diode switched antenna couplers and digital processing in receivers using linear equalization techniques with a time-gated feedback equalizer to minimise multipath problems.

D.T. Anderson of Rockwell-Collins described the new hybrid analogue/digital receiver type HF2050 (see *Communications Commentary*, October 1984) now being delivered — as the first production h.f. receiver to use digital signal processing — to Canada. In this the signal is digitized at the 2nd i.f. of 3MHz.

But as B.M. Sosin of Marconi pointed out, digitization at signal frequency, as required for an all-digital receiver, throughout the entire range of 2 to 30MHz and for a signal dynamic range of 140dB would require something like 23-bit "words" at a sampling rate of over 60MHz, resulting in bit rates still well beyond device capability.

TWTs FOR DBS

The still unproven reliability of 220-watt travelling wave tubes and amplifiers for high-power direct broadcasting from satellite is one of the factors that are contributing to the uncertainty that still surrounds the early implementation of operational services. The French are still hoping to have a four-channel satellite in operation next year, possibly with two channels leased to the

commercial broadcasting services of Luxembourg. Telefunken also have a high-power Ku-band (12GHz) TWT in an advanced stage of development but not yet tested in orbit. A TWT amplifier capable of 240W of c.w. output with an efficiency of over 40 per cent is being developed by Hughes Aircraft with a target life of seven years and with focussing by temperature-compensated samarium-cobalt magnets. Meanwhile RCA Laboratories are developing solid-state Ku-band active arrays using large numbers of GaAs f.e.t. devices with individual phase shifters which could be used to change the radiation pattern of a d.b.s. satellite in orbit.

But several of the d.b.s. systems registered with the FCC are finding it increasingly difficult tto attract investors and few expect earlier implementation of high-power satellites. One American consultant has suggested: "The would-be d.b.s. operators should be blaming themselves, not Wall Street, for their difficulties. Most have been technology-orientated. The easiest part of the d.b.s. puzzle is to put a satellite up there and to put a signal across the USA. The toughest part is to market the service nationally, and to maintain your customers over a period of time."

WIDE C-MAC

In the UK, IBA engineers have been privately demonstrating on closed-circuit an experimental system capable of providing high-definition, wide-screen pictures (up to 5:3 aspect ratio and a subjective definition of almost 1000 lines) when the receiver contains digital processing memory. The system is fully compatible with the standard C-MAC/packet system but with extra time allocated for wide screen pictures from the sound/data and frame flyback periods. The system also allows the 4:3 aspect ratio picture to be panned anywhere within the wider 5:3 picture. The still-experimental equipment is currently being re-jigged into a prototype demonstration unit when it is hoped that public demonstrations will be given. No problems are expected in putting enhanced C-MAC through a single 27MHz satellite channel.

Amateur Radio

EARS OR MODEMS?

With the spread of personal computers, a rapidly increasing number of amateurs are using various forms of electronic r.t.t.y., data transmission, including "packet radio", automatic request for repetition (ARQ) in the Amtor system, and high speed automatic morse etc.

In implementing any systems involving automatic reception, the greater vulnerability of such systems, compared with the human operator, to interference, multipath and fading becomes a major problem. The mechanical teleprinter, developed for line communication, was never intended to cope with adverse channel conditions and led to the use of space, frequency and polarization diversity systems. In the absence of diversity, it has long been recognized that two-tone and multitone systems are capable of better performance than f.s.k. but advantage has seldom been taken of this by amateurs on h.f. Parallel multi-tone systems such as Piccolo, with inherent signal integration, can produce clean copy at very low signal strengths but demand more complex modems, a very high degree of frequency stability and greater bandwidth than either manual morse or narrow-shift f.s.k. For all these reasons, manual morse has remained the optimum system under adverse conditions not only for amateurs but also in the maritime services.

At the recent h.f. conference, Peter Chapman of the Admiralty Research Establishment (formerly ASWE) described laboratory and field trials of a low-speed modem with inherent frequency and time diversity designed to provide reliable communication under the most adverse conditions. The objective is a fall-back system capable of performing better than morse and eventually to eliminate the cost of morse-operator training in the Royal Navy.

Throughput of traffic is at the slow rate of 10 bits/second (10 baud) although the signalling rate is around 100 bits/second. The modem transmits ten discrete audio tones in a 3kHz s.s.b. channel, one set of five representing "mark" and the second interleaved set for "space". The tones in each set are sequentially transmitted for 10 milliseconds each, with 10 millisecond gaps so that each symbol is transmitted five times during a 100 millisecond period. It thus differs radically from the parallel multitones of Piccolo.

Propagation trials last September between ARE Portsdown and Wick in the north of Scotland used 25-watts p.e.p. and ran throughout 24-hour periods on two frequencies about 4.88MHz. The frequencies were repeated interchanged between morse and the new modem.

While the results undoubtedly suggest that the modem can outperform morse, at least some of the delegates, who included a significant numer of licensed amateurs, felt the scales had been heavily weighted against morse. For example, it was recorded on tape, then brought to the laboratory for transcription by the operators, giving them no chance of adjusting selectivity, notch filter, audio beat tone etc., all of which could have significantly improved the copy, and allowed them to take full advantage of the remarkable characteristics of the human ear.

A truly narrowband c.w. receiver, preferably without a.g.c. and bandwidth adjustable down to under 100Hz and controllable front-end gain etc., with an operator at the controls and preferably the ability to change transmission frequency even by a modest amount would have produced very different results.

The low-cost, low-complexity and reliability of a "kiss" morse system under adverse and emergency conditions should encourage the Royal Navy and other organizations to think very carefully before finally phasing out morse telegraphists in favour of keyboard-only operators.

But perhaps it is a sign of the times to prefer the inanimate to the animate. Electronic "petsters" — stuffed, furry creatures with built-in microcomputers — are being marketed in the USA "to replace biological animals as pets and companions" by Axlon Inc. Simulated moods — from contentment to anguish, from a lazy response to bouncing enthusiasm, are software controlled by a 4-bit microprocessor with 4K bytes of memory. How soon before they begin to automate the owners?

FROM ALL QUARTERS

The number of new amateur radio licences issued in 1984 in the USA dropped by over 10 per cent compared with 1983. 30 per cent fewer amateurs up-graded their licences and about a quarter of licencees are currently not renewing, according to *Ham Radio*. For the first time in 10 years the year finished with a net loss in licence totals.

British Telecom "Ambassador" telephones and some of the other electronic models are proving a source of interference on the 144MHz band, showing a tendency to radiate wideband hash-like signals. Among the increasing number of domestic appliances showing susceptibility to strong local r.f. signals are domestic burglar alarms and smoke detectors.

The UK F.M. Group (Western) recently brought into operation its thirteenth repeater, GB3MT, at the IBA Winter Hill site (mounted on a Granada Television OB link platform) near Bolton, Lancashire. This 432MHz band, slant-polarized (45°), RB12 repeater is for r.t.t.y. and data and the first of its type in the North West. Initially only 50-baud five-unit Murray code is suitable but it is hoped to add ASCII operation at 1200-baud shortly, and approval is being sought to add an "electronic mailbox" for store and collection operation. Membership details of UKFMG(W) from Mr A. Baker, G4NYP, 26 Brooklands Drive, Goostrey, Crewe, Cheshire.

Pat Hawker, G3VA.

LIQUID CRYSTALS

I would like to draw your readers' attention to a discovery made in 1964 that liquid crystals mentioned in a number of your articles are not related to the liquid phase at all. These useful materials are anisotropic organic molecules which form a special phase of crystallites just below the freezing point of the liquid phase. Their correct description should be fluid crystals or fluid crystallites. The term liquid is entirely misleading; the term crystal or crystallite is correct and it shows that the properties of these materials are closely associated with the more familiar crystallites of the solid phase, especially when close to the melting point. It is well known that many solids are very plastic near the melting point and the fluid crystallites used in electronic displays exhibit these properties of fluidity and crystallinity which are not found in the liquid phase. This misleading term of liquid crystals should be replaced by the correct term FLUID CRYSTALS.

W.P. Holland
British Nuclear Fuels Ltd
Sellafield
Cumbria

LOGIC SYMBOLS

I awaited with interest your informative article dealing with new logic symbols. It eventually confirmed my worst misgivings.

For years the government has tried to foist B.S. (British Silly) symbols upon the industry with a delightful lack of success except upon those unfortunate enough to be working on government cotracts, where it was made a condition of contract. One is tempted to be alarmed however, when normally rational people such as the Americans endorse such symbols as the ones reported in the article. The author states that international agreement has been reached, consultations have been held, etc. Whoever asks the opinion of the average engineer? There is far too much government time and money spent on these committees who are clearly out of touch with real life, and seek to impose new methods regardless of consequence.

There is a growing madness to symbolize everything today, even when a plain English indentifier is much clearer, and frequently takes less space. An excellent example being any modern car. Try looking for a switch marked "heater", and I guarantee failure. You may however find drawings of palm trees, wavy lines, a perspiring brow, or whatever silly idea came into the designer's head at the time!

Your author states that there is no point in "sticking one's head in the sand". I quite agree. We must resist this nonsense NOW!

L. Hayward
Wareham
Dorset

MOBILE RADIO

I pity the communications of your nationalized power industries who will be forced to work on Band 3 (your issue Dec. 1984)

Also noticeable in your article on mobile radio systems is the lack of mention on 'Trunking' or the use of higher frequencies for public utilities.

Poor old 'Blighty', always behind the times.

P. Hirschmaun
Haifa
Israel

CAMPAIGN FOR REAL A.M.

The article about the heated rear window car aerial (*E&WW* Feb.1985) covered the questions of sensitivity and directivity in some detail but did not mention the inevitable degradation of the strong signal performance of receivers resulting from the use of untuned r.f. amplifiers.

It would be a pity if the widespread use of demister aerials became one more nail in the coffin of l.f./m.f. broadcasting, but it seems that each new development leads to lower quality l.f./m.f. reception.

Even the unity gain voltage follower used in the demister aerial is likely to cause significant degradation when used with a good quality receiver near powerful m.f. transmitters. Regrettably however few good quality m.f./l.f. car receivers exist.

The replacement of valves by semiconductors in r.f., mixer, i.f. and especially detector stages has done much to increase distortion and generate spurious whistles.

Developments in linear i.cs have resulted in considerable improvements, particularly in a.m. detectors but another new development — varicap diode tuning on m.f./l.f. — has definitely been a retrograde step in areas where l.f./m.f. signals are strong.

I have heard one expensive frequency synthesized car radio/cassette player which uses an untuned buffer amplifier on m.f./l.f. between its aerial input and its first varicap diode tuned circuit and which produces severe distortion on m.f. BBC Radios 1, 2, and 3 within a 15km radius of the Brookmans Park transmitters. This only goes to show that microprocessor controlled wizardry with 18 preset stations (6 on l.f.!) is no substitute for good r.f. design!

On most commercially produced receivers, m.f./l.f. is something of a token gesture with excessive harmonic distortion and an audio bandwidth of 2kHz or so. This leads to the mistaken belief among many listeners that the resulting poor sound quality is an inherent limitation of m.f./l.f. broadcasting, and exaggerates the advantages of v.h.f. M.f./l.f. still has a place, particularly in vehicles and particularly in Britain where certain programmes are not available on v.h.f.

This sad state of affairs prompted me to construct an m.f./l.f. car receiver which did not suffer from the shortcomings of commercially available models in the strong signal area where I live. The design which uses a Mullard TDA1072 a.m. receiver i.c. with permeability tuning and ceramic i.f. filter gives remarkably good sound quality but suffers from one annoying spurious response which is confined to the Barnet area. When receiving BBC Radio 1 on 1089kHz from Brookmans Park, the signal from IBA Capital Radio on 1548kHz from Saffron Green near Barnet causes a 459kHz beat frequency to be generated within the i.c. With either a 455 or 465kHz i.f. this results in an annoying whistle. Beat notes are also audible on weak stations at the l.f. end of the m.f. band. Within the receiver the problem appears to be due to the lack of provision for an r.f. tuned circuit between the r.f. amplifier and mixer stages of the TDA1072, but it is a pity that frequency planning has led to two closely sited m.f. transmitters with a frequency difference of 459kHz.

To sum up, the requirements for an m.f./l.f. car receiver with good handling of strong signals appear to be as follows:

- Permeability, not varicap tuning.
- R.f. amplifier with tuned input and output and NO untuned pre-amplifier stage.
- Good dynamic range in r.f., mixer and i.f. stages coupled with wide a.g.c. range and good detector linearity.

Unfortunately no such receiver appears to exist commercially, presumably because the majority of listeners do not live close to powerful m.f. transmitters or because they believe whistles which CHANGE their pitch when tuning to be an inherent limitation of m.f./l.f. broadcasting, which they are not.

Have any other readers in South Herts found a solution?

D.M. Lauder
Barnet
Hertfordshire

THE CATT ANOMALY

I feel I must assert that I really exist. I was in no position to protest when my parents devised my ridiculous name.

Now, following Ouida Dogg, who turned up again in January, we find Weaver-Mowes joining the act in February. This latest joker purports to be supporting me strongly.

The storm-troopers for the Establishment are happy to be identified, but dissidents tend to feel they need some camouflage. It's short-sighted, because, looking through back numbers, I find that the mean-free-path of the Establishment running-dogs is frighteningly short.

Referring to the W-M letter in February, p.77, I think the most convincing approach to the "Catt anomaly" (*WW* Sept. 84, p.48) is to concentrate on the electric *charge* on the bottom wire. W-M discusses an associated anomaly; the problem of how the electric *current* can come up to scratch. I want people to be forced to face up to the more glaring problem of *charge*. I suggest that the problem of *current* be termed the "Mouse anomaly".

When referring to the problem more generally, one would call it the "Catt and Mouse anomaly". In Feb 85 you published a letter from G. Berzins which demonstrates a failure of comprehension which may be widespread, and so merits discussion. He thinks it is possible for the energy in a TEM wave guided by two conductors, to be transferred by some mechanism within the dielectric. This notion leads to a reductio ad absurdum.

Consider a parallel plate transmission line of characteristic impedance 10 ohms. A TEM step of amplitude 100 volts is travelling down between the conductors. Power is being transferred at the rate of 1,000 watts. According to Theories N or H, electric current and electric charge exist in/on the two conductors.

Now consider a similar parallel plate transmission line lying immediately beneath the lower conductor. Again, it has a characteristic impedance of 10 ohms and a TEM step of 100 volts is travelling down between the conductors. Electric current and charge exist in/on the two conductors. The current and charge in the new upper conductor is exactly equal and opposite to that in the lower conductor of the original transmission line, immediately above it. Now all theories will claim that the activity in each of the four conductors is similar. If this activity is the mechanism for energy transfer, then total energy transfer, 2,000 watts, is made up from four contributions.

Now supposing the middle two conductors are very close together, and they become closer. Still we have four contributions to the energy transfer. Now reduce the middle two conductors to wafer thin, and then remove them. (During this process, the activity in top and bottom conductors will not change). Hey, presto! Current and charge in the two middle conductors cancel to zero, and the same activity in the surviving top and bottom conductors, previously responsible for the transfer of only 1,000 watts, now transfers 2,000 watts!

Ivor Catt
St Albans
Hertfordshire

D.C. SUPPLIES

Having read Dr K.L. Smith's article on D.C. Supplies from AC Sources (Oct. 1984 p.63), if would appear that some very important omissions have been made.

There seems to be an implicit assumption that there is a direct, linear relationship between d.c. load current and secondary winding current and the losses which arise therefrom.

Surely, if d.c. supplies are being considered, then these supplies would embody output filtering (unless the end object is, say, a very crude battery charger). That being the case, then the effects of the output filter must be considered in the design calculations for the transformer. This is particularly so in relation to the magnitude of the conduction angle of the rectifiers and the resulting size of the peak current flowing in the rectifier/secondary winding. It is the size of this peak current (very much larger than the mean current) which dictates the cross-sectional area of the wire to be employed for the winding and the consequent losses.

It is my experience that, unless this consideration is 'built' into the design and then worked backwards toward the primary winding requirements, then a poor design is inevitable.

A.M. Wheeler
West Mersea
Essex

BASIC PHYSICS

A connecting thread seems to join this month's (January 1985) correspondence items under the headings "Displacement Current", "Roots of Relativity", "Energy Transfer", and "Electric Charge from a Radio Wave"; they all present arguments over the uncertainties of the fundamental principles of physics.

I wonder, is it possible that some of our doubts arise because of over-eagerness at the outset to seize upon the first plausible explanation we happen upon, just as a panic-stricken shipwreck victim grasps at anything? Indeed our gratification in being able to grasp an idea seems to cause us to clutch it as if drowning would result from losing it!

Perhaps I may be allowed to offer a couple of remarks on specific points; first, from Chris Parton; "there is a law of physics to the effect that the velocity of light is the same for all observers, and I believe that the conclusion of Michelson's and Morley's celebrated experiment. . . that the velocity of the propagating medium. . . does not affect the observed velocity of light." This assertion by Chris Parton seems to have many fearful souls desperately hanging on to it, yet can we say that the second postulate of relativity theory, which was casually "promoted" to this status from that of a conjecture by Albert Einstein in his apparently little-read paper (ref.1), can be further elevated to a law, to stand with, for example, the Laws of Motion as annunciated with unqualified assurance by Isaac Newton? Chris Parton "believes" the conclusion generally held for the ether-drift experiment; others could just as well believe a contrary or alternative conclusion can be drawn, for it is not difficult to discern the inherent weaknesses in the experiment's design (ref.3), Michelson's interferometer, for one instance, was rigidly spaced from the emitter used, which means that if every emitter is absolutely immobile in its dedicated ethereal medium for dispersal of its individual radiation, then the obtained results are simply accounted for. It is true the Einstein discounted this possibility, but he gave no grounds for his judgement; does no-one consider he would have removed one cause for doubt had he done so?

And second, in his letter A.J. Clayton took great pains with his detailed discussion of the "imaginary experiment" with which Einstein endowed his "Popular Exposition" (ref.2.), featuring a train hit by synchronized lightning-strikes. Speaking for myself however, I think it would have been quite sufficient for him to simply draw our attention to Einstein's failure to allocate the radiation from the electrostatic discharges to a medium, which would have a status of motion with respect to all the other elements of the model — train, track, electric fields, etc. If the radiation were not to be propagated in accordance with the regulating characteristics of a medium, either substantial or ethereal, then how was the energy to be transferred — possibly in association with a material displacement in accordance with the Laws of Motion? Since Einstein left us with this problem, the explanatory value of his treatise is in some doubt. Incidentally, there are other serious problems elsewhere within this book, which was intended for the "layman's" edification!

All such concepts as displacement current, electric and magnetic force fields, energy transportation across a vacuum, ethereal media, time with properties of substance — and all such terms of an all-embracing theoretical schema — are ideally inter-related in a mode which reflects precisely action in the physical universe; so when a disturbing lack of correspondence becomes obvious, it is surely the result of human ineptitude? To what extent to our knowledge then to be advanced by ingeneous attempts at the obscuration of our misinnterpretations?

The late Prof. Herbert Dingle suggested in "Science at the Crossroads", that Einstein created his much-admired theories to cover the defects of another theory, that of Clerk Maxwell; these in turn may well be covering other misconceptions (vide Ivor Catt in the pages of this journal).

It seems possible that modern physics is based on a schema which was put together without proper circumspection, just about the turn of the century, when instruments were penetrating facets of phenomena which revealed embarrassing shortcomings in the accepted wisdom; this at the very time when public attention was turning to science for guidance in a rapidly developing world of technological innovation. Perhaps "panic" would be too strong a word to introduce here, but now as the "dust of

the old cosmology" begins to settle, should we not be attempting to gain a deeper, wider perspective over the universe?
C.B.V. Francksen
Farnborough
Hampshire

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1. "On the Electrodynamics of Moving Bodies", Albert Einstein, Annalen der Physik 17, 1905. (Translation available in "The Principle of Relativity", Dover Publications Inc., 1952).
2. "Relativity, the Special and the General Theory, A Popular Exposition", Albert Einstein, Methuen & Co., London, 1920.
3. "Michelson Morley Experiement", R.S. Shankland, Case Institute of Technology, Cleveland, Ohio, 1963.

RELATIVITY

Had A.H. Winterflood[1] read my letter[2] on the M.M. experiment, and understood it like Osinga[3], he would have found no need for his proposed measurement for it was done in 1887. Science does accept the M.M. experiment which enshrines the additive theory doesn't it?

If he can prove that this experiment does not rely on the additive theory then we should be told about it for science will be turned on its head. My earlier letter should also relieve Theocharis's mental indigestion![4]
Alex Jones
Swanage
Dorset

References
1. Letters Feb. 1985.
2. Jones, Letters April 1984.
3. Osinga, Letters July 1984.
4. Theocharis, Letters Feb. 1985.

Simultaneity refers to events having the same time but not necessarily the same place: if they also happen to have the same place, such a 'double event', at a single point in space-time, would be recorded as such by all observers, whatever their position and velocity (rest assured, Mr Marquis). But when two events are separated in space or time, the measurement of that separation depends on the velocity of the observer; no one observer can be 'right', not even the one that is 'at rest', for how can one be at rest with an event that has only one place and one time? The confusion over this point has been further confused by Dr Scott-Murray's change of concepts in mid-stream, even though his diagrams are excellent examples of explanatory geometry. The trouble with his argument is that it is not clear whether *he* means simultaneity by $\Delta t=0$ or by $t_A=t_B$. This leads to my second point. Figs 2 and 3 purport to show the same sequence of events as observed by M and M′ respectively, given that c is invariant. But they *cannot* show the same experiement because the delay between either obser 'er's *receipt* of the two flashes is zero in one diagram and non-zero in the other.

The only *conformal* transformation from M to M′ is shown by Fig. 5, where the events, and the invariance of c, are preserved, at the cost of a distortion of space-time that is perfectly 'real' to each observer.

Scott-Murray suggests that it would be easier to accept Fig. 4 and assume a ballistic theory of light, presumably explaining the negative result of the M-M experiement by postulating (with Messrs Winterflood, Aspden et al) that photons adjust to c only near an observer, having approached from a moving source with a dispersion of velocities. Such a dispersion would easily have been spotted from observing rotating systems like distant galaxies and binary stars. The transformation shown in Fig. 5 (or 6) is the only one that fits the facts — until some new facts turn up.
R.V. Harvey
Grasmere
Cumbria

With reference to the article "Einstein's Trains" by W.A. Scott Murray in Feedback column of *Wireless World*, February 85 issue, I have the following observation to make.

Einstein had taken pains to establish the 'relativity of simultaneity' by showing that events which are simultaneous to the observer in one frame are not simultaneous to another observer in another frame, and hence time is relative. However, even in the same reference frame, events which appear as simultaneous to one observer, need not appear as simultaneous to another observer situated at a different point closer to one of the places from where light originates. For instance, in the example discussed by Einstein, if an observer is situated closer to A between A & M, he is bound to observe the lightning at A earlier than the lightning at B. Thus what appears to be simultaneous to the observer at M does not appear as simultaneous to another observer even in the same frame. Thus it is not at all necessary to establish the relativity of simultaneity by introducing another observer M′ in a running train. As time is constant in a particular reference frame, the fact that an event appearing as simultaneous to one observer is not simultaneous to another observer in the same frame does not establish the relativity of time.

Time is a universal phenomenon and the relativity of time is abhorrent to the common sense, as rightly pointed out by W.A. Scott Murray in his articles in the 'Heretics Guide' series. The Michelson-Morley experiment, which was the forerunner for these mind-boggling theories of space contraction and time contraction, had only established the non-existence of an ether medium for the propagation of light, as the velocity of light was found to be the same in all directions as observed on earth. It should be possible for physicists to establish that it is not necessary to accept length contraction and time contraction in order to explain the observed constancy of the velocity of light. As light is a form of energy and is not matter, a moving light source cannot add its velocity to that of light. The Newtonian laws of addition of velocities apply only to objects of matter having mass and cannot apply to light which is a form of energy always in motion and not having a definite mass.
K. Ganesh
Director, Transmission Project
Madras
India

I thoroughly enjoyed Dr Murray's series "Heretic's Guide to Modern Physics" (*WW* Jun 82 to Jun 83); challenge and provocation are, I believe, important to the evolution of Scientific Theory. I was disappointed, however, to read Dr Murray's later article "The Roots of Relativity" (May 84), since his good intentions were spoiled by a flaw in his reasoning. Although this error was pointed out by A.J. Clayton (Feedback Jan 85). I therefore feel moved to comment myself.

In "Einstein's Trains", Dr Murray deduces from a consideration of the Second Postulate that ". . . the situation observed by M′ in his own coordinates must be as shown in Fig. 3. where the two flashes arrive at the same instant. . ." But WHY? The Second Postulate implies only that the light approaching M′ from both flashes must be c in his own frame of reference, as shown correctly in the diagram. What logic does Dr Murray use to show in addition that flashes A and B both occur at time $t'=0$? The very purpose of the 'trains experiment' was to illustrate that one's intuitive notion of simultaneity is inconsistent with the consequences of the Second Postulate. Just because Dr Murray makes an intuitive assumption about simultaneity, it does not follow that Einstein's 'trains experiment' is inconsistent with his Second Postulate.

The view from M is that while the light from the two flashes is propagating through space, M′ will edge a little closer to B and a little farther from A. M will DEDUCE therefore that the flash from B will be received by M′ before the flash from A, arguing purely from a consideration of the path lengths involved, and without making any presumption about the velocity of light relative to M′. Now by applying the logic of causality, we argue that M′ must agree, at least qualitatively, that the flash from B is seen before that from A. The situation is not therefore as shown in Dr Murray's Fig. 3.

Life would indeed be much simpler if we had transformations which did not involve square-roots, but what is wrong with challenging our pedestrian notions of space and time, and developing a theory which is really provocative. I feel Einstein may already have done so.
G.P. Clark
Castle Donington
Derbyshire

CIRCLE 22 FOR FURTHER DETAILS.

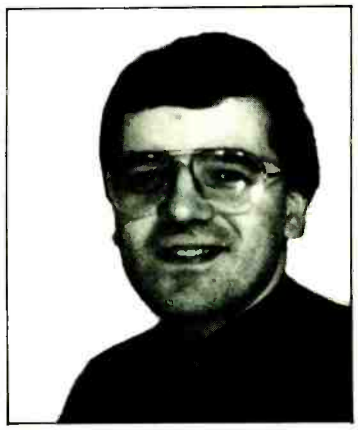
CIRCLE 25 FOR FURTHER DETAILS.

CIRCLE 45 FOR FURTHER DETAILS.

CIRCLE 43 FOR FURTHER DETAILS.

Printer buffer

by Mike Catherwood



By taking characters from a microcomputer at high speed and sending them to a printer at its leisure, this buffer reduces waiting time from minutes to seconds. It has parallel and serial ports and holds enough text for around twenty A4 sheets.

An annoying quirk of single-user computers which do not boast multi-tasking operation is that when communicating with slow peripherals, their through-put drops to that of the peripheral. Waiting for such a computer to finish working with a typical low-cost printer can seem like an eternity.

The printer buffer alleviates this problem by appearing to the host computer as a high-speed printer. It stores data from the computer in its memory (dynamic ram) as quickly as possible which reduces the waiting time from possibly several minutes to seconds. It then proceeds to send the stored information to the printer at normal speed.

Features

The buffer is built around the Motorola MC6803 eight-bit microprocessor which contains an enhanced 6800 processor with 128 bytes of ram, a 16-bit timer, a serial-communications interface (s.c.i.) and i/o lines. This processor is a rom-less version of the high-density n-mos M6801 family.

Storage capacity of up to 64 432 bytes — the equivalent of approximately twenty A4 pages — is provided by 64K-byte dynamic rams (d-rams). Centronics parallel interfaces and a serial interface using XON/XOFF protocols are used to allow parallel-to-parallel, parallel-to-serial, serial-to-parallel and serial-to-serial data transfers. Only one serial interface has been included, to simplify the design and keep costs low, so concurrent transmission and reception is only possible with the first three modes.

Since the serial port is configured as a terminal, it may be necessary to exchange the receive and transmit lines in either the printer or printer cable to allow the buffer to operate correctly in serial-to-serial and parallel-to-serial modes. The serial-interface data rate may be switched between 300 and 9600 baud (using S_1) but is the same for transmit and receive lines. It is possible to switch the data rate during serial-to-serial transfers so that data may be loaded from the computer at one rate and unloaded to the printer at another. Computer and printer interfaces can therefore operate at different rates.

Buffer-ready and error leds indicte when the buffer has space available and that a serial communication fault has occurred. An abort key is also included to allow one to prematurely terminate printing in an orderly fashion. The Centronics interface PRIME signal is used to clear the buffer within the printer during an abort sequence.

The software is interrupt driven with separate input, output and memory-refresh tasks. These will appear concurrent, i.e., printing will commence before data input is complete. Furthermore, subsequent files may be sent to the buffer before the current buffer content has been sent out.

Being general purpose, the design could be used as the basis of a variety of microcomputer applications. The address is easily changed and more i/o, eprom space, etc., could be added. The M6803 processor operates in mode three in this application so its internal ram is not available. However, the 6803 can be made to operate in mode two for applications requiring standby ram, see Motorola MC6801 Reference Manual/ MC6801RM(AD2).

Specification

Two Centronics parallel ports and one serial
Modes
- Parallel-to-parallel
- Parallel-to-serial
- Serial-to-serial
- Serial-to-parallel

Serial RS232 port
- Transmit/receive using

XON/XOFF protocols
- 300 or 9600 baud
- One start, one stop and eight data bits

Parallel Centronics interfaces
- Eight-bit parallel
- DS/ACK handshaking
- Busy and prime lines supported

64K-byte circular buffer
6803 microprocessor/6821 p.i.a.
Abort and multiply copy functions
Error and busy indicators

Interfaces

Centronics interfaces are handled by an MC6821 peripheral interface adapter (p.i.a.). Use is made of the 6821 automatic handshaking features to generate host acknowledge, ACK, and printer data strobe, DS, pulses. A BUSY signal is produced at port one, line four (P14) of the 6803 to

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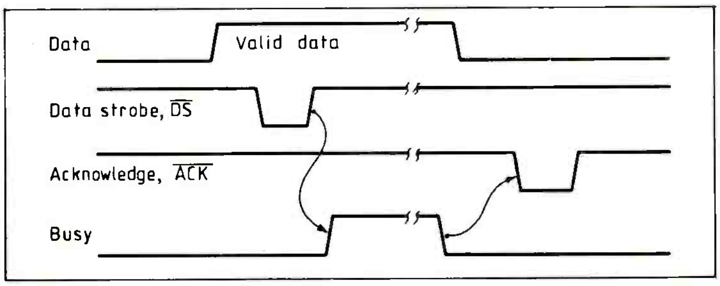


Fig. 1. 6821 Centronics handshake timing applies to both printer output and computer input. Timing with this type of interface is rarely critical.

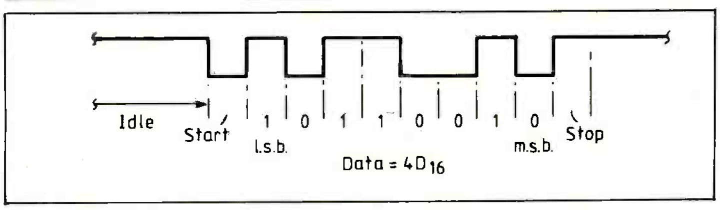


Fig. 2. In the serial interface, each character sent consists of one start bit, eight data bits and one stop bit. Data rates are determined by a programmable timer within the 6803 microprocessor.

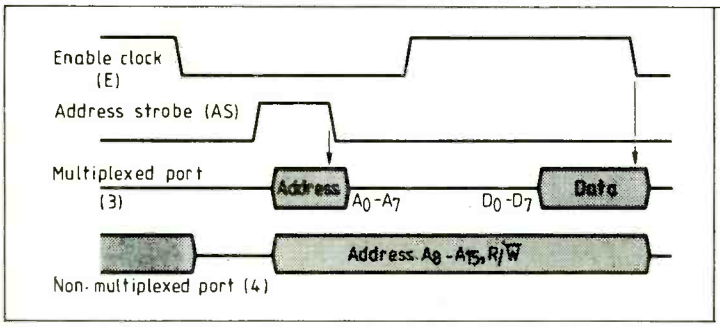


Fig. 3. Multiplexed data/address signal timings for the 6803 microprocessor. Lines are usually multiplexed in this way to make the most of pins on the i.c. package.

Fig. 4. Circuit of the 64K-byte printer buffer (r.h. page). Multiple copies of the buffer content may be made by keeping one's finger on the abort button. When using parallel-to-serial mode, data is actually available on the parallel output port, but the handshake timing may not be used.

Using a microprocessor with built-in serial data facilities and a parallel interface adapter with handshaking, this 64K-byte printer buffer operates with any Centronics or RS232 compatible computer and printer. Software handshaking (XON/XOFF protocol) is used on the serial port.

indicate to the host computer that the buffer is full. Some computers may not use this line. A PRIME line is also provided (P15) to reset the printer.

Figure 1 shows the 6821 handshake timing. Once set up, the data is transferred by pulsing the data strobe signal DS. Data must remain stable while DS is low. There are also associated set-up and hold times to be considered, but timing with this type of interface is rarely critical. Data transfer is acknowledged by the receiver some time later by pulsing the ACK line; some interfaces define a time-out period for this. The interface is now ready for further transfers.

If you intend using very long cables then the p.i.a. lines should be buffered using line drivers. Unbuffered, the 6821 will drive up to around 2m of ribbon cable. It is wise to interleave ground with the signals to remove any coupling effects.

The serial interface uses the full-duplex s.c.i. within the 6803, which operates using a standard mark/space (n.r.z.) form. It can also support a bi-phase mode of communication, although not in this application. Each character sent consists of one start bit, eight data bits and one stop bit, Fig. 2, and uses the on-chip programmable timer as a data-rate generator. The buffer operates at either 300 at 9600 baud but data rates of between 150 and 76 800 baud are possible using different crystal frequencies and software-selectable prescaler values.

To generate common data rates, a bus frequency of 1.225MHz is necessary (equivalent to a 4.91MHz crystal) which requires the use of a 1.25MHz bus version of the MC6803. Consequently a 1.5MHz MC68A21 is also theoretically required, although it is unlikely that a standard 1MHz part will not do the job if you have one available. If the serial interface is not required, you can use a 4MHz crystal and the slightly cheaper 1MHz bus version of the 6803. The RS232 interface buffer could then also be omitted.

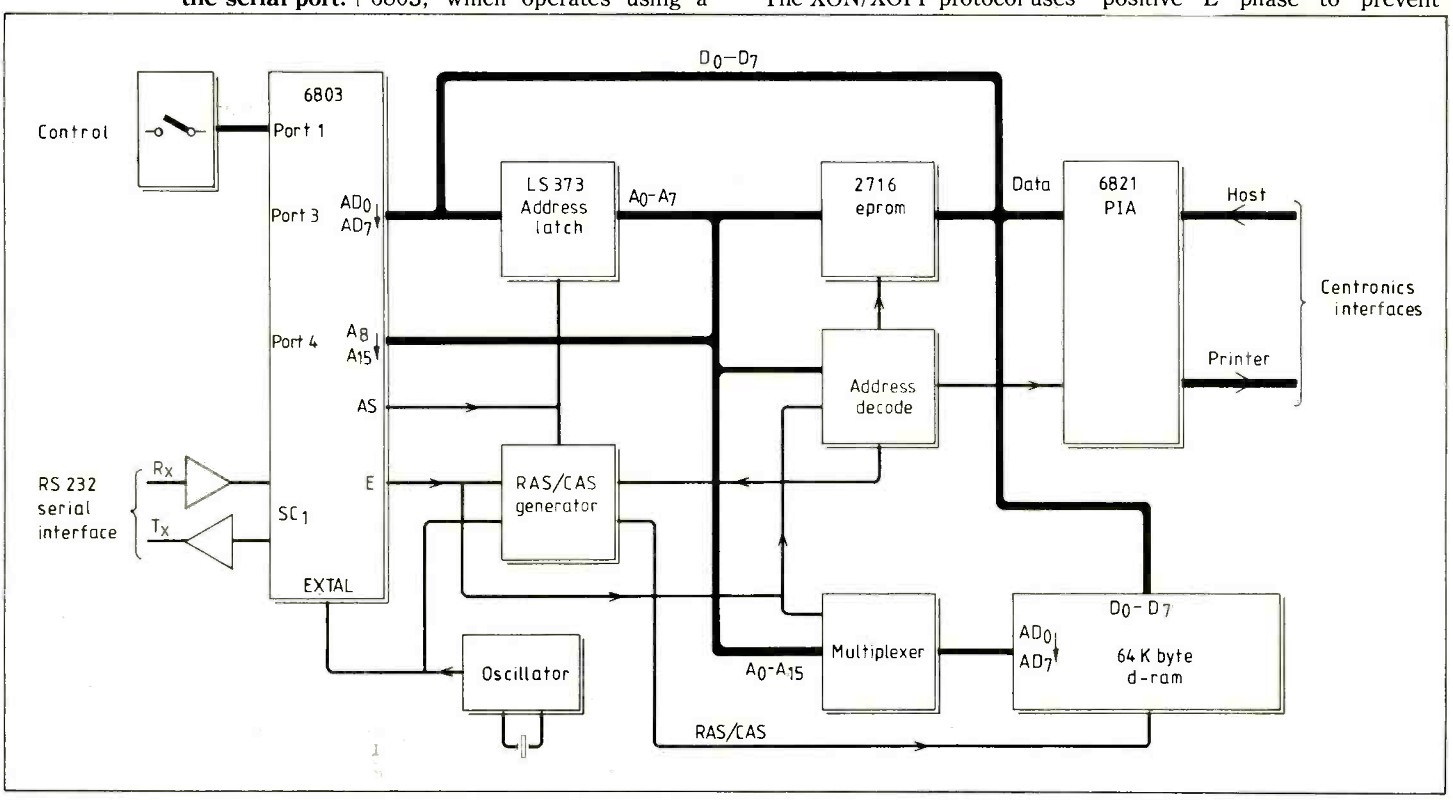
Use of XON/XOFF protocol on the serial port removes the need for any active handshaking lines. It would be relatively easy to add an asynchronous communication interface adapter like the MC6850 to the system to provide an additional serial interface with hardware handshake facility if required.

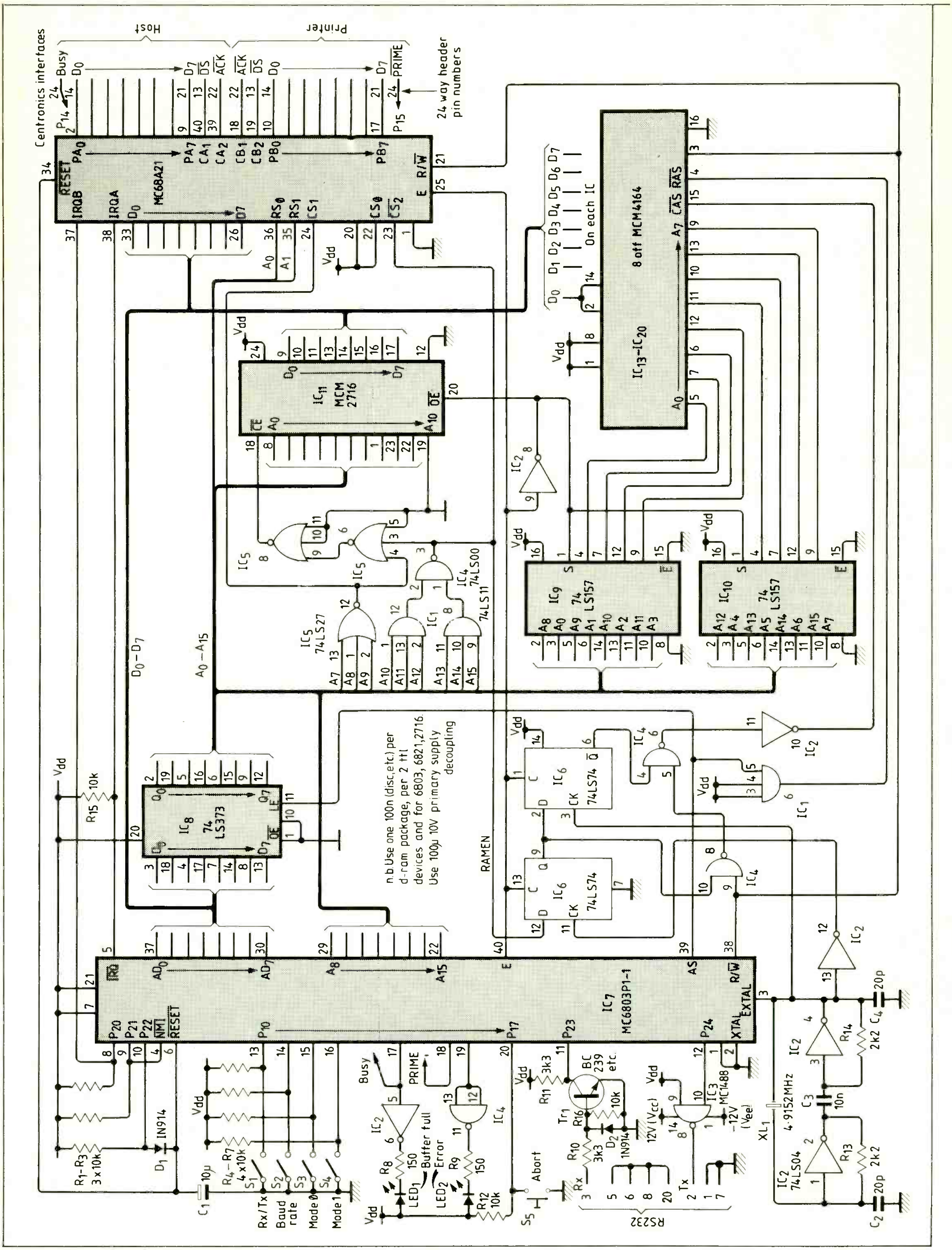
The XON/XOFF protocol uses Ascii codes DC1 and DC3 to provide the transmitting device with receiver buffer empty/full status. When the receiver buffer is within a predetermined number of characters of being full (64 characters in this design) the receiver sends Ascii code DC3 to the transmitting system, indicating that transmission should stop fairly soon (XOFF). After a while, the buffer will empty and when sufficient space becomes available (256 characters in this case), the receiver sends Ascii character DC1 to the transmitting system, indicating that it may resume transmission (XON).

Hardware

All members of the 6801 family have a multiplexed address/data bus when in their expanded mode, Fig. 3. Address lines A_{0-7} are multiplexed with data lines D_{0-7} on port three. An address-strobe pulse occurs during the low phase of enable signal E. The address is only guaranteed to be valid on port three during the falling edge of AS, at which time it is frozen by an LS373 latch i.c., Fig. 4. Address lines A_{8-15} produced by port four are not multiplexed and are valid throughout most of the enable cycle.

During the E-clock high phase, port three either presents data for writing or expects to see data for reading. Read/write line $R/\overline{W}$ should only be lowered during the positive E phase to prevent





Centronics interfaces
Host
Printer
24 way header pin numbers
MC68A21
IC11 MCM 2716
8 off MCM4164
On each IC
IC13–IC20
IC9 74 LS157
IC10 74 LS157
IC8 74 LS373
IC5 74LS27
IC4 74LS00
IC1 74LS11
IC6 74LS74
IC7 MC6803P1-1
IC3 MC1488
IC2 74LS04
n.b.Use one 100n (disc,etc) per d-ram package, per 2 ttl devices and for 6803, 6821, 2716. Use 100µ 10V primary supply decoupling
RAMEN
D0–D7
A0–A15
4·9152MHz
Buffer full
Error
Abort
Rx/Tx
Baud rate
Mode 0
Mode 1
RS232

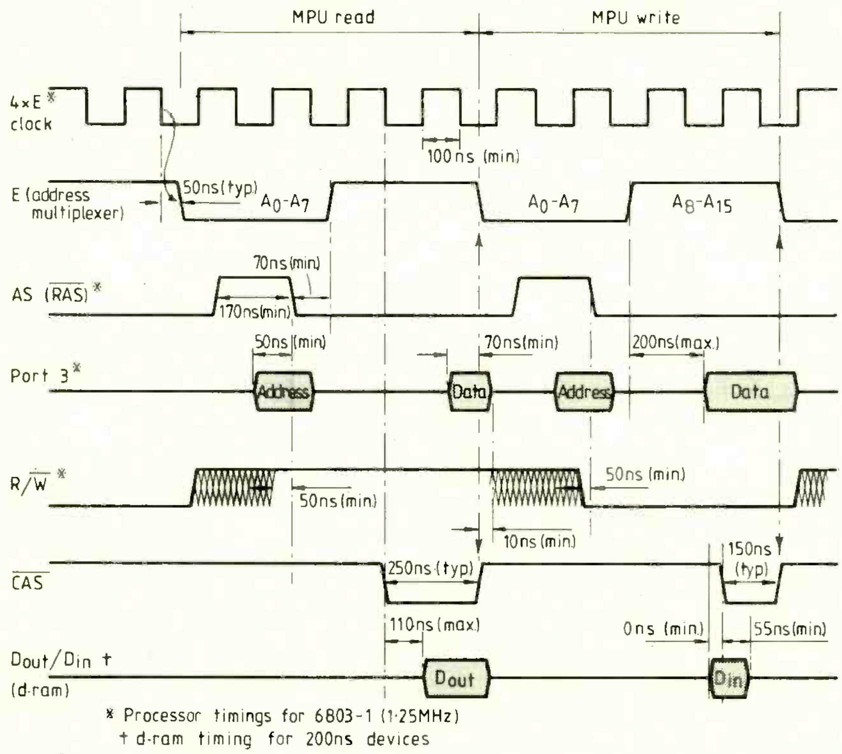


Fig. 5. **Printer buffer timing required for dynamic rams. An address must be multiplexed into the rams in two halves on eight lines. Half of the address is latched by the row-address strobe, RAS, and the second half by the column-address strobe, CAS.**

erroneous writing. Data is read by the processor during the E-signal falling edge. As with all multiplexed bus systems, care must be taken to ensure that all device output buffers are disabled during the E-signal low phase, otherwise bus contention will result. Having obtained essentially separate address and data buses, connection of the 2716 eprom and 6821 p.i.a. is easy.

Memory decoding is arranged to keep as much of the 64K-byte address space as possible free for buffer ram while using a minimum of i.cs. As the software is less than 1K-byte long, only half of the 2716 is used; address line A_{10} is tied low.

Most systems using dynamic ram have d-ram controllers to generate timing signals and to refresh the memory independently. These controllers tend to be costly and as their performance is not essential in this application I chose to use a software refresh technique (described later). As a bonus, the hardware required to implement this is minimal.

To reduce the number of pins used, 64K-bit dynamic rams multiplex address lines A_{0-7} with lines A_{8-15} using two signals called row-address strobe, RAS, and column address strobe, CAS, Fig. 5. Referring to Fig. 4, the address bus is multiplexed with the E signal using two LS157 quad two-to-one-line multiplexers. The timing of AS allows it to be used directly as RAS during the low E-signal phase.

Generating CAS is a little more difficult. When the ram is accessed the RAMEN signal is clocked through two D-type latches by the microprocessor input clock. The E signal is derived from the processor clock and is one quarter of its frequency. The D-type devices are however held clear during the E-signal low phase (CAS is held high). In order to meet data set-up times for the processor and d-rams, CAS is also conditioned by the R/$\overline{W}$ signal. Hence, CAS will only fall if RAMEN is true and the latches have been clocked twice during the high E phase for a write and once for a read.

Propagation delay through the 6803 internal dividers has not been characterized as it is intended that the device is used with its on-chip oscillator, i.e. with a crystal connected between pins one and two. Using the internal oscillator makes the relationship between pins three (EXTAL) and 40 (E) of little consequence. For an injected clock, however, values are typically less than 50ns over the standard temperature range of 0 to 70°C, which is well within the specification for this design using 200ns rams even though it almost unforgivably violates worst-case design practice!

Software, construction and operation will be discussed in a subsequent article.

Silk-screened plated-through p.c.bs for the buffer, currently being manufactured, will cost £14 including vat and UK or overseas postage from Combe Martin Electronics, King Street, Combe Martin, North Devon EX34 0AD. A complete kit of parts, excluding p.c.b. and case, is available from Technomatic Ltd, see advertisers' index.

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April 30 to May 2
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Your Generation, IEE Faraday Lecture. Dominion Theatre, London.
Tickets free on receipt of ann s.a.e. by the Farada Officer, IEE, Station House, Nightingale Road, Hitchin, Herts. SG5 1RJ.
May 1
Personal and Domestic Robots IEE colloquium at the IEE Savoy Place. London WC2R 0BL. Tel: 01-240 1871 Ext. 269
May 2
NDT in undergraduate engineering. IEE discussion meeting. Phone as above
May 3
Image restoration and two-dimensional filtering. IEE colloquium. As above
May 6 to 9
Radar 85. International IEEE/IEE conference in Washington, D.C. Details from Radar 85, 1331 Pennsylvania Avenue NW, Washington DC 20004, USA.
May 7
Fault-tolerant microprocessor control systems. IEE Lecture. Telephone as above. The human contribution to technology: IEE Lecture in Edinburgh. As above.
May 8
Vision modelling. IEE colloquium. As above.
The UK 5000 project. IC design made easy. IEE lecture. As above.
May 13
Software, does it enhance accuracy? IEE discussion meeting. As above.
May 15
Applications of CAD packages to the design of control systems: IEE colloquium. As above.
GTO devices and their applications. IEE colloquium. As above.
May 16
Microwave acoustics and acousto-optics. IEE colloquium. As above.
Intelligent knowledge based systems and Alvey. IEE lecture in Oxford. As above.
May 17
Optical mass data storage. IEE colloquium. As above.
May 20
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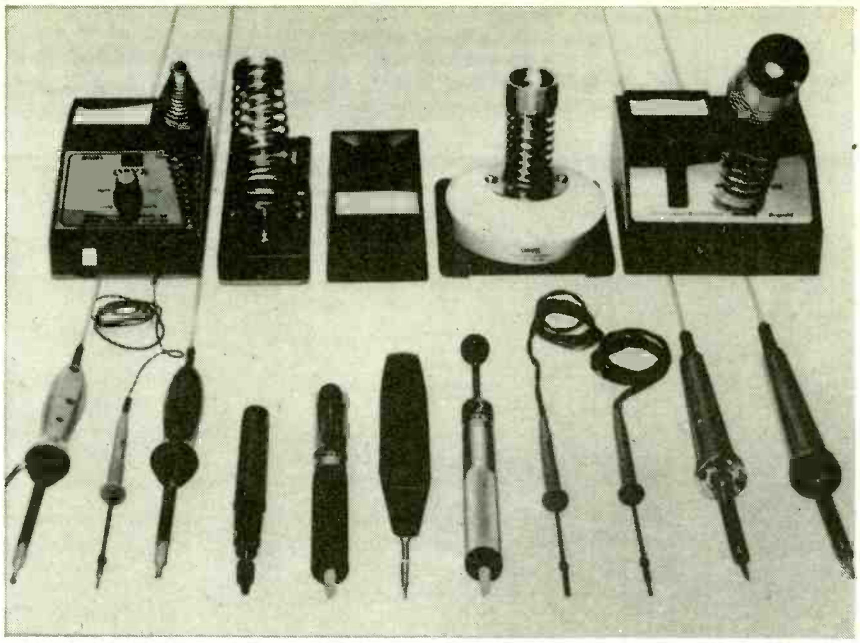

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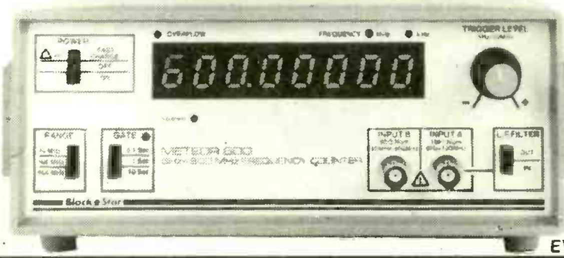

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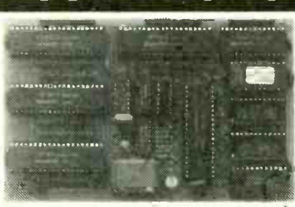

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Channel code and disc format — 1

By J.R. Watkinson

Eight-to-fourteen modulation, eye patterns, subcodes, flags and error correction.

The channel code used in the Compact Disc has to operate within a number of constraints.

○ First, the d.c. content of the code should be as small as possible for several reasons. Disc run-out and contamination cause low frequency noise in the replay signal which can be filtered out if there is no information content at those frequencies. The code d.c. content will also appear as noise in the tracking and focus servo systems. Finally, a d.c.-free code simplifies the design of the data separator.

○ The efficiency of the code, which is the relationship of bit rate to channel bandwidth, should be high as this has a major influence on the playing time. High-density run-length-limited codes are usually selected by balancing the maximum run length against d.c. content. Fortunately the jitter of a non-contact rigid medium such as CD is relatively low, permitting the use of a long maximum-run length[1].

○ The CD system depends heavily on error correction and a channel code that uses symbols of the same size as those in the error correction will reduce the possibility of error propagation[2].

○ The bit rate is lower than those used in computer discs, thus no simplification is necessary to achieve the necessary operating speed. A complex encoding process is acceptable because relatively few encoders are necessary.

The March and April articles 'Principles of Optical Storage', parts 1 & 2) showed that there is a cut-off frequency due to the n.a. of the optical system. All recorded frequencies must be below this cut-off by a sensible margin to allow for disc warp and focus errors. This determines the minimum time between transitions. It is fundamental to the channel code that the period between successive transitions is an integral multiple of one-third the minimum period. The basic time period T is one cycle of 4.3218MHz or 231.4ns. Fig. 1 shows that the minimum wavelength allowable is 6T and that this corresponds to 720kHz. The minimum period between transitions is 3T, but it can also be 4T, 5T etc. To retain a reasonable clock content, the maximum period between transitions (the run-length limit) is 11T, corresponding to a frequency of 196kHz. There are consequently time periods used in all CD recording.

The basic clock period is three times smaller than the minimum transition spacing, so the resolution of the medium has apparently been increased by a factor of three. This gain cannot be fully realised because some data patterns cannot be recorded it the 3T spacing rule is to be obeyed. Data to be recorded must be converted to a form which accepts the restriction.

The basic period T is assembled into symbols of 14T length. Examining all the possible combinations of a 14T symbol (2^{14}), there are 267 patterns where the run length is neither less than 3T nor more than 11T. From these, 256 patterns are selected to uniquely determine all possible combinations of an eight-bit data symbol. Fig. 2 shows some actual patterns and some invalid patterns for comparison. This conversion process gave rise to the name of e.f.m. (eight-to-fourteen modulation) for the CD channel code.

To prevent violation of the rules by certain 14T patterns following others, and to control the d.c. content of the code, three packing periods are placed between each symbol. Each eight-bit data symbol therefore requires 17T to be recorded. This coding is 8/17 efficient, and when multiplied by the resolution improvement of three times, yields the actual efficiency

$$\frac{3 \times 8}{17} \times 100\% = 141\%.$$

Although the highest frequency in the channel code is 720kHz, or 1.44 million transitions per second, the bit rate is

$$4.3218 \times \frac{8}{17}\ \text{Mbit/s} = 2.0\text{Mbit/s}$$

This series is outlined in an introductory article which appeared in January's issue. The second article in the series, entitled 'Principles of optical storage', is in two parts and appeared in the March and April issues. A second part of this present article will be provided next month.

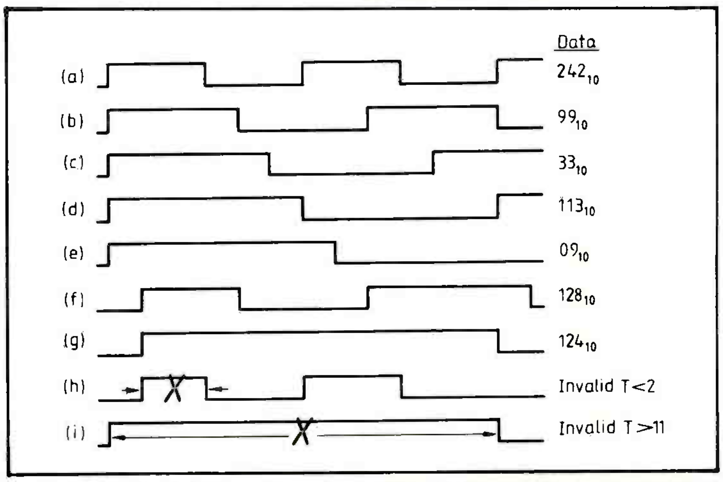


Fig. 2. **Part of the code block for E.F.M. code showing examples of various run lengths from 3T to 11T.**

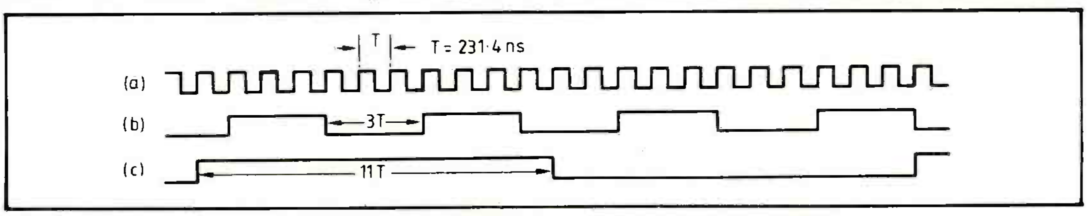


Fig. 1. **Limit frequencies of CD channel code: master clock frequency of 4.3218MHz, T=231.4ns (a), highest recorded frequency with transition 3T apart, frequency 720kHz (b), and lowest recorded frequency with transitions 11T apart, frequency 196kHz, (c).**

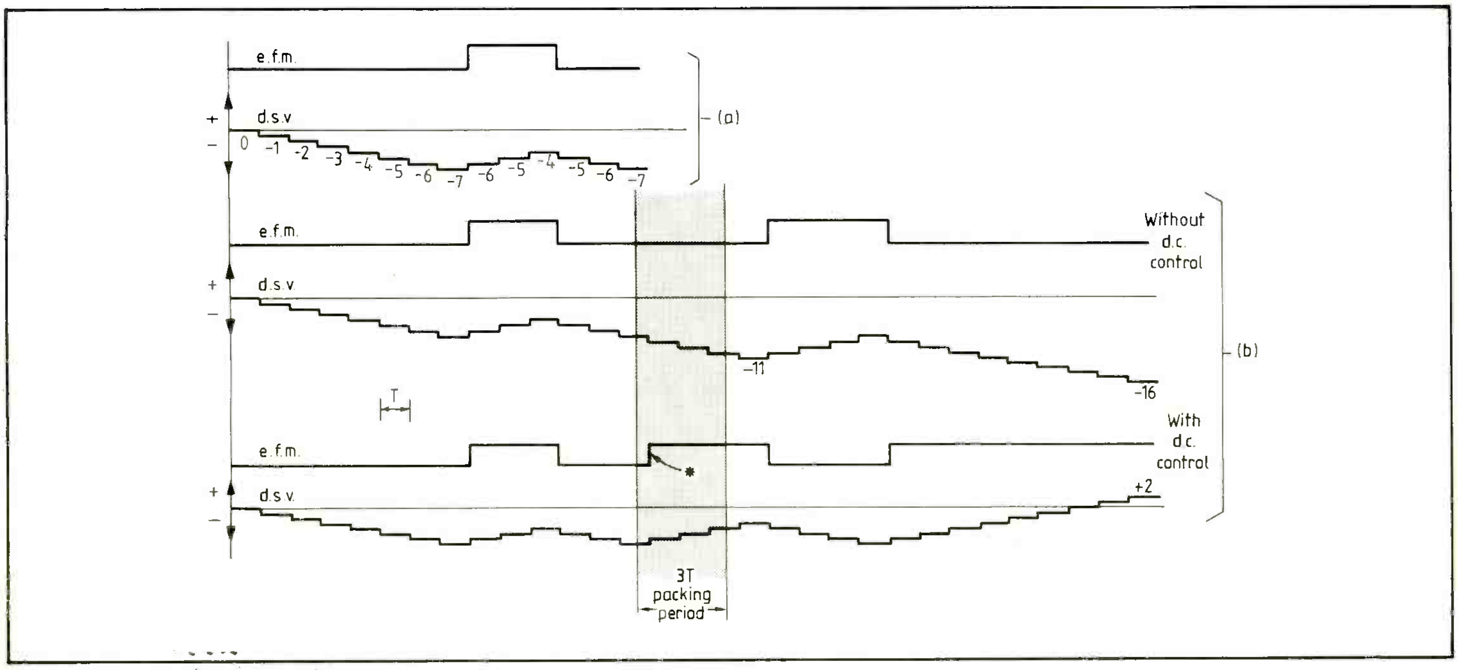
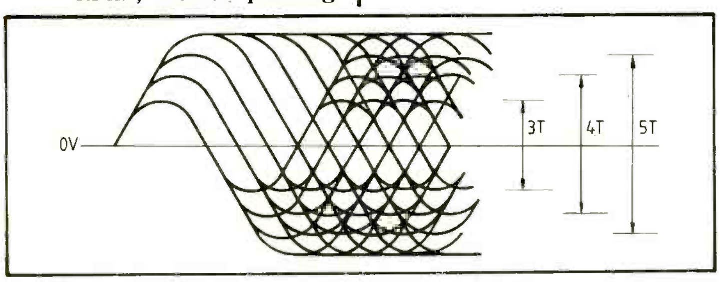
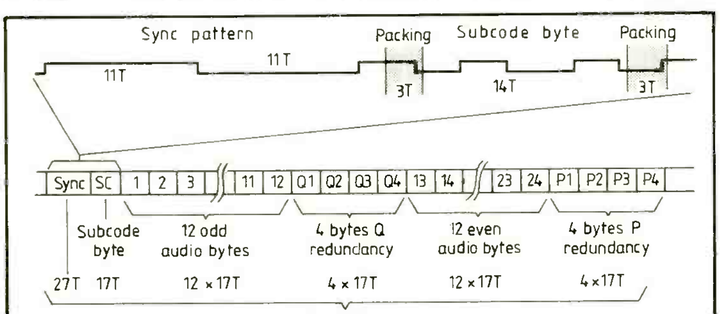


Fig. 3. **Digital sum value example calculated from e.f.m. waveform (a). Two successive 14T symbols without d.c. control (upper) give d.s.v. of −16, (b). Additional transition (*) results in d.s.v. of +2.**

Fig. 4. **Characteristic eye pattern of e.f.m. observed by oscilloscope. The only information of interest is the time when the signal crosses zero. Notice reduction in amplitude of the higher frequency components.**

Fig. 5. **One CD data block begins with a unique sync. pattern and one subcode byte followed by 24 audio bytes and eight redundancy bytes. Each byte requires 14T in e.f.m., with 3T packing.**





The choice of packing bits for d.c. control is determined as follows. The digital sum value (d.s.v.) of the channel patterns is derived as shown in Fig, 3(a). If the channel code is true during a T period, one is added to the d.s.v., if the code is false, one is subtracted. Clearly if the channel code is to be d.c.-free, the average d.s.v. must be zero. In Fig. 3(b), two successive 14T symbols are shown, both of which have a positive d.s.v. By adding a transition in the packing period, the second symbol is inverted, and the overall d.s.v. is reduced[3]. As the only parameter of interest is the time (3−11T) between transitions, this inversion has no effect on the data.

The interference read-out process causes the reflected light to increase and decrease about some average value, which superposes a d.c. level on the readout signal, in addition to a component at the rotational frequency of the disc (3.3 to 9.5Hz) and harmonics thereof. Because the code is d.c.-free, a simple coupling capacitor can be used to remove these effects.

If a typical read-out signal is observed on an oscilloscope that triggers on a positive zero-crossing, the next zero-crossing could be 3T, 4T etc later, as shown in Fig. 4. The 'scope superposes all of these waveforms to give the characteristic eye pattern of CD.

Notice that the amplitude of 3T, 4T and 5T period signals is less than the othes becuase they are closer to the optical cut-off frequency (see March and April articles).

The quality of the optics and focus servo can be assessed by comparing the 3T amplitude with maximum amplitude.

The first step in data seperation is to locate the zero crossing in the waveform and to produce a transition in a binary signal at these points. Since the code is d.c.-free, the threshold or slicing level can be obtained by integrating the signal itself. This recreates the channel code. Every read-out transition is used to phase-lock a data seperator clock of period T. The clock is used to establish the number of T periods between transitions and thus recreate the 14T symbols. These are converted back to data bytes using either a rom or gate array. The truth table, known as the code book, has been optimized to permit decoding with minimum logic[4].

Like most r.l.l. codes, e.f.m. requires a preamable to synchronize the phase-locked loop before data can be read. This unique preamble consists of three transitions separated by 11T.

Each of the data blocks shown in Fig. 5 consists of 33 symbols of 17T each, following the preamble, making a total of 588T or 136 μs. Each symbol represents eight data bits: the first symbol in each data block is used for subcode, the remaining 32 bytes represent 24 audio bytes and 8 bytes of redundancy for the error correction system.

The subcode byte forms part of a subcode block that is built up a byte at a time from 98 successive data blocks. The start of a subcode block is denoted by the presence of S_0 and S_1 synchronizing patterns in the first symbol positions of two successive data blocks. These are two of the (267-256) patterns which are not in the code book and can be uniquely identified. The presence of these two sync. patterns reduces the size of the subcode block to 96 bytes. A future article of the series is devoted to subcode.

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2,4. EFM — The modulation method for the Compact Disc digital Audio System,, Hiroshi Ogawa and Kees A. Schouhamer Immink. AES convention, N.Y. June 1982.

3. Optimization of low frequency properties of eight-to-fourteen modulation, Kees A. Schouhamer Immink ahd Ulrich Gross. IERE Conference on Video and Data Recording, Southampton, April 1982.

The post-war stride into aerospace.

by R.E. Young, B.Sc. (Eng.) F.I.E.E., M.R.Ae.s.

R.E. Young continues the story of British electronic invention. The notorious delays and overspending which beset industry are not the whole picture

During the movement of the aircraft industryfrom'ordinary'aeroplanes into the new world of rockets and supersonic travel, the role of British electronics changed from being a supplier of the proverbial 'Black Boxes' to that of an equal partner with extensive technical responsibilities varying from instrumentation to project coordination.

Both industries already had what was probably unequalled experience of dealing with fresh areas of technology. During the greater part of World War II, and during the period immediately after it, the aircraft industry handled intensive power-plant development, and especially the jet engine. In the electronics connection, they had encountered various forms of airborne radar such as AI (Air-Interception) and the (largely) radar-based navigational aids. Over the same period, radar had over-shadowed all other electronics developments; and the R & D effort alone had been on a scale which had not been seen in the country before, with the possible exception of nuclear research. In parenthesis it may be added that it has been stated that at this time, the British radio industry — essentially based on radar — reached a "- - war figure exceeding £100,000,000 annually"[1]. Allowing a conservative factor of 10, the modern equivalent becomes £1 billion a year, which by any standards, and especially for a 'light' industry, represents an outstanding total.

Early aerospace/electronics projects

In the introduction to this series it was pointed out that "- - since the late 1950s, a significant number of technological projects - - have not reached their target" and that "In extreme cases they have been abandoned; in others the project time scale has become so extended and the overall cost so high that the further development, which it would have been uneconomic to have carried out, has been completely blocked".

This statement, based on the performance of the United Kingdom as a whole, is pessimistic in that a large proportion of British aerospace projects *did* reach their target; but often — it must be admitted — after delays and consequent increase in costs which were several orders higher than the original 'worst-case' predictions.

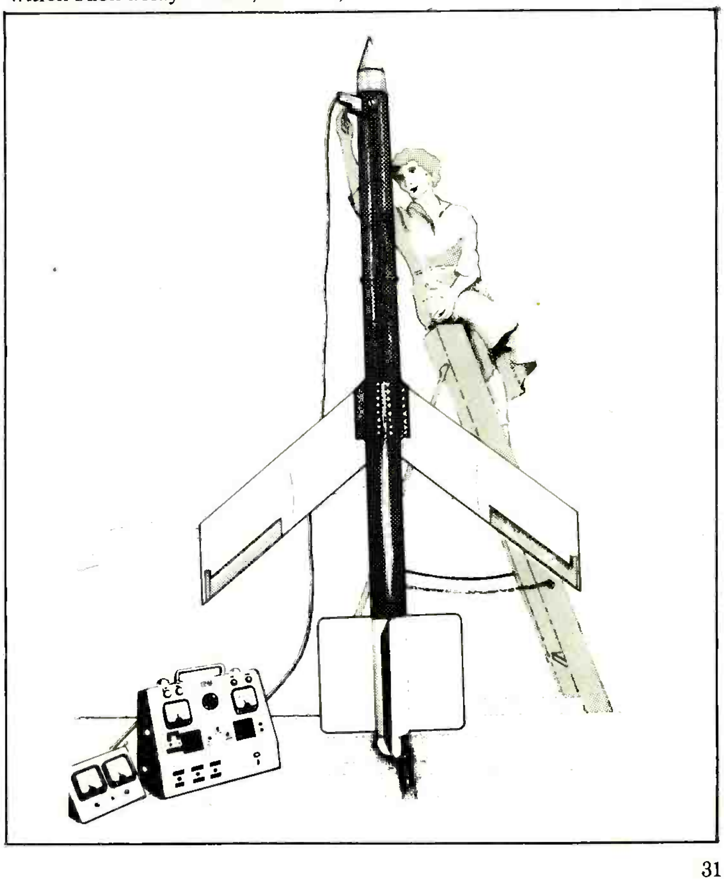
The late 1950s are particularly significant for these aerospace projects because, by this time, the publication of details of programme delays and 'huge' increases in R & D expenditure had given rise to a great deal of critical comment. This was, of course, added to the general criticism which, as noted in the introduction, was being directed against the alleged failure of the British to keep up — in terms of *successful* development — with modern technology.

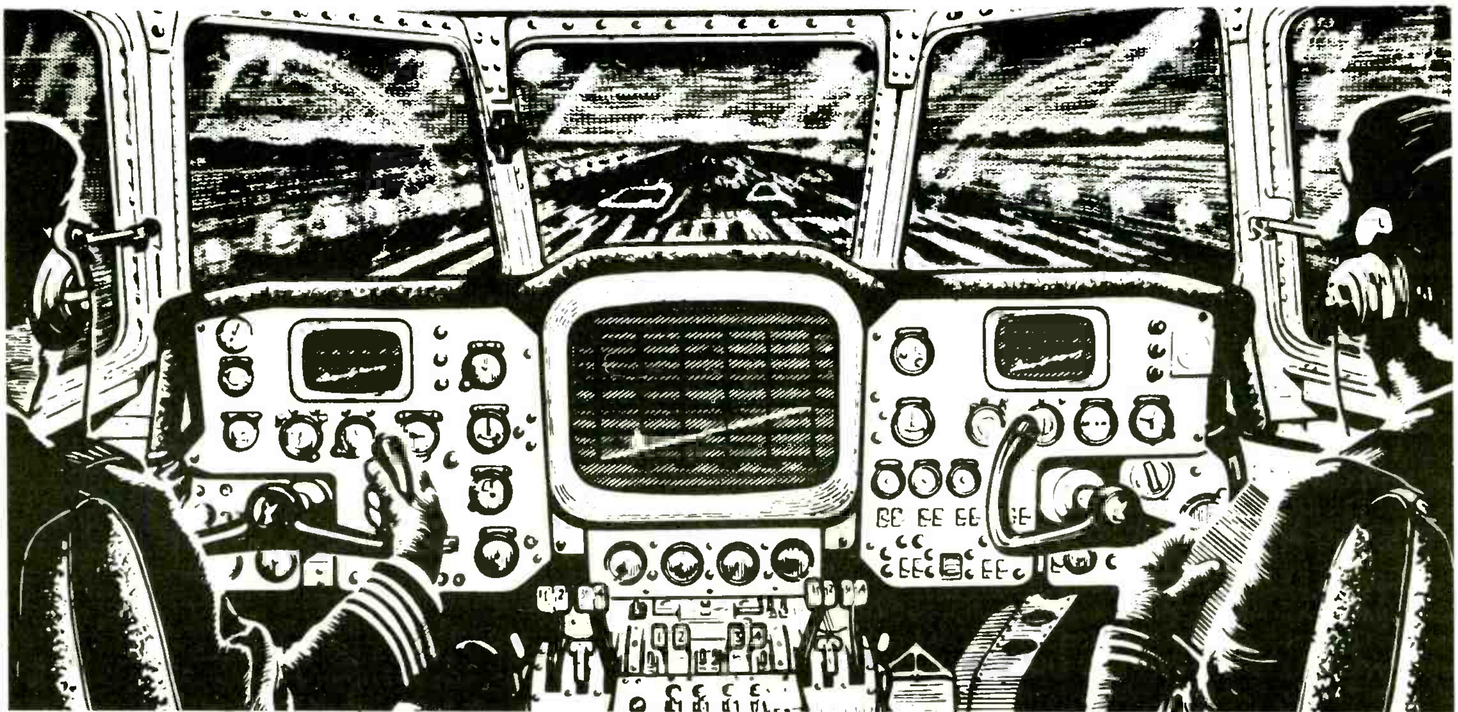
Part of this criticism, which has been maintained until the present day, concerned itself with the scale of the resources that had been made available for the individual projects. The general conclusion reached was that these resources — both human and material — had been totally inadequate; and that, in any case, the scale of effort required for this new technological world in which aerospace and electronics were involved had not even been glimpsed.

Like all such generalised statements, it contained an element of truth in seizing on this 'world' being new; but it did not get anywhere near analysing the root cause of the trouble — the almost interminable delays which individually could stop progress on the project as a whole, until they had been cleared. Thus, on the face of it, this was a matter of insufficient resources.

Clearly it is not possible even to survey briefly all the ways in which such delays could, and did,

1. The 'Flutter Dart' research rocket





2. **Final descent on to the runway with 'derived-information' landing system in use.**

arise with so many *interacting* — mutually dependent — factors combining to obscure completely the real sources of technical failure.

Nevertheless, not only were such intractable — frequently intermittent — 'fault clearance' problems tackled much more quickly than is usually realised; but new techniques and basic principles of attack were evolved which broke new ground for a much wider field than 'aerospace/ electronics'. The latter can be illustrated by looking at the concept of data marshalling which has been taken into a number of fields exemplified by 'Crisis Control'[2] with its original background lying in aerospace instrumentation and aircraft testing. Further instances of this spread into other fields will be given in this series.

Data marshalling, with its definition as 'the separation, streaming and systematic presentation, of "masses of data", has been chosen in this instance to bring out one of the far-reaching and fuundamental problems of aerospace development: to obtain measurement (including 'binary' state) information which can be relied on, and then to interpret it correctly.

Flight trials — dual problem

'Trials' uncertainty and hence delay have two main causes. The first is associated with the success of actual flight trials where the testing and proving of the aero- space systems is obviously utterly dependent upon the 'goodness' of the derived information. There is no need to stress the virtually insurmountable difficulty of identifying (at best) trouble in, say, the main rocket control system when the telemetry (instrumentation) equipment is suspect. It will also be realised that, with unmanned vehicles in particular, there is always an element of doubt when the data coming from an isolated (inaccessible) source cannot be verified. Means for reducing these uncertainties to an acceptable minimum — particularly 'independent check' techniques[2] — are discussed later in this article, where an example will be given of how full advantage was taken of 'having an aircraft available' to investigate and develop telemetry systems, using tv techniques.

The second aspect — associated with interpretation in its widest sense — is concerned with:

(a) the mode of presentation of measurement information so that it is unambiguous and can be read out with the minimum of error; and

(b) the direct data marshalling function of separating out information vital to a specific section of an investigation from an accumulation of data which is so varied in form and so large in amount that it saturates conventional methods of extraction. By the very nature of trials work, these difficulties are particularly great during the early stages of the project; and where the design of the elements in the various systems is far from being finalised.

When these main-system uncertainties are compounded by additional possibilities of error in the instrumentation chain, it is clear that — as noted in connection with 'setting to work' in the first article — the process of reaching a satisfactory solution is extremely lengthy. In turn this means almost invariably that the main project is held up until a final *overall* solution has been arrived at and found acceptable. From talks with engineers in several countries, it can be said that they find it almost inevitable that "at least one crisis" will appear in an R & D programme; and that their main difficulty was to extract the data they needed from the near-infinite amount available to them, if they were to avoid 'shut-down' scale delays. Although extensive theoretical investigation and simulation work had been carried out throughout design and prototype manufacture, both the main and the instrumentation systems were untried in terms of being 'put together' for flight trials and some 'unknowns' were almost certain to be encountered. Also, this was a new world, certainly as far as detailed engineering practivce was concerned.

Thus it says much for the teams themselves and their powers of adaptability that they were able to take advantage of earlier experience and 'know-how' and apply them successfully in this new world. This flexibility in approach was shown to the full in the way in which equipment, e.g. a specific telemetry installation, was, in effect, developed during use and the fresh unknowns thus introduced, were anticipated.

Reducing uncertainties — key divisions

Environmental testing. One of the outstanding features of aerospace development has been the growth of environmental testing, first for individual components, then for, say, a control or telemetry system assembly, and finally for whole rockets or satellites. The range of 'environments' that were simulated grew correspondingly, beginning with variable-frequency vibration, steady acceleration forces (by centrifuge methods), and, — found imperative for telemetry installations, — high values of shock. These various 'mechanical' conditions were then supplemented by three main kinds of climatic - environmental — chamber in which controlled temperature, air pressure and humidity testing could be carried out; in addition, these tests could be made on a long term or cyclic basis[34].

It may be noted that the wind tunnel may be regarded as the earliest form of environmental chamber, but also as providing mechanical-type testing by virtue of the air flow; while one of the largest electronic firms in the UK carried out prolonged vibration tests on radio sets, as mechanical assemblies, well before World War II, by means of an oscillating platform on which the sets were mounted.

Research rocket — the 'Flutter Dart'. It will be appreciated that the cost of setting up a complex wind tunnel testing programme — especially to include supersonic flow — is extremely large; and, in practical terms, can become prohibitive when a number of entirely new testing techniques have to be evolved. Thus if, as with the 'Flutter Dart', a relatively cheap rocket can be equipped with suitable electronically (telemetry) based instrumentation to give the required research information, then testing under 'real' conditions becomes possible; and the need for complex simulation and large-scale facilities generally is eliminated.

Briefly, the Flutter Dart[5] was a five-inch (13cm dia.) solid-fuel rocket with special attachment points enabling wings (and control surfaces) of various configurations to be fitted for testing under accepted flight trials procedures. As the name implies, the rocket and its instrumentation were designed to yield research information on aerodynamic 'flutter' of different wing forms at airspeeds going through the transonic barrier to supersonic values. Flutter, 'divergence' and control surface characteristics were obtained from sampled information telemetered over a time division system with up to 24 channels available. Data sources included accelerometers, strain gauges and a specially designed transducer giving aileron movement, crucial for the flutter measurements.

That this special transducer was developed and built in-house is a telling illustration of how the joint team operated, with — in this case — electronics providing instrumentation required by aerodynamics; and of how, it will be realised, close liaison was maintained throughout between all members of the design and development manufacturing groups. The adaptability shown and the coordination achieved both within the organisation and outside will be brought into the next article.

'Independent check' television development. For this work[6] associated with aerospace telemetry, the primary research task was to take advantage of being able to monitor and control the operation of airborne telemetry-type equipment which normally would be 'inaccessible to human agency'. Also, at the same time as information was being gathered on the specific communication (sender-plus-receiver) channel, it was possible to obtain data on individual telemetry components and sub-systems inserted in the main installation and this included evaluation of television not only as an instrumentation technique in itself, but also as an independent check method for 'difficult' remote measurements. The importance of this last aspect is, if anything, greater now than it was at the time, especially for the emergency conditions of crisis control[2,4], while the wideband information capacity which was provided means that the results obtained have equal relevance today.

Amongst other practical points, flying-spot scanning was employed for the airborne camera chain. This enabled a compact and low-cost assembly to be designed where no external source of illumination was required for the conventional dial instruments being viewed. It should be noted that the data transmitted from them was, in essence, in digital form; while once the data had been, in effect, 'encoded' (brought into video form), no further degradation in its accuracy could take place[4].

Landing systems for 'zero — zero' operation. In 1967 it was possible to write that "Stemming from the original work of the Blind Landing Experimental Unit (B.L.E.U.) of the Royal Aircraft Establishment, and developed under their aegis, the Autoland system has now over 20,000 aircraft landings to its credit".

This quotation, taken from a *Wireless World* article[7], stands on its own as a statement of the success of the development of this automatic landing system. The development programme itself was also a model of its kind with full interchange obviously maintained between the operational side and the system designers, and, in turn, between them and the development teams.

The blind-landing system was based on 'leader-cable' azimuth guidance, and final 'flare-out' descent to the runway under radio altimeter control; in 1967 this general principle was being retained with further development effort largely being given to improvement rather than to

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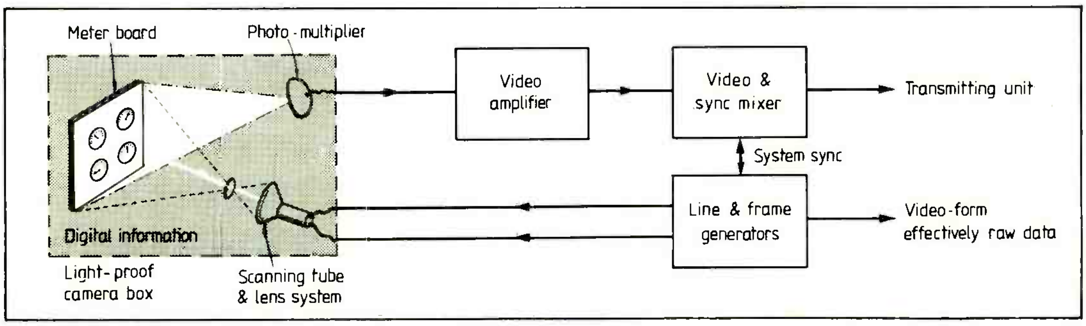

3. **'Flying-Spot' tv telemetering — schematic.**

change of principle. These improvements were, of course, of a major character, especially with regard to replacement of the leader-cable by radio methods.

As indicated in the *WW* article, the problems with leader-cable were essentially those of physical installation, particularly with regard to the need to extend azimuth guidance — and hence the leader cables — to at least a mile beyond the approach end of the runway. In practical terms, this problem becomes insuperable where the runway is built close to the sea or even, in some cases, when access cannot be gained to areas surrounding the airport. In fairness it must be pointed out that radio guidance can suffer from reflections from buildings and imperfections of the site; and the discussion of these aspects was taken further in the 'state of the art' sections of the *Wireless World* article.

Finally, the role of the pilot as a 'systems manager' will be reviewed in the light of suggestions put forward at the end of the 1950s. Some details of these suggestions were given in the article, largely without comment; but they take on a new significance in relation to e.g. control under emergency conditions and to accurate 'at-a-glance' presentation of information. With regard to the article itself, it may be added that it had attracted considerable interest not only in the UK but also internationally, giving, as it did, a comparatively wide picture of British achievement during the pre-1970 period.

Reverting to the question of the suggestions introduced above, they were concerned with presenting to the pilot *instantaneous* information (as far as possible without ambiguity) of this position relative to the runway and the path of his descent to it.

Two basic systems were put forward[8]. The first employed a primary radar in the nose of the aircraft which, with television-type scanning of passive reflector runway markers, gave a picture to the pilot corresponding to what he would see with ordinary runway lighting and clear weather conditions. One of the main advantages of this system is that it is virtually independent of ground installations — particularly telling in remote areas where maintenance of complex equipment may be difficult.

The second scheme — a 'derived-information' system — was somewhat different in that it presented ground-derived (radar) guidance intelligence to the pilot in two ways. For the vertical plane, the display of a pulse height-finding radar — as used in GCA (Ground-Conttrolled Approach) — was sent to the pilot over a television-capacity radio link; and without delay or transfer errors being introduced.

Azimuth guidance was transmitted to the aircraft in audible "dot-dash" or similar form, being derived either from a static radiated twin-beam pattern or a microwave radar system strobing in azimuth[7,8].

The conduct of the research design studies lying behind these two schemes will be examined in the next article in the context of R & D management. An anecdotal illustration of the interchange that took place is afforded by the remark of the test pilot who, on seeing the GCA type height display shown, said that he liked the speed and 'clarity' of the system, but that he "did not think that he would like to see himself sideways on".

This was one of the pieces of evidence which pointed — as one would expect — to the greater acceptability of the primary radar system; although it must be noted that the derived information scheme would enable a monitoring GCA controller to keep in touch with the descent, and to intervene in an emergency with speech superimposed on the 'dot-dash' channel.

These considerations lead to the crux of the pilot's role in automatic landing — the assumption of control in an emergency. The fundamental point at issue is the degree to which the pilot should "surrender his direct authority" during an automatic landing in anticipation of a low-probability emergency[7].

As treated in the next article, this question can clearly be approached in several ways; but in the present context it does appear from the more recent parallel work on crisis control that the primary radar system, in particular, would provide an 'innstantaneous' and accurate independent check on the automatic-landing process. This means that the guidance control data supplied to the pilot should be in such a form that time is not required for analysis and interpretation, so that he can act without delay — due to distraction — in an emergency.

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2. Young, R.E.: Crisis Control, *Wireless World*, June and July 1982
3. Charlish, G.: 'Making sure the product will always work', *Financial Times*, London, Friday March 6, 1964, p.15.
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5. Poole, S., Potton, A., and Titley, C.O., 'Analogue Telemetry Equipment and Systems — Pt. 2', *Electron. Eng.*, London, Vol. 33, No. 396, February 1961.
6. Young, R.E.: 'Analogue Telemetry Equipment and Systems — Pt. 1', *Electron. Eng.*, London, Vol. 33, No. 395, January 1961.
7. Young, R.E.: 'Automatic Landing in Airline Service', *Wireless World*, November 1967.
8. Young, R.E.: 'Aircraft Landing Techniques. . . and the Future', *Electron. Eng.* London, Vol. 33, No. 402, August 1961.

BOOKS

Creative Animation and Graphics on the BBC Micro by Mike James: Collins, 212 pages, soft covers, £7.95, ISBN 0 00 383007 1. Covers animation, sprites, two-dimensional technical graphics (though not graphs and charts), three-dimensional graphics and painting. Examples are in BBC Basic. Many useful tips.

Colour and Mono Television: volume 2, display tubes, timebases, synchronising and power supply circuits, by K.J. Bohlman. Dickson Price Publishers Ltd., 235 pages, soft covers, £8.95, ISBN 0 85380 155 X. Textbook for tv receiver technicians. Many of the circuit examples relate to older sets, perhaps inevitably: there is little enough to see inside the latest ones. For those who collect spellings of 'Schmitt' (as in trigger), there is a novel one here. Schmidtt. Volume 1 deals with the tuner, i.f., video and audio stages; volume 3, to follow, will describe colour decoders and digital circuitry.

The Commodore 64 Roms Revealed by Nick Hampshire with Richard Franklin and Carl Graham: Collins, 215 pages, £8.95, ISBN 0 00 383087 X. The bulk of the book consists of a reconstructed source-code listing of the Commodore roms, with extensive explanatory notes. Other chapters describe memory usage and list main entry points. Essential for the serious programmer.

Commodore 64 Wargaming by Owen Bishop and Audrey Bishop: Collins, 252 pages, soft covers, £8.95, ISBN 0 00 383010 1. Programming techniques and listings for war games in a variety of settings from ancient times to the distant future, and how to adapt and extend them.

CP/M Techniques by Ken Barbier: Prentice-Hall International, 224 pages, soft covers, £19.35, ISBN 0 13 187857 3 (PBK). For the programmer with some knowledge of assembly language. Covers programming techniques, i/o, tricks with discs (both floppy and hard) and customizing your Bios. Good clear explanations.

The Dandy Dipole by Daniel Bostick (WA2ZYR) and Donald Shatraw: Unadilla/Microwave Filter Company Inc. (6743 Kinne Street, East Syracuse, NY13057, U.S.A.), 24 A4 pages, soft covers, $3.95. Good pactical guide for the radio amateur, although rather expensive. Discusses layout, matching, s.w.r., baluns and traps for dipoles from 1.8 to 28MHz, with tables, illustrations and technical details of Unadilla products.

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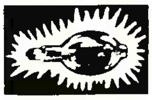

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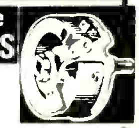

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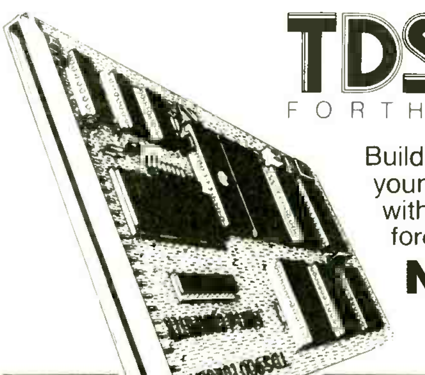

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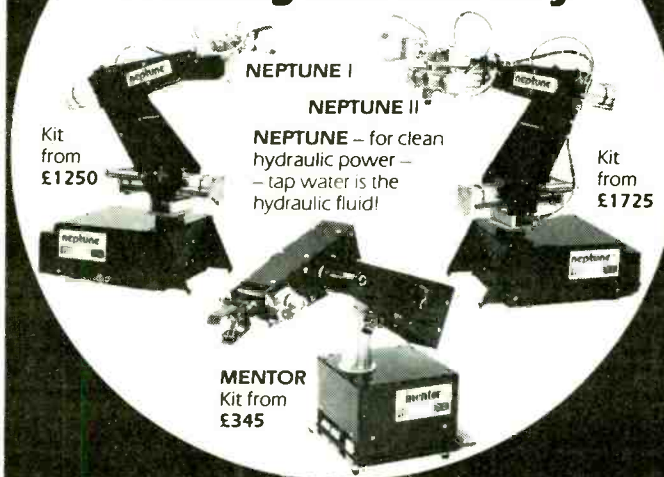

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Electronic altimeter

This low-cost instrument also indicates the rate of climb or descent. Groundlings can use it as a barometer.

by Frank Ogden

The author's version is fitted with straps for fixing to the pilot's knee. To the right of the altimeter display is the variometer, which is sensitive enough to reach almost to full-scale deflection in the lifts at Quadrant House. The black insulating tape is for vibration-proofing.

Proper aircraft instruments are hideously expensive because they have guaranteed accuracy over a wide range of environmental conditions. I fly a microlight aircraft and find little need for instruments which read way beyond the performance limits of the machine. The design outlined here is a combined altimeter and variometer (vertical speed indicator) which provides accurate and reliable readings to transition altitude (3000ft).

Naturally I have optimised the design to my own requirements, but selection of other resistor values would allow the circuit to be used as a weather barometer — there is enough long term stability — or as a straight altimeter reading to 20 000ft and beyond. It would be more difficult to incorporate a vario function on the extended height scale, though.

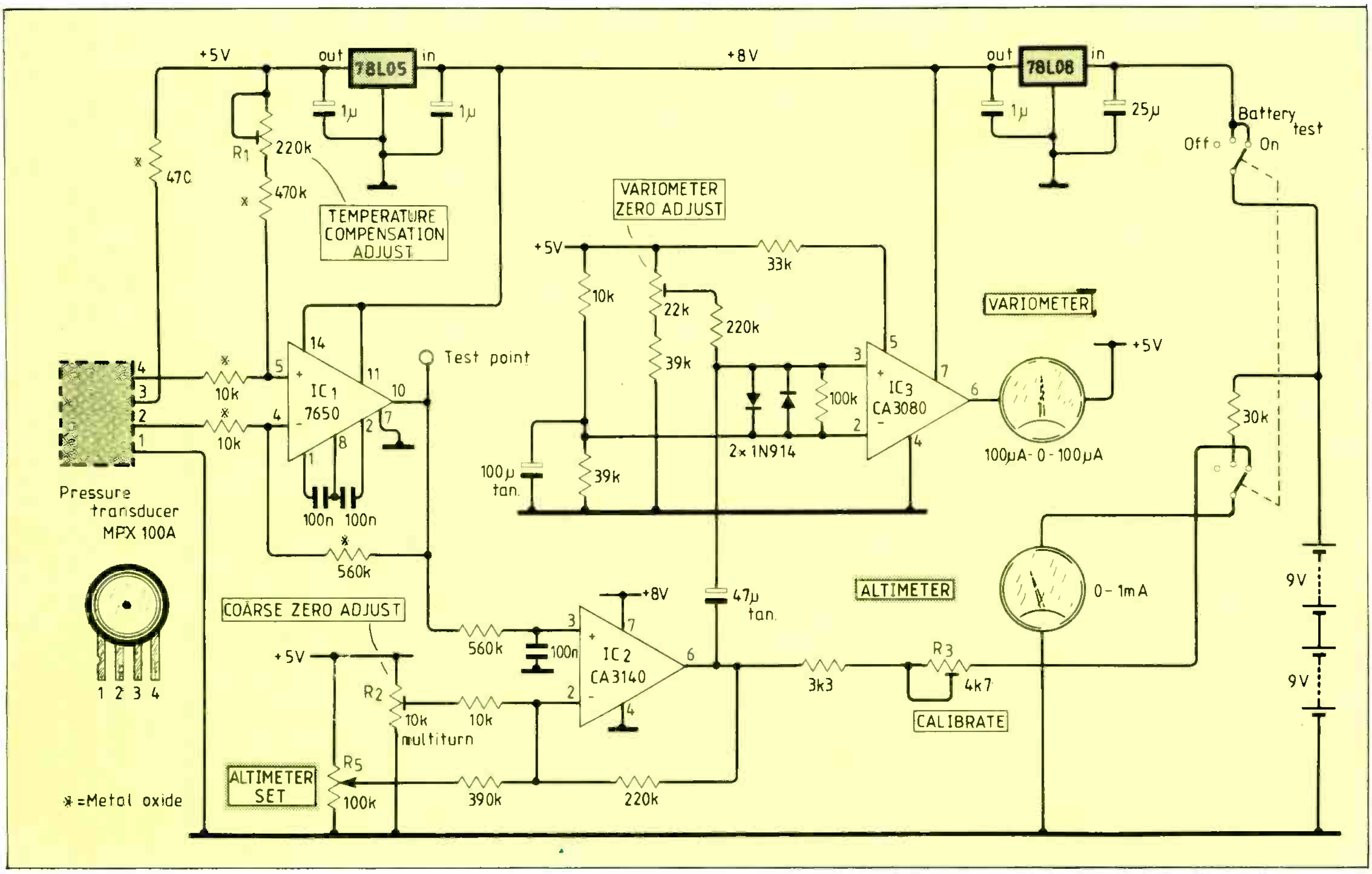
The design is a true aneroid barometer. The pressure transducer, an MPX 100 manufactured by Motorola, was intended as a cheap and cheerful unit to measure the vacuum in an induction tract for automotive fuel injection systems. Designed to read over the range 0 to 15p.s.i., it comprises a silicon strain-gauge configured as a Wheatstone bridge with an in-built vacuum chamber under the silicon die. Variations in air pressure cause flexing of the gauge resistors. This leads to a voltage change across the bridge of roughly 1mV/1000ft (30mbar).

IC_1 is a chopper-stabilised op-amp connected in the differential mode with a gain of about 50. Thus the output at the test point (pin 10) would show a 1V positive change for an increase in height of 20 000ft.

Anyone who wishes to make a large-range altimeter should note this. A digital voltmeter module with a scaled f.s.d. of 1V (reading 1999) connected to this point would make a very effective digital altimeter with a resolution of 10ft. Note however, that liquid crystal displays tend to fade at the low temperatures associated with this altitude.

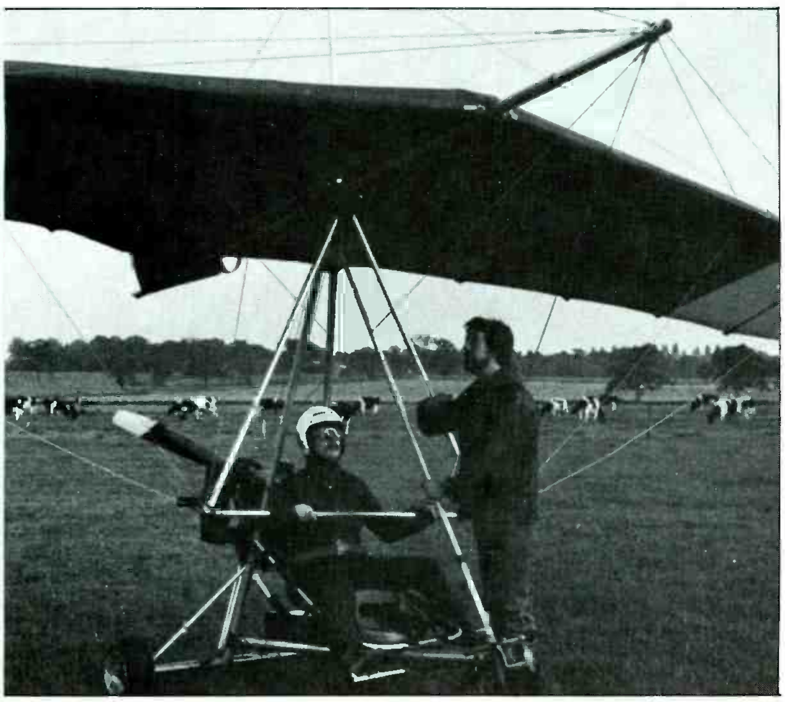
IC_2 provides further voltage gain, about 20 times with the resistor values shown, and also acts as a buffer for IC_1. This is important because the current output of the 7650 chopper amplifier is very limited. The voltage change at pin 6 of IC_2 is about

The pressure transducer can be ordered through Motorola distributors, including Hawke Electronics (45 Hamworth Road, Sunbury on Thames, Middlesex), who list it at £11.50 plus v.a.t. An equivalent device is the Sensym SPX100A, stocked by Farnell Electronic Components (Canal Road, Leeds LS12 2TU) at £20.35 plus v.a.t.



Pressure transducer is a low-cost device intended for the motor industry. Temperature compensation is achieved by the 7650 chopping op-amp and a Wheatstone bridge circuit.

1V/1000ft, which is available to drive a meter movement for altitude indication. The resistor and preset associated with the meter movement are for altimeter calibration purposes. The original design used a 1mA instrument; other movements could be used provided that a suitable scaling resistor chain is provided.



The altimeter was designed for low cost flying such as microlighting. Here the author prepares to get airborne in a 40hp Striker, G-MJPJ.

The main reason for wanting a large voltage change with height is that the vario circuit can then be very simple. IC_3 is a transconductance op-amp (voltage in, current out) connected directly to a centre-zero meter movement.

A low-leakage tantalum bead capacitor couples the voltage changes at pin 6 of IC_2 to the input of IC_3. This translates any changing voltage into a static output current proportional to the rate of change of the voltage and deflects the centre zero meter, giving an accurate indication of rate of climb or descent.

As shown, the circuit is sensitive enough to produce deflection by just running up or down a flight of stairs. In keeping with the requirements of hang gliders and microlights, it is much more sensitive than standard aircraft varios. Maximum output current from IC_3 is controlled by the single programming resistor attached to pin 5.

Power is provided by a couple of PP3 batteries: total current drain is about 18mA. The cascaded voltage regulator chain ensures that the 5V supply which powers the transducer and other components is of extreme stability over the life of the batteries. The circuit will operate down to a combined battery voltage of about 11V.

My original was built on Veroboard and housed in a small ABS box. Layout is uncritical but care should be taken to avoid voltage gradients around the front-end components. Leakage through the board around the input pins to IC_1 can cause 'noise' to affect the vario. A good soaking with Damp Start or other proprietary water-repellent silcone compound is a good idea. Guard bands around the input circuitry may also be useful. The keener contructor — not me — would want to make a proper p.c.b. using glass epoxy material, finally passivating with some sort of conformal coating.

Setting up the circuit is a little bit involved because most of the adjustments are interactive. Preset R_1 controls temperature compensation. R_2 provides coarse adjustment of output voltage. R_3, instrument calibration, should initially be set to its minimum value.

The most pressing design problem with any electronic altimeter circuit is the removal of temperature drift. The silicon strain-gauge resistors in the transducer possess an extremely large temperature coefficient. The Wheatstone bridge connec-

Continued on page 41

The new logic symbols — 3

by Ian Kampel, M.I.E.R.E.

This third and final part considers the practical aspects of implementing the standard.

Part 1 of this series gave a preview of a complex symbol in Fig. 8. This figure will now be explained in detail, and for convenience, is repeated as Fig. 27. It depicts what amounts to three separate logic functions in one symbol, and this is achieved by embedding common control boxes, as may be seen. This is, in fact, the 74690 device. An outer multiplexer (MUX) block has embedded within it a 4-bit register; the register block has embedded within it a 4-bit synchronous counter.

For the moment let us leave aside why one should want to condense all these functions into one symbol and instead consider the meaning of the symbol, for in so doing, we shall also see how the same logic functions may be represented at different levels by means of the new logic symbols.

The easiest way to explain the logic symbol shown in Fig. 27 is to show a simplified lower-level representation of the same logic functions in Fig. 28. Here may be seen the three primary logic functions, and suddenly the whole thing becomes much more simple.

The following explanation of the device's function is applicable to either figure since identical labels have been employed. The counter/divider is a decade counter (signified by the '10' after the 'CTRDIV' portion of the general qualifyiing symbol. The input on pin 13 selects mode (high for count or low for load). Pin 1 is an active-low counter-clear, and the ripple-carry output on pin 19 goes high at a count of 9 (CT=9), subject to Anding with input ENT. Parallel loading is performed at the A, B, C, D inputs when pin 13 is low (Mode 1), in response to a clock pulse at pin 2. Pin 2 has an alternative function signified by that portion of the label to the right of the solidi: the counter is clocked by a pulse at pin 2 provided that pin 13 is high (Mode 2) and both enables (G3 and G4) are high. The '+' sign signifies an 'up' counter.

The 4-bit D-type register is used to staticise the output from the counter when clocked by a positive-going pulse applied to pin 9. This register may be independently cleared by a low on pin 8.

The output multiplexer selects either the output from the register if the select input on pin 11 is high (dependency label 21 true), or the output from the counter if the same pin is low (dependency label 21 false). Three-state outputs (signified by the inverted triangle on the four outputs) is enabled by a low on pin 12 (EN dependency labelled 23).

The above is readily followed with respect to Fig. 28, and if this is firstly understood, the explanation of the symbol in Fig. 27 follows by comparison. Note that Fig. 27 divides the three separate functions into what amounts to three vertical columns, and the inputs to each segment of the common control blocks correspond to those taken to the different common control blocks in Fig. 28. Because of the need to take an output from the inner (CTRDIV10) common control block (to pin 19) it has been necessary to introduce interconnection dependency in Fig. 27 (Z22). Particular note should also be taken of the two horizontal sections of the upper element of the array portion of the symbol; this enables the two alternative inputs to the multiplexer to be shown with their respective dependency labels; as explained previously, it is implied that the same rules apply for the lower elements in the array (i.e. all bits feed a register and an output multiplexer).

Getting the level right

I would now like to consider the practical aspects of different levels of representation. The forgoing example has clearly demonstrated two important points about the new logic symbology:

(a) the form is dependent upon the originator;

(b) the level of representation is variable for complex functions.

I believe that the level of representation should be selected with the purpose in mind. If the simplest representation for understanding the logic function is required, then this must be a merit judgement. If the most compact form of representation is required (say on a compact circuit diagram) then a complex condensed symbol may be used.

Let us consider the two alternatives shown in Figs 27 and 28. The device manufacturer may choose to use the complex symbol given in Fig. 27 because it takes less space on his data sheet. To the newcomer to the symbology it is more difficult to understand this than the expanded version given in Fig. 28, but with regular use and familiarity, it is perfectly adequate. The device manufacturer could also legitimately argue that this complex symbol is an alternative to the simple and uninformative rectangle which would have been used prior to the new symbology, and that as such, it is a great improvement, since the full logic functions are represented (for those who can understand it).

On the other hand, if the purpose is to explain the purpose of the device to someone not

Further reading

IEC Publication 617:12, Graphical Symbols for Diagrams: Binary Logic Elements. (This is the international standard which has resulted from discussion by all participating countries, and this forms the basis for all complying national standards). International Electrotechnical Commission, 1 Rue de Varembe, Geneva, Switzerland.

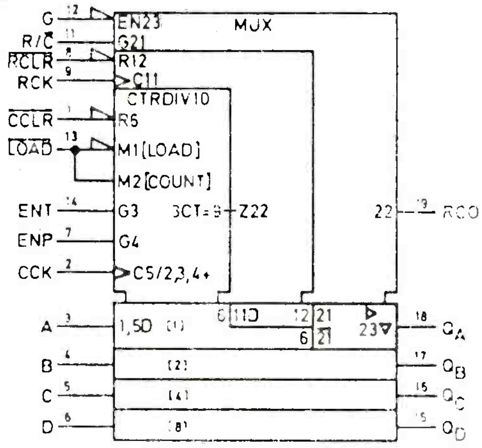
British Standard 3939: Section 21, Graphical Symbols for Electrical Power Telecommunications and Electronics Diagrams: Binary Logic Elements. (This is the relevant British Standard. At the time of writing, Issue 3 is expected to be published in the Spring of 1985, and should be identical in detail to the IEC publication mentioned above). British Standards Institution, British Standards House, 2 Park Street, London W1A 2BS. (Telephone: 01-629 9000)

A Practical Introduction to the New Logic Symbols by Ian Kampel. (Butterworth Scientific Ltd).

Acknowledgements

The author is greatly indebted to the following: D.B.J. Hicks of the British Standards Institution, C.J. Stanford and L. van Rooij, General Secretary and Deputy General Secretary of the International Electrotechnical Commission, for their invaluable assistance in the research work for my book, N. Warnock-Smith of Butterworth Scientific Ltd., for his kind co-operation in the use of illustrations from my book for this article, and J. Molyneaux, who penned the excellent illustrations.

27



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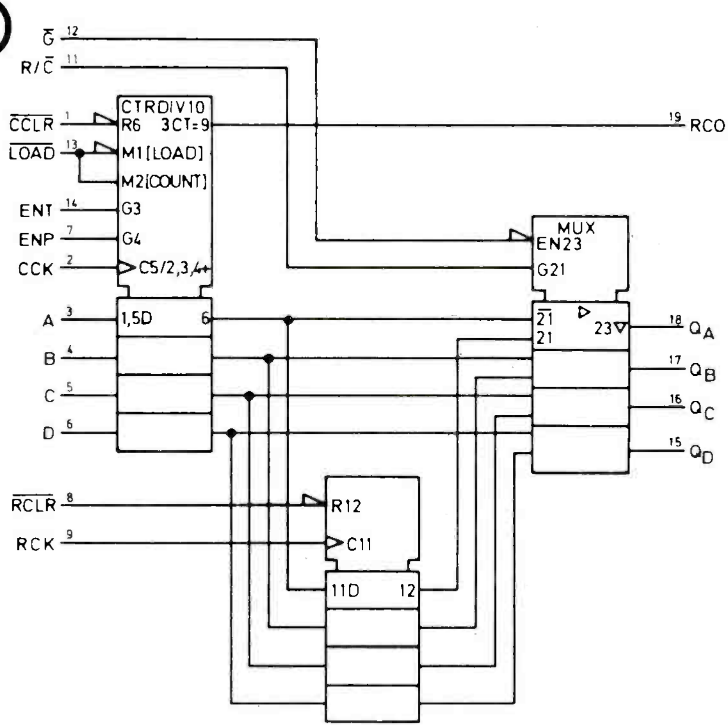

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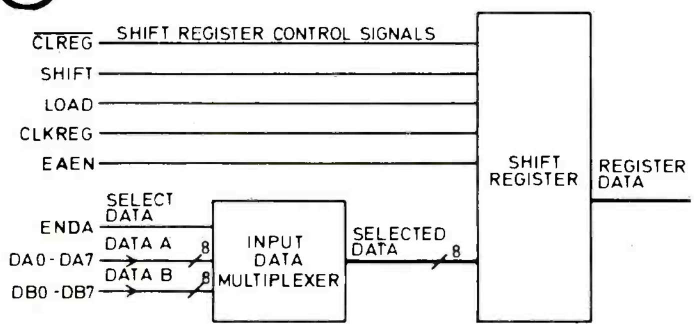

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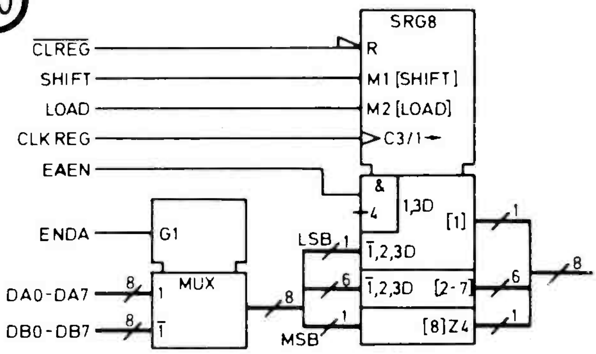

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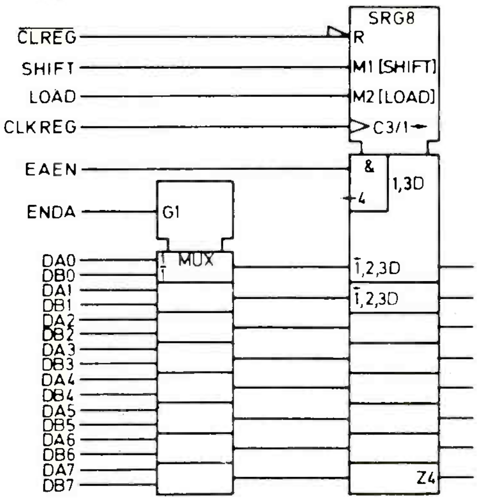

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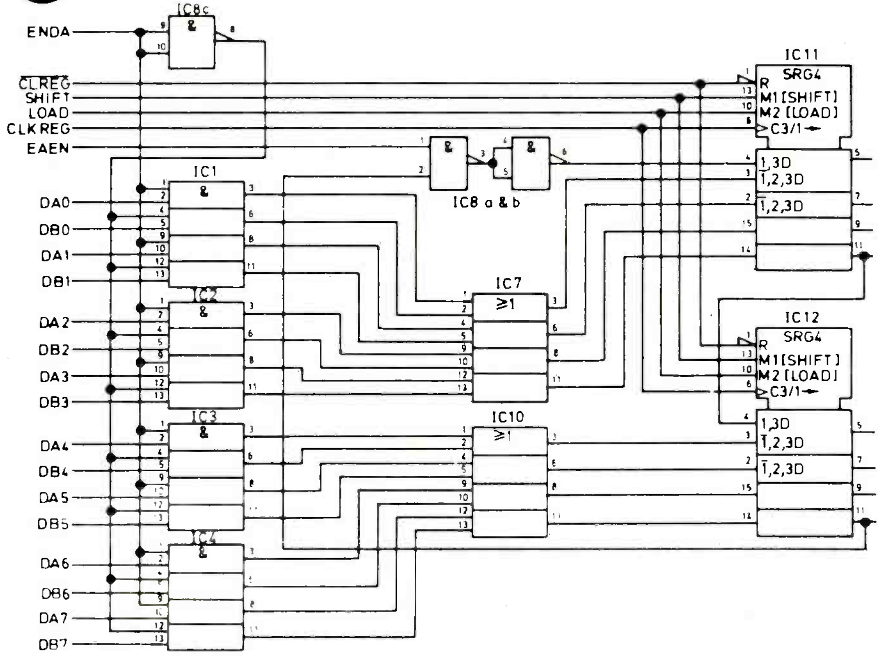

Fig. 27 **Example of a more complex symbol — a 4-bit synchronous counter with output registers and multiplexed 3-state outputs (74690)**
Fig. 28 **Simplified representation of Fig. 27.**
Fig. 29. **Block diagram showing all the interface signals for a circuit.**
Fig. 30. **Pure logic diagram of Fig. 29.**
Fig. 31. **Logic diagram version of Fig. 30.**
Fig. 32. **Circuit diagram version of Fig. 31.**

expected to understand such a complex symbol as that shown in Fig. 27, then undoubtably the version shown in Fig. 28 should be used.

During the transitional period when old and new symbols will exist side by side (as they presently do in a single Texas Instruments data book), I think that manufacturers should provide both versions for a complex device such as that considered here. The compact form can then be used accurately by engineers on logic circuit diagrams, yet the simpler equivalent version is available in the data sheet to aid understanding (for them and the end-user). As time passes, the simpler circuits could gradually be phased out.

Beware of academics

The new logic symbology is a sitting target for those academically-minded persons who might get a kick out of purposely creating over-complex symbols. If the new logic symbols are to be a success, let no one take this particular path, for it will bring forth wrath! *Understanding is the thing,* especially over the next few years when so many are required to learn so much so quickly.

Practical implemention in design groups

I shall finish this series with an example of how the new logic symbology might be used to good advantage in a design group where system engineers, equipment engineers and board designers have to work hand-in-hand. To do this I have taken a portion of a more complex example given in my book on this subject (see Chapter 18 of the book).

Figure 29 shows part of a design requirement at the level that a system designer may wish to consider matters. He wants to multiplex two 8-bit parallel data streams (DATA A and DATA B) and apply the output to a shift register (true, this is too simple for a *system* but a simple example is necessary — this represents a small portion of a much larger design requirement). The block diagram is how he might initially present the requirement. Figure 30, on the other hand, is a representation of the same thing as he can now present the requirement employing the new logic symbols. Where the block diagram left certain aspects in an ambiguous form (e.g. the polarity of the SELECT DATA, SHIFT, LOAD, and enable signals, not to mention the form of clock and direction of shift), the pure logic diagram makes everything clear. It also enables him to show the requirement for an end-around capability controlled by the EAEN input; the block diagram requires many words to make all this clear, whereas the logic diagram using the new symbols specifies *everything.*

Where the pure logic diagram given in Fig. 30 depicts the logic functions in the simplest manner without specific reference to methods of physical implementation, an equipment engineer might turn this into a more detailed *logic diagram* as shown in Fig. 31. This shows the detail of *all* logical relationships but does not, in this case, show the point-to-point wiring. It provides sufficient detail, however, for him to place a specific design requirement for a board designer to follow.

The design engineer receiving the logic diagram shown in Fig. 31 might then produce a *circuit diagram* such as that shown in Fig. 32. (This might be far from an optimum implementation of the design requirement, but does serve to show how a logic diagram and a circuit diagram can greatly differ in form). We can see here that for reasons best known to himself, he prefers to use two 4-bit shift registers than a single 8-bit shift register, and perhaps for economic, supply, or a host of other practical reasons, he prefers to build his own multiplexer with And or Or gates than use multiplexer devices.

Improved clarity

The rather pathetic design implementation shown in Fig. 32 is really chosen to illustrate one of the tremendous advantages of the new logic symbology. Let us now consider the problem in reverse, and assume that we are stuck with this circuit diagram and wish to clearly represent this in a handbook. Figure 31 does just that, in a much simpler form, yet still provides all the necessary information about overall functions including all input and output lines; all that is missing is implementation detail. Figure 30, on the other hand, provides an even simpler representation of the overall function if individual lines need not be shown. Now whilst words may be aded to complement either the logic diagram or the pure logic diagram to explain it more simply, *they cannot convey any extra information about logic function.*

Conclusion

These final examples show the great features of the new logic symbology. *It is both concise and precise.* Amazingly, this statement holds true no matter what the level of representation chosen.

This article can only scratch the surface of the new symbology, and as you will have seen, this is far from a standard for drawing office personnel — it is for *engineers.*

Electronic altimeter

from page 38

tion cancels much of the temperature drift, but the bridge is essentially unbalanced towards the high end of the pressure range.

The full drift voltage with temperature is developed as a large common-mode variation on the input to the differential amplifier. The basic 7650 chop-amp has an exceptional common mode rejection ratio. This is artificially reduced by unbalancing the input circuit through adjustment of R_1, the temperature compensation trimmer, in a direction which cancels any change in the differential voltage across the transducer with temperature. The standing voltage on pins 2 and 4 of the transducer is about 1V: this changes with temperature at the rate of (roughly) 1mV/K.

Having checked that the standing current of the assembled unit is in the region 15 to 20mA, connect a voltmeter to the test point on IC_1. This should read in the region of 0.5 to 2.5V with R_1 at mid-setting. Adjust R_2 such that the output voltage of IC_2 (pin 6) is around 2V. Warm the transducer gently with a hair-dryer and note the direction of any change in output voltage from IC_2. Adjust R_1, noting the direction of adjustment. This will alter the standing output voltage from IC_2. Readjust R_2 to bring the output voltage back to 2V.

Allow the transducer to cool back to room temperature. Warm (gently!) the transducer once more and note if temperature drift is increased, reduced, reversed or eliminated. Repeat the process until any sensitivity to temperature is eliminated. Make sure that the voltage on the IC_1 test point (pin 10) does not go outside the range 0.5 to 2.5V.

With temperature stabilization achieved, calibrate the instrument using R_3. This is best done by comparing readings with that of a certified instrument. Set R_5 to mid position. Set R_3 to minimum. Adjust R_2 such that the readings on both instruments are the same at ground or airfield level. If the airfield has an altitude of above 100ft, readjust both instruments such that both ground level readings are just under this figure.

Fly both instruments up to 1500ft or more. The electronic instrument should considerably over-read. Note the reading of both instruments accurately.

On the ground once more, use R_2 to reproduce the meter deflection achieved at the known altitude. Back off R_3 so that the instrument now reads the same as the certified instrument did at that altitude. Re-adjust R_2 to bring instrument within the normal adjustment range of R_5, the 'altimeter set' control. Finally, carry out a flight check of the instrument against the certified altimeter.

R_4 zeroes the vario. If a less sensitive rate of climb/descent indicator is required, simply reduce the value of the capacitor connected between IC_2, pin 6 and IC_3. Happy flying.

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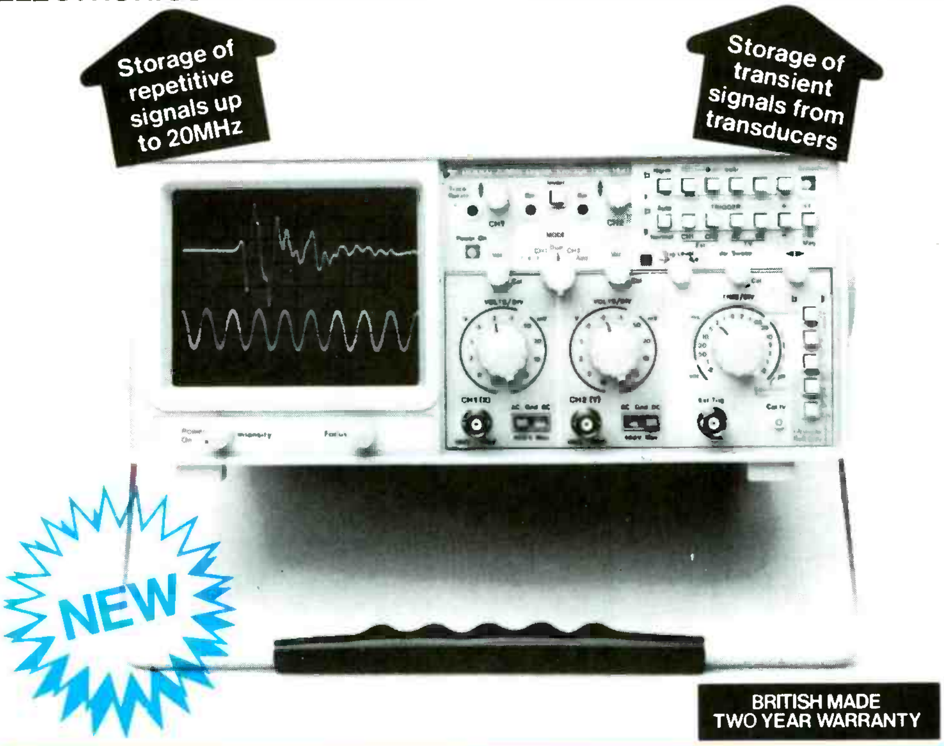

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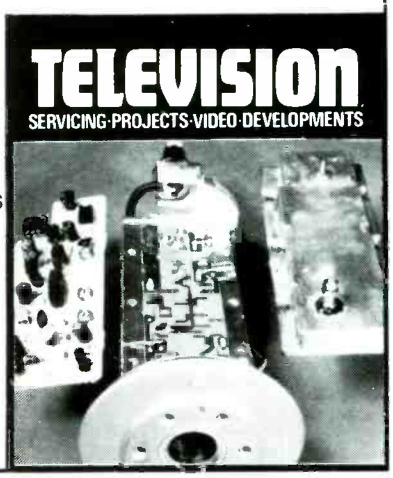


Automatic enlarger timer

by J.L. Linsley Hood

This instrument is intended as a labour saving device in the photographic darkroom in the preparation of enlargements on bromide or similar (black and white) printing paper.

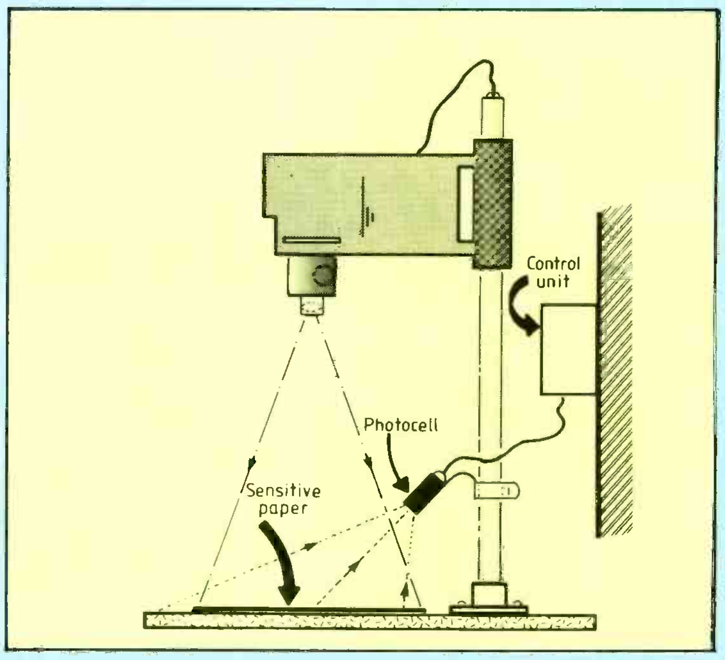


Fig. 1. Layout of reflex automatic photoelectric enlarger timer system

In conventional photographic practice, it is necessary to determine the required exposure of the paper to compensate for variations in the density of the negative, the light output of the enlarger, the aperture of the enlarging lens, and the activity of the print developer, and this is normally done by making a series of test strips having graded exposures, so that the most satisfactory exposure can be determined subsequently by inspection.

The only snag with this practice is that it is time consuming, and if a large number of prints is to be made from negatives having differing optical densities, a large part of the darkroom time may be occupied in making test strips for each negative.

Techniques which have been evolved for minimising this wasted time, determining the required exposure by optical or photoelectric techniques, have relied in general upon the use of some device which could be moved into the region of the projected image so that the enlarger exposure timer could be set, prior to the exposure, to give an appropriate exposure duration. My own thoughts, however, had turned to the possibility of a system which measured the light scattered back from the surface of the printing paper so that the printing exposure could be controlled 'in real time', as contemporary phraseology would have it.

This has the advantage of being much quicker in use, since all that is necessary, when the negative is in place and correctly focussed, is to place a piece of printing

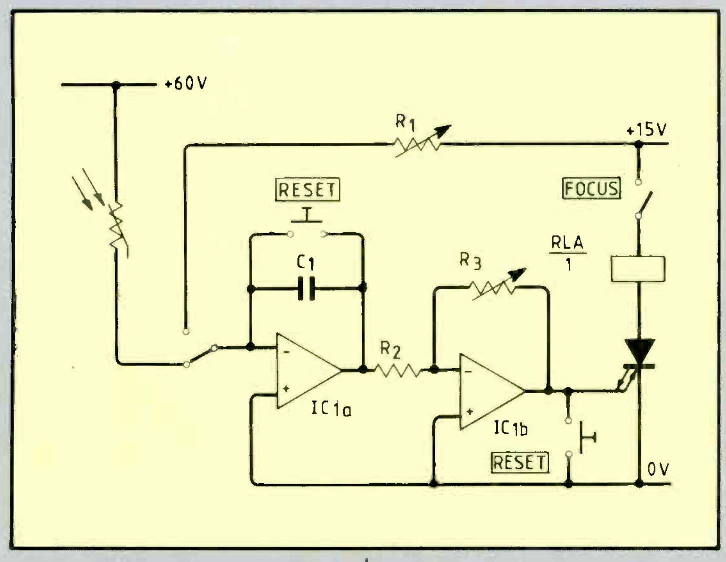


Fig. 2. Basic circuit of timer

paper in the correct situation, and press the 'on' button. The enlarger then switches on for a suitable period, and when the photoelectric sensor judges that an adequate exposure has been given, switches the lamp off again.

I have had such a system in use in my own darkroom for very may years, since I tend to use a 35mm camera as a photographic diary, and I like to print the majority of the resultant negatives to somewhat larger than contact print size. My earliest model used a photomultiplier tube/lens assembly, but this was delicate and prone to damage, and I have, in consequence, revised and updated the system over a period of many years to take advantage of improvements in electronic and photocell technology.

Although a similar system could be evolved for colour printing, there are additional problems there, associated with the colour sensitivity of the photocell in use, and I have not sought to confront these, since my own interests lie mainly in the field of monochrome photography.

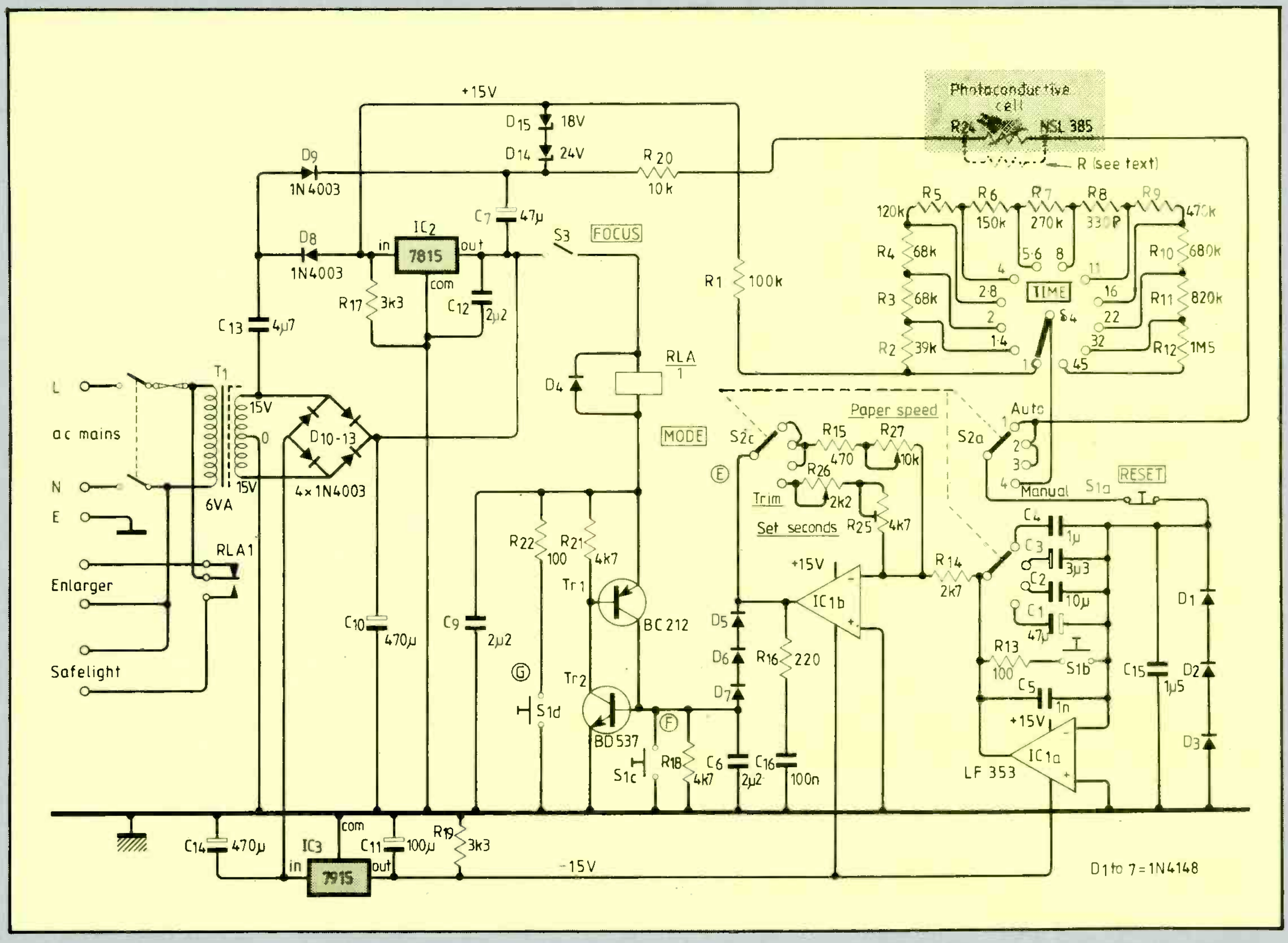
Fig. 3. Complete circuit of enlarger timer

Practical problems

The use of any reflected-light photoelectric system obviously leads to the possibility of exposure errors due to variations in the amount of light reflected from the surface of the bromide paper sheet, in the general layout shown in Fig.1, depending on whether the paper is glossy or matt in surface finish. However, provided that one is consistent in the use of a particular paper type in the making of a series of prints, differences of this kind are merely reflected in apparent differences in paper sensitivity — which will, in any case, probably vary from one batch of paper to another.

A more basic snag, assuming that the photocell viewing system has been chosen so that it 'sees' the whole of the desired printing area, is that the system operates by averaging the print to a notional 'grey' tone.

While this averaging effect, in determining the exposure which is required by the sensitive paper, works surprisingly well with the majority of 'normal' subjects, where the amount of dark tone is balanced by a similar quantity of ligher area, there are, clearly, occasions when the expected appearance of the picture will be light — such as where the bulk of the picture area is occupied by sky, or other light-toned objects. There will also be occasions when the overall tone of the picture will be very dark,



and again the exposure determining system cannot be expected to give an exposure which will produce this effect.

It is therefore necessary to build into the circuitry some control, at the disposal of the user, which will allow him to decide whether he wishes an overall light, or overall dark result. Fortunately, most enlarging papers allow some measure of latitude in printing exposure, which can be compensated for by adjustment to the developing time of the print, where complete development is usually assessed visually, so complete precision in exposure is not normally imperative. Experience suggests that with printing papers of normal contrast an exposure error of ±30%, relative to an ideally correct exposure is tolerable.

In the contemporary version of this instrument, a cadmium selenide photocell is employed, as R_{24} in Fig. 1, housed in a simple tubular holder, which permits a field of view of about 30°, mounted on a bracket on the enlarger column below the enlarger lens. It should be remembered in this context, though, that although it is desirable for the photocell to 'see' the whole of the required exposure area, in order properly to average the subject matter, this metering function also requires the photocell to sit at a constant distance from the printing area.

So, while it is convenient, in practice, for the photocell to move up or down with the enlarger head, if one is making different sizes of prints, in this case it is necessary to recalibrate for each working size. If, on the other hand, it is merely desired to make a similar sized print with the head in another position, thereby giving differing effective enlargements, it is desirable that the photocell should remain in the same position relative to the sensitive paper, when the instrument calibration will remain constant.

To avoid difficulties due to ambient light during the exposure of the paper, the switching circuit in the timer is arranged to switch off the darkroom safelight during the time that the enlarger light is switched on, though if the enlarger is situated in a position where the safelight does not shine very strongly on the enlarger easel, this provision may be omitted.

The effectiveness of the system may be judged from the observation that a series of prints, with the enlarger head in a constant position, and with the enlarger lens head in a constant position, and with the enlarger lens aperture adjusted between f/2.8 — f/16, (an exposure range of 64:1), could be made which were identical in density and contrast, merely by allowing the timer to adjust the exposure duration in response to the light reflected to the photocell.

Since there are occasions when a manual timing facility would be

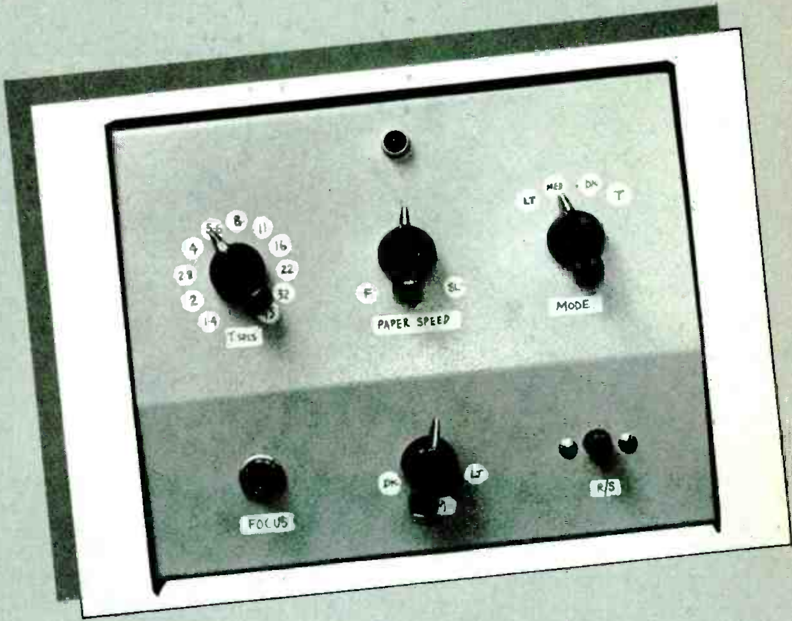
Circuit design

The basic circuit is shown, in very simplified form in Fig. 2. In this, a capacitor (C_1) is charged through either a variable resistor (R_1) to give a manually set time exposure, or through a photocell to give an automatically determined one. The positive-going voltage change, through IC_{1a} and IC_{1b} is used to trigger a resettable thyristor and actuate the switching relay RLA1, which is normally energised in the 'lamp off' condition. A switch in series with the relay allows the enlarger lamp to be switched on for the purposes of inspection of the negative or for focussing.

Because the possible range of illumination levels of the photocell is low, since it is only actuated by light scattered back from the surface of the sensitive paper, and this itself may be relatively dimly lit, it is necessary to use a very sensitive cell. Cadmium selenide photoconductive cells, such as those manufactured by Silonex (formerly 'NSL'), offer an adequate low-level light sensitivity, coupled with an adequate speed of response at these levels to permit a timely cut off of enlarger illumination.

Unfortunately, the penalty paid is that the total current flow through the photo-conductive cell is relatively low, even at moderately high voltages applied to the cell, so the timing circuit must operate at a fairly high impedance. This requirement is easily satisfied by the use of fet input op-amps and polycarbonate timing capacitors.

The desired linearity of the RC charging circuit is attained, even with a simple variable resistor, such as R_1 in Fig. 2, by using $IC_{1(a)}$ as an active integrator. In this configuration, although the potential across the capacitor continues to increase, as it charges, the actual potential drop across the photocell or R_1 remains constant, leading to a linear charging



rate.

The 'gain' of the system; in the sense of the magnitude of the voltage required to be developed across C_1 before the thyristor is triggered; is set by the ratio of R_3:R_2, a value which is determined by the user, and the system is 'reset' following a timing cycle by switches which discharge C_1, and return the thyristor to its formerly non-conducting state.

Many photographic timer systems, devised by electronic engineers for the use of photographers, go to considerable lengths to ensure that the precision of the timing cycle is as high as present circuit technology allows. While I would not wish to decry this attempt, it is apparent that accuracy in timing is usually both more costly to achieve, and more elaborate in its method, than that necessary in a less precise system, and if one is thinking of the cost to oneself, in time and money, of such an exercise, the question inevitably arises as to whether it is really worth all the effort.

I make this point as a photographer, since it is very clear to me that changes, of only a few volts, in the supply voltage to the enlarger lamp, or of a few degrees in the temperature of the developer bath, or of the oxidation of the developer solution, or of the quantity of accumulated bromides in the solution as a consequence of its repeated use, from one print to another, or even of the duration of the print development, can all bring about variations in the print density which greatly exceed those likely to arise through inaccuracies in the timing circuit.

With this reservation in mind, I

Fig. 4. **Author's prototype unit, which can be mounted on a wall. Leads connect to sockets below panel.**

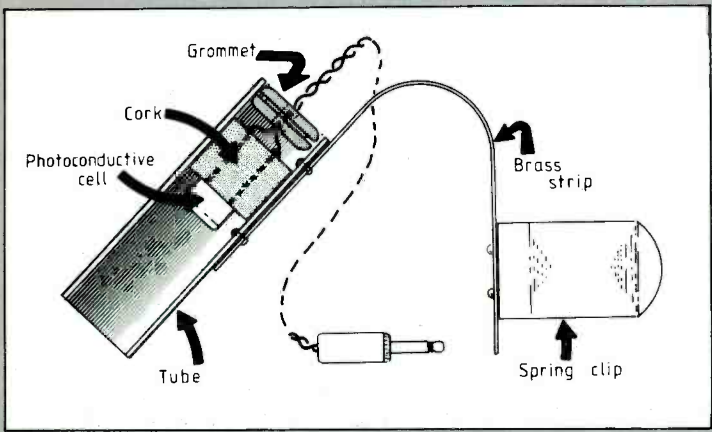


Fig. 5. **Tubular holder for photosensitive cell giving a 30 degree viewing angle. Terry clip fixes to enlarger column.**

have chosen to employ a circuit which is adequate for the purpose in hand, and with no greater complexity or cost than is demanded by its specification, and I have shown the final circuit employed in Fig. 3.

This follows the circuit layout shown in Fig. 3, but with a few additional adjustments being provided. In order to obtain a reasonable operational stability, I have derived a ±15V stabilised power supply from the mains by the use of a pair of 15V i.c. stabilisers, IC_2 and IC_3, while a simple voltage doubler circuit, driving a pair of Zener diodes (D_8,D_9,D_{14} and D_{15}) generates the higher-voltage, very low-current supply for the photo-conductive cell.

'Subject control' (light, normal or dark) and 'Auto/Manual Timing' is controlled by the input switch $S_{2a,b,c.}$ of which the first positions effect only the automatic (photocell controlled) circuit operation. I have chosen the timing capacitors in these positions to give exposures in the range 1:3.3:10, as offering, in practice, a reasonable approximation to the average print density of a high-key, normal, or low-key presentation.

In the manual timing position of this switch, a chain of resistors, connected across the poles of switch S_4, (R_2-R_{12}), provide a sequence of timing durations in the ratio 1:1.4:2, etc., which offers the practical convenience that each step will allow a comparable, and useful increment in print density, and a two-step movement, up or down, will double or halve the given exposure.

A preset control, R_{25}, allows the timing period to be adjusted to the correct seconds value, with the 'Trim' pot. R_{26} set in the middle of its travel. In the other limb of switch S_{2c}, R_{27} gives a 'Paper Speed' control. I will discuss the functions of these controls later, when I describe its method of use.

The diode chain D_1—D_3 prevents the input voltage applied to the input of IC_{1a} from becoming too positive when the timing cycle continues beyond the normal time of completion, and the diode chain D_5—D_7 sets a 2V nominal trip level for the 'resettable thyristor' Tr_1, Tr_2 returned to its non-conducting state by $S1_c$.

A minor snag which arises when transistors are coupled, in the manner shown, to simulate thyristor action, is that, because of the high current gains and high transition frequencies of the devices which must be used, the transistor pair is very sensitive to inadvertent triggering by short duration, fortuitously arising voltage spikes at either its input or its output connections.

The capacitors C_6, C_9 and C_{12}, which should be non-polar types, are included to avoid this possibility. Resistors R_{17} and R_{19} are included to discharge the supply line capacitors following switch off. The photocell R_{24} normally performs this function for the +57V line and R_{20} limits the possible current flow through R_{24} and D_1—D_3 under strong illumination conditions.

As mentioned earlier, the darkroom safelight is switched off during the time that the enlarger lamp is 'on'. This function is accomplished by the relay RLA1.

The whole unit is mounted in a small sloping panel earthed metal box, fixed to the darkroom wall, close to the enlarger, to prevent actuation of the switches causing undesired enlarger vibration, and is shown in Fig. 4.

Method of use

Over the years I have experimented with various photocell housings, and have ended up with the very simple layout shown in Fig. 5. This is held on the enlarger column with a 'Terry' clip — since it is very light, strong fixing is unnecessary — so that it can be positioned as I have sketched in Fig. 1 and receive light from the desired printing area.

Stray light around the edges of the negative, which would give misleading results, is masked off at the negative stage — this is, in any case, good photographic practice if the worker wishes to preserve the highest degree of brilliance and sparkle in his prints.

Setting up the 'manual timing' chain to give time intervals reasonably close to the specified values should not be too difficult if one chooses a time duration position of, say, 16 or 22 seconds, and then adjusts R_{25} to give the best fit. The 'Trim' control, which should be positioned in the centre of its travel for this purpose, is then used, in practice, if, for example, a print exposure duration of 8 seconds is thought to give slightly too light a result, and 11 seconds is thought to be over-generous in exposure.

The use of the 'Automatic' function, may, however, call for a little more experimentation, since the light falling on the photocell is very dependent on the geometrical layout of the enlarger easel and photocell mounting. Ideally, a 'normal' type of print, which will, again depend on the photographers typical subject preference, should be rendered to its best advantage with S_2 in the position which gives C_3 as the timing capacitor, and with the 'Paper Speed' control in the middle of its travel for a normal paper/developer combination. This will then allow some scope for compensation for print variables in normal use.

If it is found that C_2 or C_4 give better 'normal print' results, with the photocell assembly employed, the values of C_2,C_3 and C_4 can be modified in the light of these experimental results. It should be remembered that papers do vary quite a bit in effective speed, from one to another, with modern 'resin-coated' bromide papers being the fastest, fibre-based chlorobromides being the slowest, and with variable contrast papers (relying on light filtration for change in contrast) lying somewhere between these extremes.

It is also useful to remember that papers will have a higher effective speed in a 'PQ' than in an 'MQ' developer, and with a warm developer, as compared with a colder one, and with developer which is fresh, as the beginning of the print session, as compared with the rather more tired solution of an hour or two later, so too hasty a judgment of component value modifications for C_2—C_4 or R_{27} should not be made.

Very low light level linearity in the photoconductive cell response may be assisted if a resistor, in the range 150-300 Megohms, is connected in parallel with the cell. A low level of residual ambient light — from a remote safelight, or from the enlarger lamphouse — may achieve the same result.

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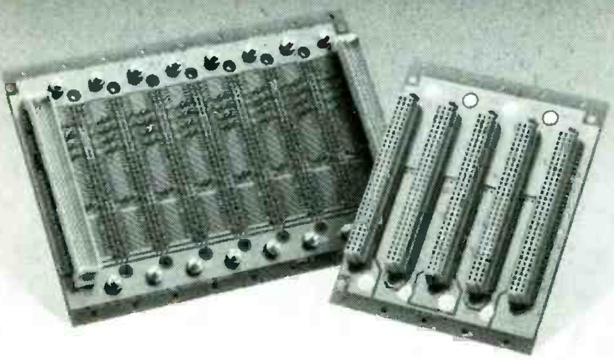
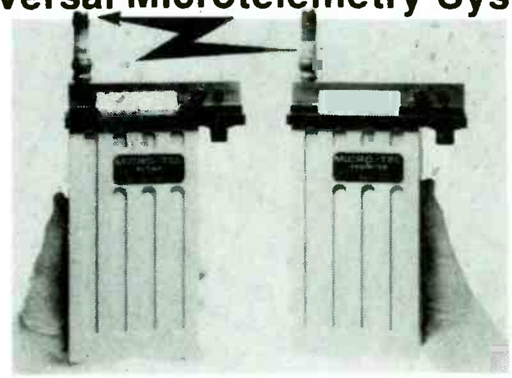




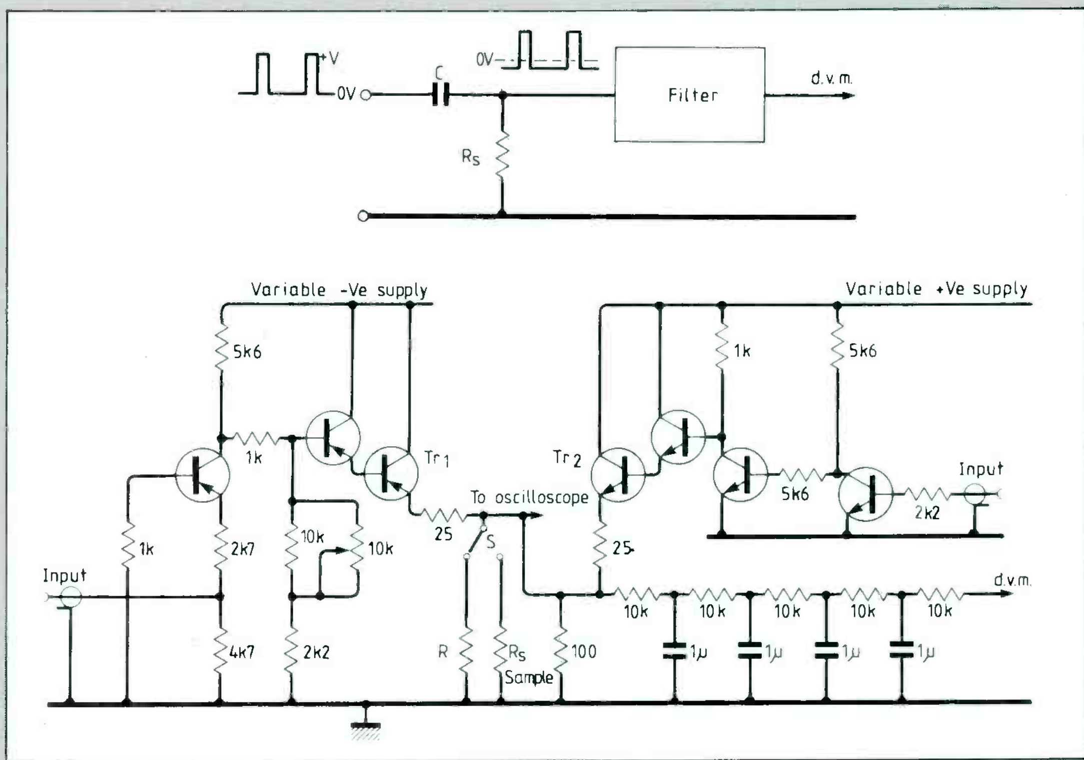
Pulsed hot-strip measurements

The origin of a metallic resistor's non-linearity lies in its temperature coefficient and the thermal properties of the substrate, which is usually an insulator. Thermal properties of the insulator, such as thermal conductivity and thermal diffusivity, are determined by the circuit shown in the small diagram.

A train of pulses of a fixed period and duty cycle is applied to the non-linear resistor, R_s, through a suitable blocking capacitor. Average voltage across R_s is then measured with a digital voltmeter after filtering. This average voltage should be zero if there is no non-linearity as the capacitor causes a base-line shift to ensure that no net charge can flow over a complete period.

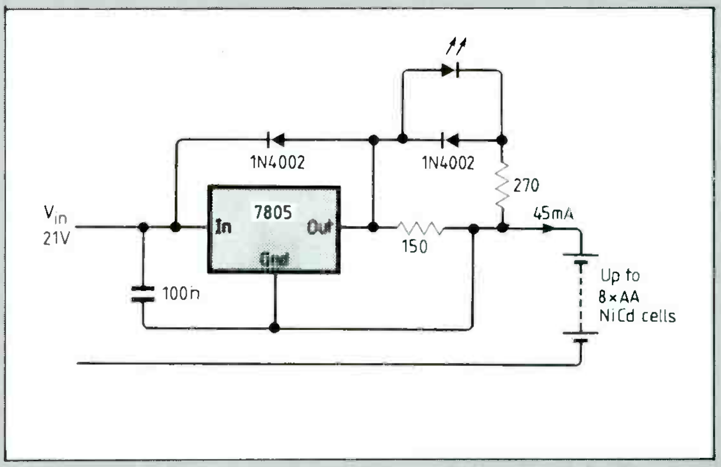
Measurements of this kind at low frequencies (large duty cycle and long period) are however made impossible owing to the need of a prohibitively large capacitor, especially if the sample resistance R_s is small.

We designed a new circuit to overcome this difficulty. It simulates the action of the blocking capacitor, irrespective of period length or duty cycle. Essentially, the circuit consists of two current sources, one positive, the other negative, and so generates a base-line shifted waveform of the type shown in the small diagram.



The positive and negative current sources are switched on alternately. Linear resistor R has a value equal to cold-sample resistance R_s. Amplitudes of the current pulses are adjusted using R, the variable power supplies and the 10kΩ potentiometer so that the voltmeter reads zero. The required average voltage across R_s is then obtained using the switch to bring R_s into the circuit. Transistors $Tr_{1,2}$ are power devices.

Ijaz-ur-Rahman
Quaid-I-Azam University
Pakistan



NiCd charger

An indicator on this simple 45mA charger for AA cells shows whether or not charge current is flowing and not just that the charger is switched on. Two further diodes protect the i.c. and led against reverse bias when power is removed.

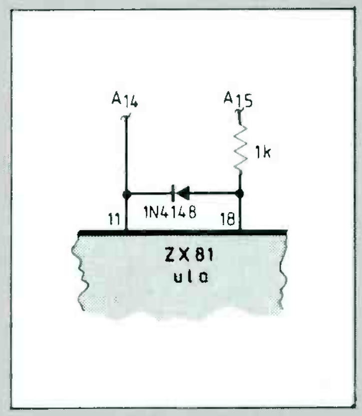
A.R. Walker
Brighouse
Yorkshire

Cheapest ZX81 memory expansion

Owners of a ZX81 with a 64K memory expansion can use this tip to increase the amount of memory available for machine-code programs by 16K. Hardware required is just a resistor and diode.

Machine-code programs cannot be run above 32K because of the way in which the tv-display output is produced. Each time the u.l.a. senses that address line A_{15} is high and $\overline{M1}$ is low, indicating that the processor is looking for an instruction op-code fetch in the 32 to 64K area, it starts working on the display.

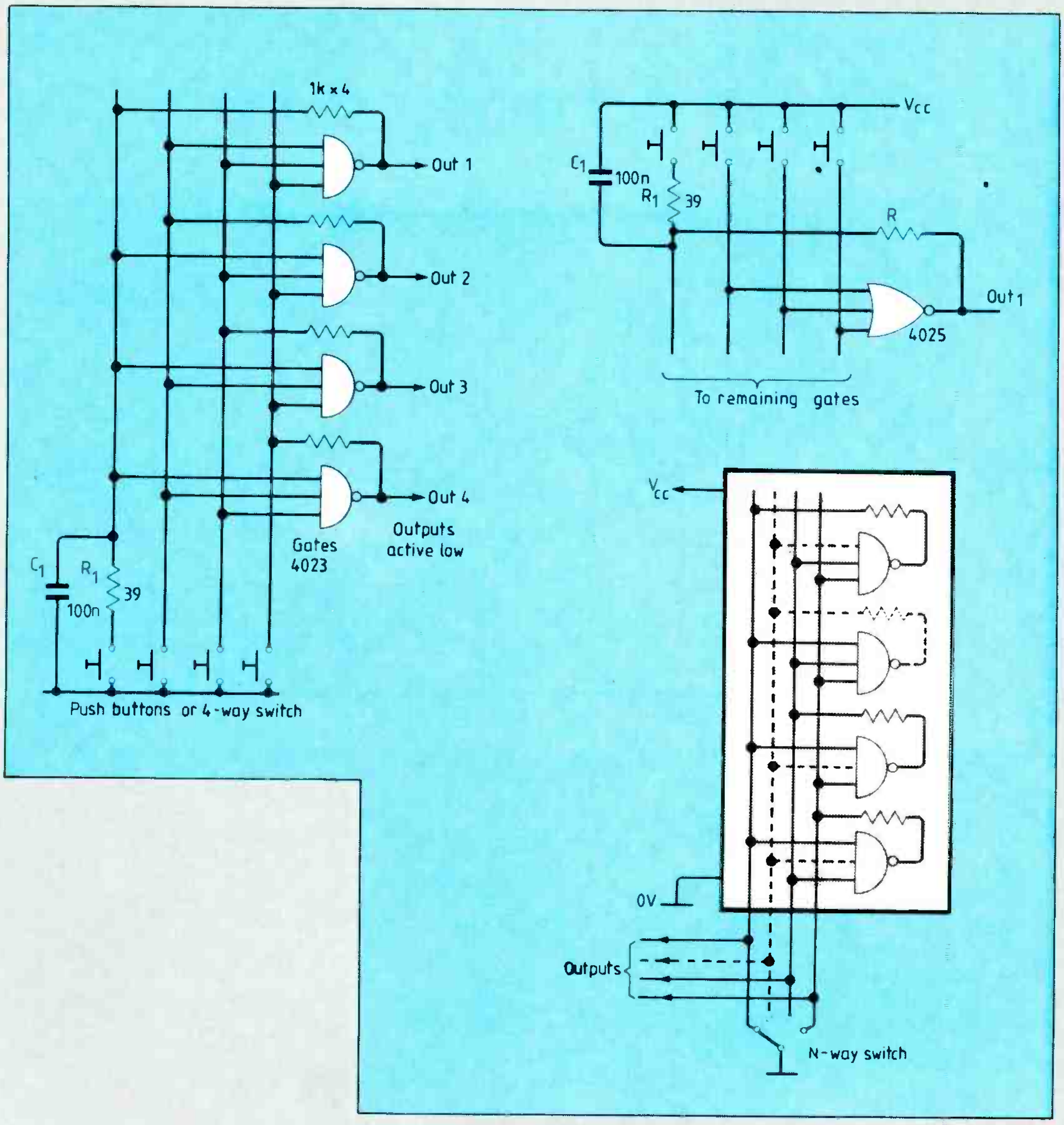
My solution is to change the circuit so that the u.l.a. A_{15} input only goes high when both A_{15} and A_{14} from the processor are high. The modification requires cutting the track carrying A_{15} close to the u.l.a. and adding a resistor and diode.



On an issue three computer, the most convenient position for these components is in the u.l.a. socket under the i.c.

This change makes it possible to run machine-code programs all the way up to 48K. The disadvantage is that Basic programs have to be shorter than 16 467 bytes, excluding variables, to keep the display file below 32K. Is there a ZX81 program that doesn't fit in that space?

Christofer Tolis
Stockholm
Sweden



One-in-n-way latch

Contact debounce, a predetermined power-up setting and simplicity are features of this one-in-n-way push-button latch. When any button is pressed, its corresponding button line is taken low, forcing all others high. Only one line can be low at a time.

Resistors are included to prevent shorting of the gate outputs and an optional RC element makes sure that the first line is selected at power up. Further gates and button lines may be added following the same principle, i.e., each gate must have inputs connected to every button line except its own.

A Nor-gate version with active-high output is shown in the second diagram. The circuit seems suitable for monolithic implementation since the inputs and outputs can share the same pin if necessary as shown in the third diagram. Using this method, a 14-pin dil package could provide latching and debounce for a 12-way switch. Power-up setting would be achieved as in the first diagram using an external RC element.

Louis D. Thomas
Comdial Comms Systems
Pentwyn
Cardiff

Resistance-indicating continuity tester

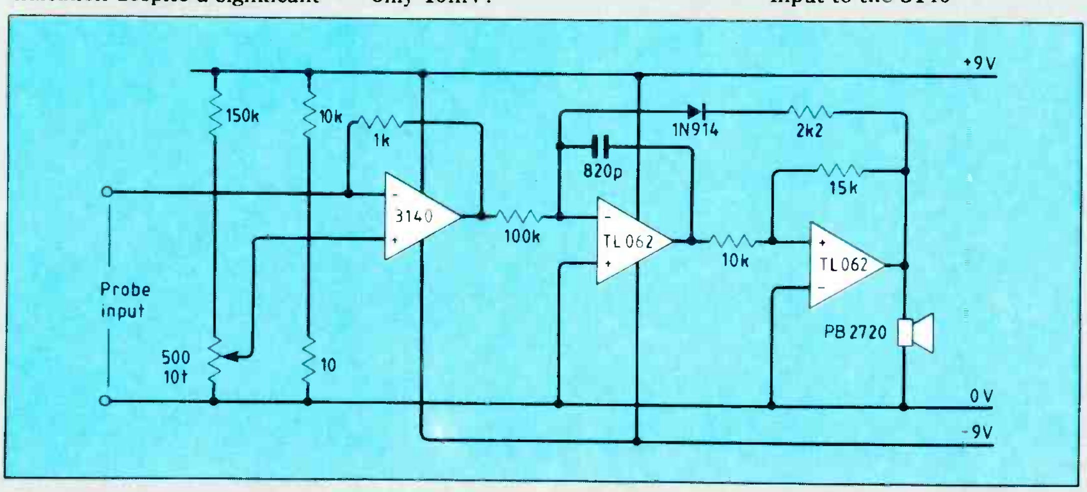
Continuity testers giving simple on/off indications have always been useful for circuit checking. There are many occasions though when a continuity indicator will give a short-circuit indication despite a significant resistance between its terminals. This instrument gives an audible indication of residual resistance of the nominal short circuit and its open-circuit probe voltage is only 10mV.

Two TL062 i.cs form a simple oscillator whose input frequency is determined by the small input voltage fed to it by the 3140 through 100kΩ resistor.

Input to the 3140 comes through a resistive bridge.

When the probes are open circuit, the bridge is in balance (set by a 500Ω, ten-turn potentiometer) and no output occurs. When the probes are shorted, the bridge becomes totally unbalanced and there is a high-pitched sound from the piezoelectric buzzer. Any small resistance between the probes moves the bridge toward its balanced condition and reduces the pitch of the note.

Residual resistance ranges other than 10Ω are produced by changing the 10Ω resistor. We found that using two resistors of 1 and 10Ω and selecting them by a switch is most useful.



T. Lavin and R.T. Irish
Royal Military College of Science
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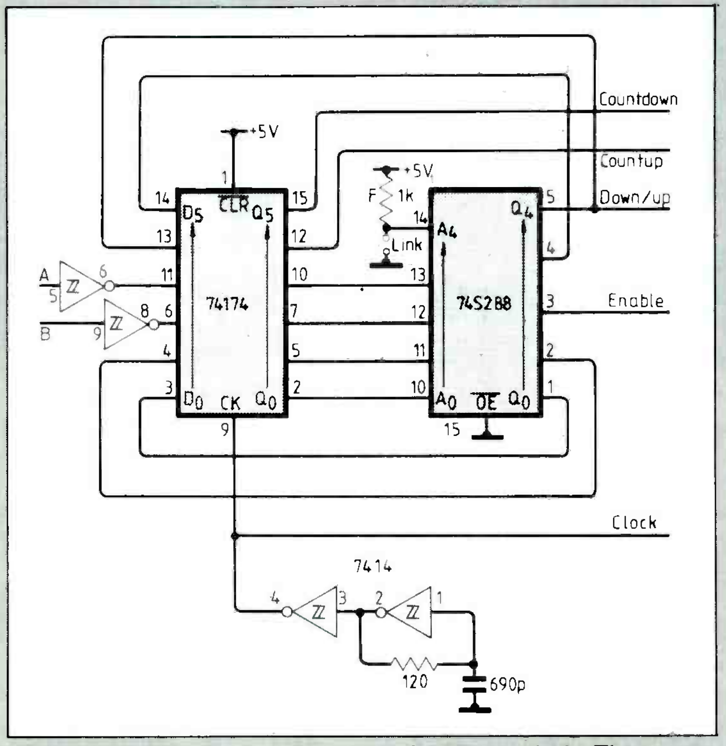
Wiltshire

Shaft encoder interface

This is an interface between an optical incremental shaft encoder and a counter, designed as a finite-state machine. Although finite-state machines have been used for a number of years to implement sequential logic functions, the cost and complexity of designs using standard logic gates and bistable i.cs has restricted their range of applications. However, availability of read-only memory (rom) at reasonable cost makes the state machine an attractive solution to sequential logic design.

This interface drives 74190/191-type synchronous counters and asynchronous 74192/193 types. It uses a 74S288 32-byte prom programmed with the data shown later. Five outputs are provided: COUNTUP and COUNTDOWN, which may be used with 192/193 counters, and ENABLE and UP/DOWN for use with 190/191 counters. Outputs for asynchronous counters are taken through latches since the rom outputs are strictly speaking only valid on the clock edge.

For 190/191 counters, the clock input must be connected to the system clock. The two outputs from the shaft encoder (must be t.t.l. compatible) are connected to the A and B inputs of the interface. A further input, F, allows the circuit to respond to either a single edge of one input (F low) or to both edges of both inputs (F high), giving approximately four times greater resolution.



Data for shaft encoder prom.

Address	Data
00-07	1C 10 1C 1C 09 1D 1D 1D
08-0F	1F 1F 1F 1F 1E 1E 1E 1E
10-17	1C 10 1C 08 09 1D 11 1D
18-20	13 1F 0B 1F 1E 0A 1E 12

In certain applications, it may be important to have each count representing exactly the same amount of shaft rotation and this will not be achieved if counting is performed on every edge since the output edges will not be evenly spaced. The system clock runs at roughly 5MHz, which allows the interface to operate correctly with a 1000-line shaft encoder rotating at up to 150 000rev/min. The design is easily modified for use with eproms, but the speed advantage is then lost.

M.H.S. Winder
Dept of Engineering
University of Reading

Divide-by-clock circuit

Besides being relatively simple, this circuit has the advantage that it does not require changing of passive components when the division ratio is altered.

In the phase-locked loop circuit, a clock-controlled voltage-to-frequency converter, VFC100, is used instead of the internal voltage-controlled oscillator. Due to this converter, input frequency in the lock state is

$$f_{in} = V_d f_{cl}/20V_{cc}$$

where f_{cl} is the applied clock frequency. The internal v.c.o. is connected to the output of the system so that the ouput frequency, f_{out}, yields

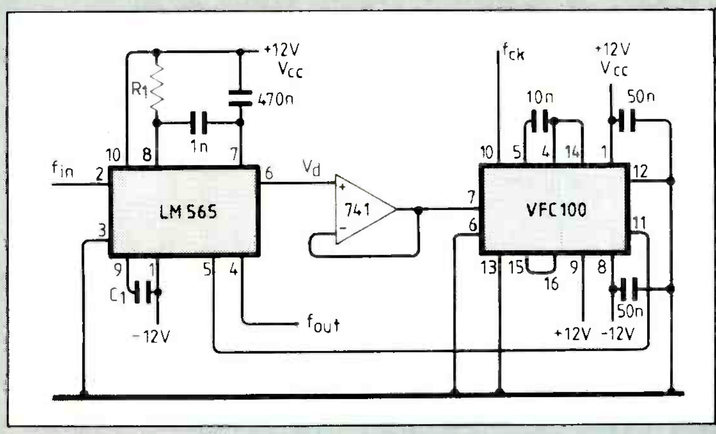
$$f_{out} = V_d/R_1C_1V_{cc}.$$

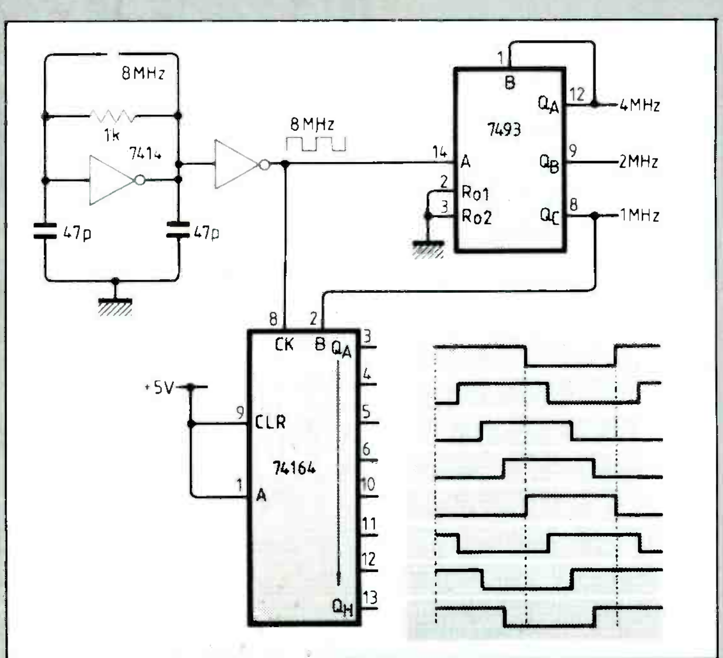
Eliminating the ratio V_d/V_{cc} from both expressions gives

$$f_{out} = 20f_{in}/R_1C_1f_{cl} = \text{const} \times f_{in}/f_{cl}.$$

Output frequency may be set to a required value by the choice of clock frequency only.

Kamil Kraus
Rokycany
Czechoslovakia





Eight-phase clock

Eight 1MHz square waves, each separated by $\pi/4$ radians in phase, are useful for running eight processors in parallel.

The 7493 is a negative-edge triggered counter arranged to divide by eight. The 74164 shift register, being positive-edge triggered, shifts the 1MHz output half way between changes of the counter to avoid uncertainties in the output condition on each negative transition of the 8MHz clock. Square waves of up to 32MHz could be produced by a different clock circuit.

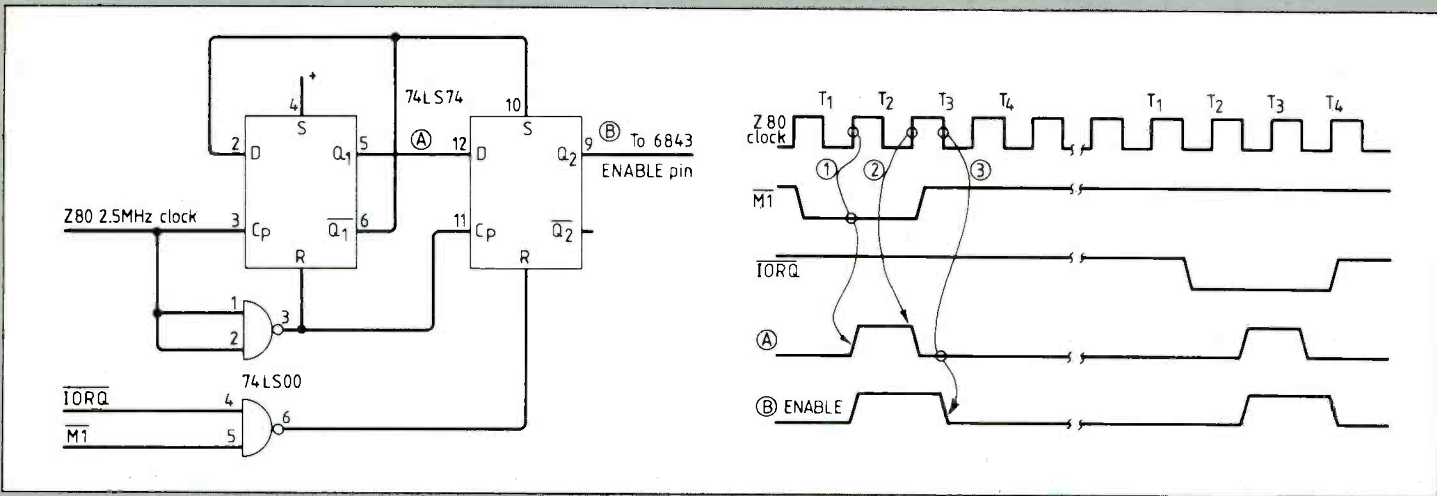
G.A. Hardy
Nottingham

Running 68xx peripherals with Z80

While expanding my Z80 computer system I had to interface a disc drive using an MC6843 controller since I could not find a device directly compatible with the Z80 at the time. The resulting circuit could be useful for connecting other 68-series peripherals to the Z80.

The only thing that prevents direct connection between the Z80 and 6843 is the latter device's enable input. This signal is essential for correct operation, especially its negative edge which latches data into the chip. When the Z80 fetches a memory or i/o instruction, both D-type bistable i.cs are set by the Z80 clock positive edge. The next clock positive edge resets the first bistable circuit and enables reset of the second on the clock negative edge. Output of the second bistable i.c. is the required enable signal.

M. Darko
Zagreb
Yugoslavia



Marker processor for sweep measurements

I have been using this circuit in a network analyser for up to 100MHz. It produces clear rectangular marks, actually a burst of pulses, which can be summed to the detector or log. amplifier output and fed to the Y channel of the display device.

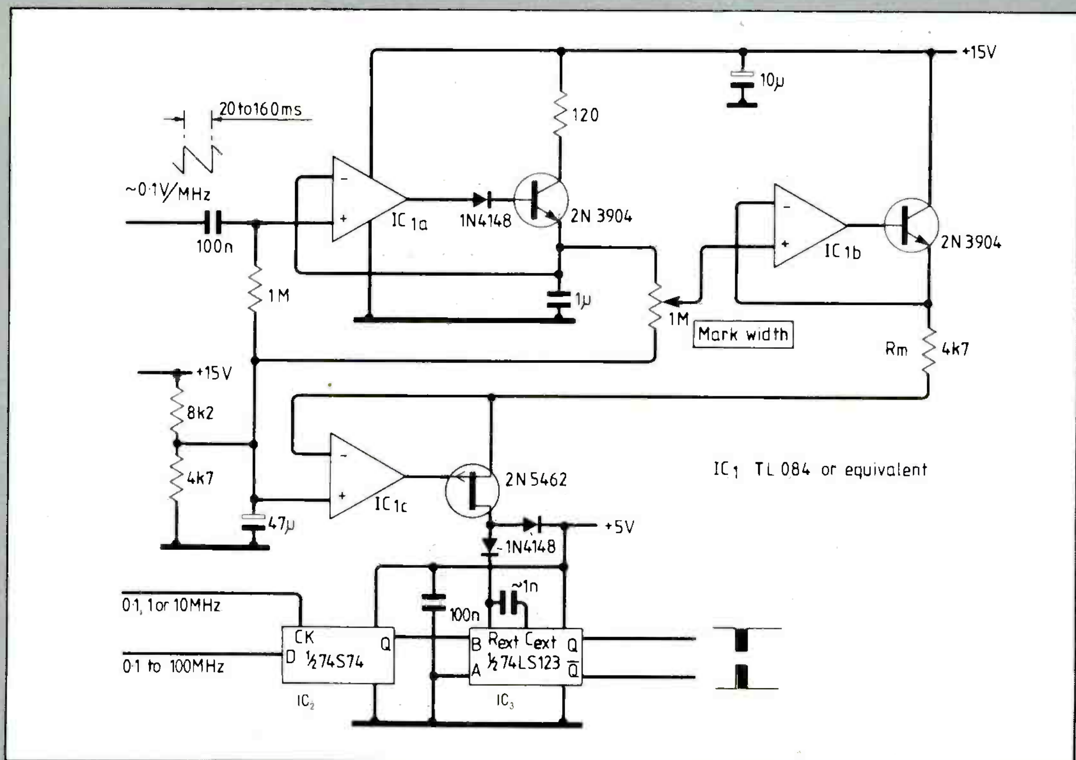
One half of IC_2 is taking samples at the mark rate from the incoming t.t.l.-level sweep signal. Looked at in the frequency domain only the lower sideband of the mixing products of the sweeping frequency and the nearest marking oscillator harmonic exist at the 74S74 output. Unlike with conventional mixers, the reference input does not have to be an impulse train. A t.t.l. input signal will suffice because the 74S74 is an edge-triggered bistable D-type device.

Retriggereble monostable circuit IC_3 (a 74LS122 may be used) serves as a digital low-pass filter, delivering output pulses only while its pulse width remains shorter than the cycle time of the incoming beat. Circuit IC_{1a} is a peak detector, IC_{1b} is a unity-gain buffer and the circuit around IC_{1c} translates the detected amplitude into current.

An essential feature of a good mark system is that the mark width on the screen does not depend on the frequency band swept. This is accomplished by making current to the LS123 pulse width determining circuit a linear function of the amplitude of the sawtooth voltage deviating the v.c.o. Hence the low-pass cut-off frequency is made a linear function of sweep bandwidth.

The mark width regulating circuit has proved effective with sweep bandwidths ranging from 100 to 1MHz. Faster logic i.cs should allow use of higher frequencies.

Jouni Verronen
Oulu
Finland



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Avoiding failure of sealed nickel-cadmium cells

by Rod Cooper

Despite using the same basic materials, the life expectancy of sealed nickel-cadmium cells is in stark contrast to that of the traditional open or vented type, which have been known to give in excess of 20 years of service life. Premature failure is often a complete mystery to the user, who may see no tangible reason for their demise. Rod Cooper throws light on the many failure modes, proposes avoidance tactics and suggests experimental cures.

To understand the main failure mechanisms of sealed nickel-cadmium cells it is necessary to have a grasp of the chemistry of the basic reactions taking place inside the NiCd cell and the chemical properties of the materials used in cell construction. The basic reaction is well known:

$$\underset{\text{pos plate}}{2NiOOH} + \underset{\text{neg plate}}{Cd} + \underset{\text{electrolyte}}{H_2O} \rightleftharpoons 2Ni(OH)_2 + Cd(OH)_2$$

Charged state **Discharged state**

Notice that water is essential to the reaction, not just a means of dissolving the chemicals used in the electrolyte. This important point is raised later — no water, no reaction!

It is the reaction during overcharge that is significant. In a vented cell, overcharge results in the electrolysis of water, hydrogen and oxygen being released as gases at the negative and positive plates respectively. This loss of water is replaced by topping up. In a sealed cell a different reaction takes place. It is sometimes stated (even in the august pages of *WW!*) that hydrogen combines with oxygen to re-form water, but this is not strictly true. Oxygen is indeed formed but instead diffuses over the cadmium negative plate where the following reaction takes place, shown in three steps for clarity.

Step 1 $\underset{\text{neg plate}}{2Cd} + \underset{\text{pos plate}}{O_2} + \underset{\text{electrolyte}}{2H_2O} \rightarrow 2Cd(OH)_2 + \text{heat}$

Step 2 $2Cd(OH)_2 + \underset{\text{charge current}}{4e^-} \rightarrow 2Cd + 4(OH)^-$

The cadmium that is oxidized to the hydroxide reverts back to cadmium metal, the net result of steps 1 and 2 being the evolution of heat and excess hydroxyl $(OH)^-$ radicals. At the nickel positive plate:

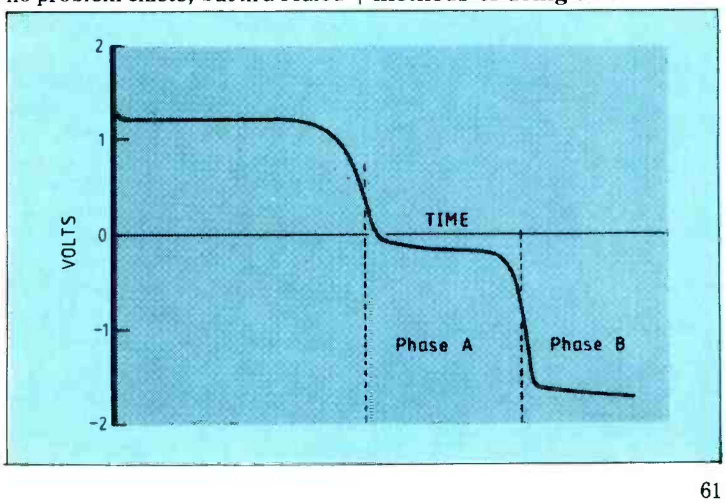
Step 3 $4(OH)^- \rightarrow 2H_2O + O_2 + 4e^-$

Oxygen produced at the positive has to find its way back to the negative plate for step 1 to take place. This it does by diffusing across the gap between the two plates.

Of course, these reactions do not occur as three steps, but as a circulatory reaction, an equilibrium existing between $Cd(OH)_2$ in the discharged state and Cd in the charged state. The position of equilibrium is determined by pressure, temperature, physical layout of the cell, and the amount of cadmium available for reaction. To enable this reaction to take place, excess cadmium is provided by the manufacturer at the negative plate, and the nickel positive plate is brought as close as possible to the cadmium negative to enable oxygen to diffuse from one to the other without too much difficulty. Unfortunately the close proximity of the two plates brings problems — see failure mode 3 (part 2).

The overall result of overcharge is the evolution of heat. No hydrogen is involved; it has, in the manufacturers parlance, been 'designed out'. If hydrogen combined directly with oxygen there would be no need to provide excess cadmium at the negative plate, and the two plates could be made equal. But this is not so. Naturally, a liquid electrolyte barrier between the two plates would impede the diffusion of oxygen, so the bare minimum of electrolyte is used. However, water is vital to the basic reaction. In a vented cell the amount of water used in reaction is a negligible part of the electrolyte, and no problem exists, but in a sealed

Fig. 1. **Complete discharge graph for a sealed cell, showing what happens when the cell is reverse-charged in a battery. Electrolyte decomposition occurs in both phases A and B, and results in permanent reduction of the cell capacity, so batteries are to be avoided where possible — see text for methods of doing this.**



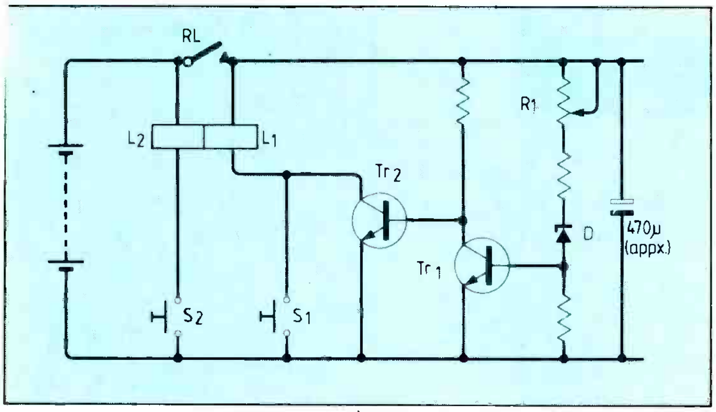
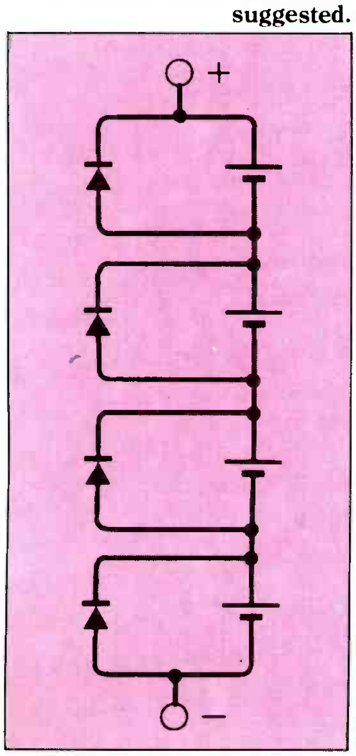


Fig. 2. **Low-voltage cut-out circuit is turned on by pressing push-button PB_2. Relay closes, but Tr_1 clamps base of Tr_2 and holds off the coil L_1 of the relay. If voltage falls below that set by pre-set pot R_1 and zener, Tr_1 releases Tr_2, the turn-off coil L_1 opens the relay and the load and circuit are switched off. Alternatively, the load may be turned off by pressing push-button PB_1.**

Fig. 3. **Reverse-charge damage illustrated in Fig. 1 can be ameliorated but not eliminated completely by adding reverse-biased Schottky diodes to a battery. This type of protection is not needed if cells are discharged singly, using either a dc/dc converter to step the voltage up to a usable level, or low-voltage components which work from 1.25V like those suggested.**



cell the water of reaction is a large part of what little electrolyte is present.

It follows that removal of what to the uninitiated may seem to be very small amounts of water from the cell results in a large reduction in cell capacity. The ways in which water can be removed are discussed in failure modes 1 and 2.

The material separating the plates is usually either nylon or polypropylene, both of which have good resistance to potassium hydroxide solution used as electrolyte, while the outer case is generally nickel-plated steel. These materials are involved in failure mechanisms of their own, as shown in part 2.

Failure mode 1: loss of electrolyte water due to reverse charging

When cells are connected together to form a battery, there is bound to be a cell of lesser capacity that the rest; it is impossible in manufacture to produce cells of exactly equal capacity, even if they are all of one type. In any case even if a good balance was possible, unbalance is likely after a period of operation for reasons which are detailed later.

If such a battery is discharged fully, the cell or cells of slightly less capacity than their neighbours will be discharged first and then driven in reverse until the rest of the battery is also exhausted. This causes permanent damage to sealed cells. The following explanation refers to the discharge graph of Fig. 1.

Readers will be familiar with the upper part of the curve, the one most often published by makers to show their cell characteristics. It is the lower part of the curve which is of interest here. When current is passed in the wrong direction, oxygen is evolved at the cadmium electrode which oxidizes any remaining cadmium to the discharged state:

$$2Cd + O_2 + 2H_2O \rightarrow 2Cd(OH)_2 + \text{heat}.$$

This reaction takes place during phase A. At the nickel electrode, hydrogen is evolved as gas, increasing the internal cell pressure. Eventually, the cadmium available for oxidation runs out and phase B is entered, where oxygen is evolved as well as hydrogen. The pressure in the cell rises rapidly and in due course the pressure-release valve will open to vent gases to atmosphere. During phases A and B it is the water of the electrolyte that is consumed. With a conventional vented cell this is of no great importance because of the large excess of water, but in a sealed cell there is no great amount of water and the water of reaction is encroached upon quite early on during the reverse charging process. A permanent reduction in cell capacity results.

Moreover, this process is a vicious circle — it is the cell that has been reverse charged which will be the prime candidate for more reverse charging next time the battery is discharged, because its capacity will have been marginally further reduced in relation to the other cells in the battery. The end result is often a battery of, say, six good cells and one completely dead cell. With encapsulated batteries like the PP3 and PP9 types this is disastrous because the whole battery has to be scrapped, there being no really practicable way of dismantling and reassembling the battery to service the dead cell. In any case, putting a new cell into a partly-used battery is asking for more trouble for the very reasons under discussion.

Avoidance tactics

Clearly it is possible to prevent reverse charging by stopping short of 100% discharge. Unfortunately there are difficulties. Deciding where to halt is one. It is not feasible to monitor the remaining capacity in individual cells, so the usual method is to monitor the total battery and operate a cut-out at, say, 1 volt per cell. Thus a seven-cell battery of nominal 8.75V would be halted at 7V. Such a voltage-sensing unit cannot distinguish between a battery of six healthy cells at 1.25V each and one completely dead cell being reverse charged at −0.4V, and is of limited value. One could raise the threshold of the cut-out to 1.1 or 1.2V but this means discarding a significant part of the battery capacity. But the technique is worth considering if capacity is not all that important to the application.

This problem with voltage-sensing increases with the number of cells in the battery and cut-outs of this kind are most effective with just two to five cells. Neither are cut-outs universally applicable; it is no consolation to know that the battery in your NiCd-powered handlamp is being protected against reverse charge if the cut-out abruptly plunges you into pitch dark, nor if your radio transmitter stops working half-way up a mountainside. These are cases where half a loaf is better than no bread!

Of course, extra features could be built-in, such as a pre-cut-out alarm or a manual overide, but human nature being what it is, the last-mentioned would be self-defeating and both would increase the size, complexity and cost of the cut-out, all these things being at a premium in portable battery powered equipment. Some voltage sensors introduce a small voltage drop in the circuit which may be unacceptable. This need not be so if a latching relay is used as the cut-out switch. Such a relay uses no power in the on or off-state and introduces virtually no voltage drop for all practical purposes. I have used the circuit shown in Fig.2.

Prevention diodes. This method of avoiding damage from reverse-charging consists of a reverse-biased diode connected across each cell in a battery, Fig.3. If a current attempts to pass in the wrong direction through any given cell it is provided with an alternative path through the diode. Referring to Fig.1, such diodes would have to exhibit a V_f lower than that of phase A to avoid electrolyte decomposition at the rated current of the load. At a load current of, say, 0.5 amp, V_f would have to lie in the region of 0.3 to 0.4V. This is a tall order for most diodes.

Schottky diodes can present a practical proposition, although they are on the expensive side. A graph of V_f versus current is shown in Fig.4 for a 1 amp wire-ended Schottky but this is only a typical graph and I have found it necessary to select for low V_f from a batch of devices to get the best results. Care is also required in selecting the type of device because they are primarily intended for use in s.m.p.s. and low V_f types tend to have high leakage currents, low leakage types tend to have high V_f. Leakage current is obviously important as it must be kept small in relation to the internal self-discharge of the cell. For a standard D-cell this self-discharge current may be of the order of several hundred μA so the 10μA of this particular diode at 20°C can be disregarded.

Having experimented with deliberate reverse charging, I found diodes to be most effective at higher currents. For example a C-cell reverse-charged at 0.5 amp can have this current reduced by a factor of between 5 to 10 with a Schottky diode but only by a factor of two at 100mA. So although it is not a perfect method it does help to delay cell destruction.

The difficulty with this technique lies in its practical implemenation. Where batteries are made up using cylindrical cells in the strapped-together arrangement, the diodes may be inserted in the gaps between cells. In the type of battery where the cells are connected end-on in a common plastics sleeve it may be necessary to slit the sleeve to make the connection, weakening the assembly in the process. In either case the presence of soldered joints where there is the possibility of electrolyte leakage may be unacceptable for some applications. With encapsulated batteries like the PP3 and PP9 it is well-nigh impossible to incorporate these diodes. However, it is very easy to do so where the battery consists of cells housed in individual holders, so it is worthwhile paying some attention to the battery compartment when considering reverse-charge protection with diodes.

Avoid batteries

By far the best method of avoiding reverse-charge failure is not to use batteries at all! One way of doing this is to use a single cell in conjunction with a d.c./d.c. converter to step the voltage up to a reasonable level where most of the present generation of semiconductor devices operate. Clearly such a system has no reverse-charge failure mechanism, and so does away with voltage cut-outs and protection diodes. Needless to say, the reliability of the NiCd power source is greatly improved.

Taking a closer look at this technique reveals several other important benefits of both technical and economic nature. Firstly, there is only one set of rubber seals to go wrong with a single-cell system, whereas there are many sets of seals on a battery, so the probability of electrolyte leakage — which will be shown later as a failure mode — is very much reduced. Secondly, single cells of equivalent capacity tend to be more physically robust than strings of interconected small cells. This is important in hand-carried equipment or in vehicle-mounted applications which can be subjected to very rough treatment, like being dropped! Thirdly, by standardizing on one type of cell and using a range of converters giving appropriate working voltages for different pieces of equipment, it is possible to reduce the inventory of battery types. This could be of interest if you have several items of equipment and are faced with stocking a miscellany of batteries. Also, it follows that recharging requirements are much simplified. Lastly, a single-cell system can work out to be cheaper in the long run, stemming from the fact that the cost per watt-hour for a single cell is less than for a battery of equivalent capacity. For example, a PP9 of 10.4Wh costs £12 but a super-F cell of 12.5Wh costs only £9. Allowing for converter losses, these two systems give about the same amount of useful engergy, but the single cell costs 25% less. Of course, the initial cost of the converter must be taken into account, but since a well designed device is likely to outlive several NiCd cells the real cost spread over a period of time will be small in comparison.

The lower cost of single cells makes the carrying of a spare cell with portable equipment a more attractive proposition than for batteries — £24 in the above for a PP9 and spare, only £18 for a super-F and spare. Also, if you are unlucky in having a recharging accident, a random or premature failure due to one of the modes under examination, it is not then such a hard financial blow to replace a single cell. The same argument applies when the time comes to replace the NiCd power source due to old age.

Against these benefits must be set the inefficiency of conversion from such a low starting voltage as 1.25V. The voltage drop across typical switching transistors and diodes is not so much less than this figure, so it is notoriously difficult to design a converter with a respectable efficiency specification. However, it can be done using special techniques. The Texas Instruments TL496 is a switching regulator i.c. which can be used as the basis for such a converter, Fig.5. Although it is more efficient operated from two cells, when it can give 80mA and 8.6V and about 55% efficiency, it can also operate from a single cell to give 40mA at about 7V.The inductance should have a value of it 40 to 50μH and as low a d.c. resistance as possible — less than 0.15Ω. Achieving this is not difficult considering the comprehensive data now provided by the ferrite manufacturers. An RM5 or RM6 core is satisfactory. Working frequency is about 10kHz. Some designers may consider it a disadvantage to have to provide their own wound component for L, not being an off-the-shelf item. For those wishing to avoid coil-winding, the Verkon V9-a provides a solution as it is self-contained dc/dc converter, providing nominal 9V d.c. output at currents up to 80mA. The V9-a is specifically designed to operate from a single NiCd or other low-impedance cell, is small enough to be p.c.b.- mounted, and has a quoted conversion efficiency of around 75%.

Another way of avoiding batteries is to design circuitry so that operation from one cell is possible. There are several suitable c-mos op-amps on the market which can work perfectly well from 1.25V, such as TLC251, ICL7611, ICL7622 and also audio amps like LD502. Although very useful for certain applications, the limitations are severe — e.g. driving relays, meters, leds is difficult. Nevertheless too many circuits for portable instruments are designed for 6 or 9V operation when they could work from a single cell equally well, simply through lack of imagination on the part of the designer.

Continued Next Month

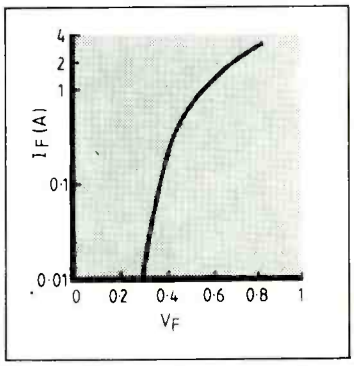


Fig. 4. **Graph of I_f versus V_f for wire-ended Schottky rated at 1 amp.**

Sources of components
Texas switching regulator i.c. TL496. Quarndon Electronics Ltd, Slack Lane, Derby.
Osmor latching relay CLA-5. Electrovalue, St. Judes Road, Egham, Surrey.
Verkon V9-ad.c./d.c. converter and wire-ended 1A Schottky diodes. J. Biles Engineering, 120 Castle Lane, Solihull, West Midlands.

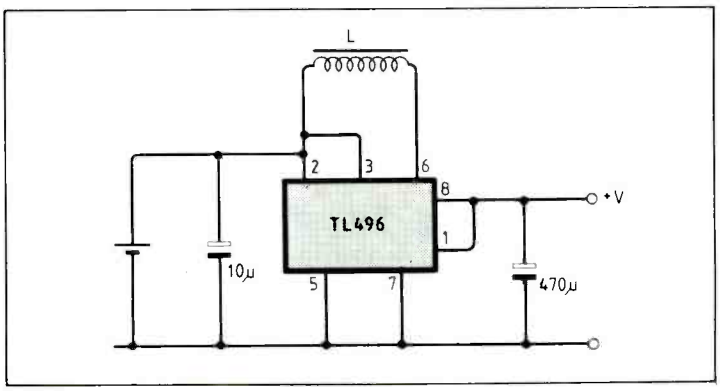


Fig. 5. **Circuit to step up 1.25V to about 7V at 40mA using the TL496 as a step-up dc/dc converter. See text for inductor details.**

Sampled-data servos – a new analysis

by D.M. Taub M.Sc., Ph.D.

Prior to computing servo performance Dr Taub considers the reverse of sampling: conversion from a sampled-data signal to a continuous signal

When the error signal in a servo loop is of sampled-data form, then at some point before it can be used to drive the plant it has to be converted back to continuous form. The point at which this conversion takes place depends on the type of compensator used. In the case of a compensator designed to work with sampled-data signals e.g. one using digital*, charge-coupled device or switched-capacitor techniques, it is done at the compensator output, whereas with compensators designed to work with continuous signals it is done in two stages, a sampled-data stage followed by a continuous-signal stage, in which case conversion is carried out at the interface between the two.

*Compensators based on digital techniques are often called 'controllers'.

The circuit which carries out the conversion is generally known as a 'hold' circuit, and various types exist. In the simplest and most widely used type, the output between one sample and the next is held constant at a value proportional to the weight of the sample most recently received. Typical input and output signals are shown in Fig. 15 (a) and (b). In mathematical terms one can say that the output between one sampling instant and the next is described by a polynominal equation of zero order; hence the circuit is known as a 'zero-order hold' circuit.

In a more complicated arrangement the output immediately after the sampling instant is proportional to the weight of sample just received, but it then changes at a uniform rate proportional to the difference between that sam-

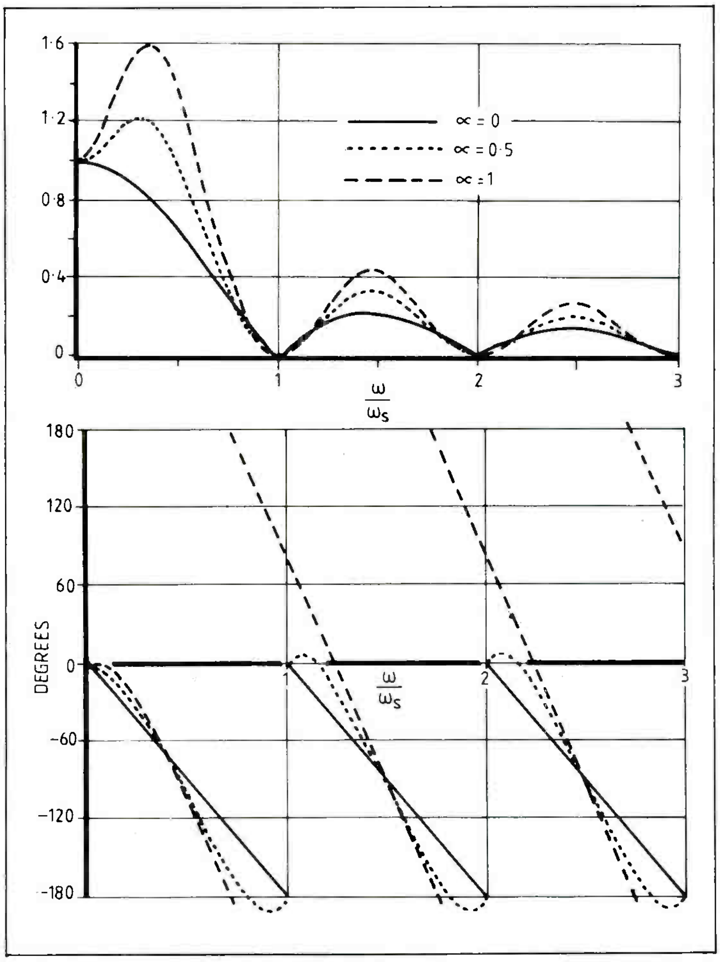


Fig. 17. **Gain characteristics of various hold circuits, amplitude above, phase below.**

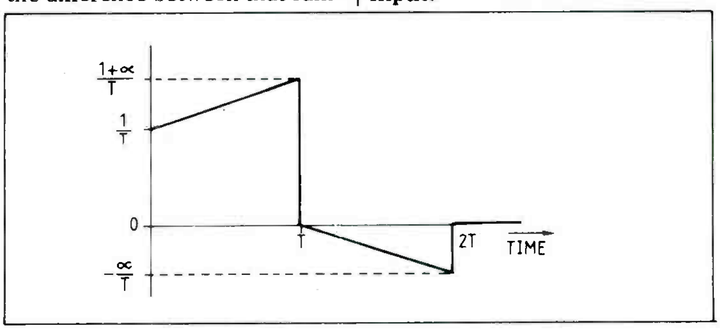


Fig. 16. **Response of a hold circuit to a unit-impulse input.**

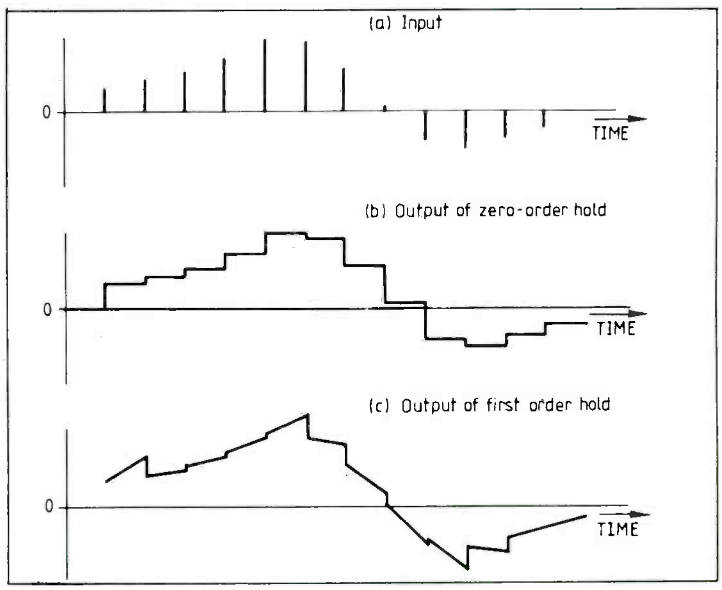
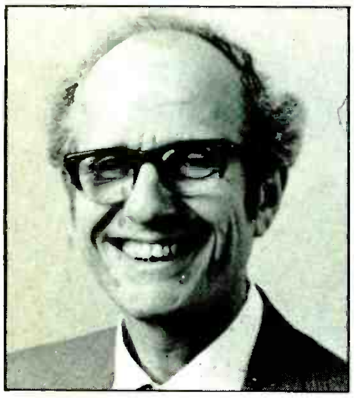


Fig. 15. **Input and output signals of zero-order hold circuits: the hold circuit converts a sampled-data signal back to a continuous signal. Input at (a), output of zero-order hold (b), and output of first-order hold (c).**



Since 1950, Matthew Taub has been continuously engaged in development work on digital electronics. After five years with Ericsson Telephones Ltd (now part of the Plessey Group), where he worked on electronic switching in telephone exchanges, he went to Leo Computers Ltd (now part of ICL), contributing to the development of the mercury delay-line store and input/output section of the LEO 2 computer. He joined IBM UK Laboratories Ltd in 1957 and is now a Senior Technical Staff member. Areas of work at IBM included magnetic core logic circuits, computer architecture, read-only and magnetic disc techniques, and circuits for c.r.t. displays. During the past two years he's been active on the working group developing Futurebus multiprocessor systems.

He has 22 publications in journals, a further 26 in the IBM Technical Disclosure Bulletin, and is named as inventor or co-inventor on 27 patents. The published work earned him a PhD degree from Cambridge University in 1982. Previously he'd studied electrical engineering at University College, Nottingham, gaining the B.Sc (Eng) degree in 1945, and after a short period with Ferranti went on to carry out research into noise phenomena in electron tubes at the Cambridge University Engineering Laboratory, for which he received the M.Sc. degree.

ple and its predecessor. The input signal of Fig.15(a) then produces an output as shown in Fig.15(c). In this case the output the output between sampling instants is described by a first-order equation, giving this circuit the name of 'first-order hold'.

The zero-order hold can be regarded as a limiting case of the first-order hold, in which the constant of proportionality governing the rate of change of output is zero. Higher-order hold circuits are possible, but are not important in practice.

Gain characteristics of hold circuits

The gain of zero and first-order circuits can be covered in a single analysis. To produce the output described above, the response a(t) to a unit impulse at the input (i.e. a sample of unit value) must be as shown in Fig.16. The factor of 1/T in the amplitude is necessary for consistency with the sampling process assumed in the (April issue): a continous signal of unit value gives rise to samples of weight T, which on reconversion to a continuous signal, produces unit value again. Positive values of α represent the first-order case, and $\alpha = 0$ the zero-orde case.*

The gain characteristic is found by taking the Laplace transform of a(t), as follows (see ref.5, section 3.4).

$$H_1(s) = \int_0^\infty a(t)\, e^{-st} dt$$

$$= \frac{1}{T}\left\{\int_0^T \left(1+\frac{\alpha t}{T}\right) e^{-st}\, dt + \alpha\int_T^{2T}\left(1-\frac{t}{T}\right) e^{-st}\, dt\right\}$$

$$= \frac{1-e^{-Ts}}{Ts}\left\{1+\alpha\left[\frac{1-e^{-Ts}}{Ts} - e^{-Ts}\right]\right\} \quad \ldots 3.1$$

The gain at real frequencies is found by setting $s = j\omega$, which gives

$$H_1(j\omega) = \frac{1-e^{-jT\omega}}{jT\omega}\left\{1+\alpha\left[\frac{1-e^{-jT\omega}}{jT\omega} - e^{-jT\omega}\right]\right\} \quad \ldots 3.2$$

* Textbooks generally restrict the term 'first-order hold' to the case where $\alpha = 1$, and Kuo (ref.6) describes circuits in which $0 < \alpha < 1$ as 'fractional-order', but this is a misnomer.

List of principal symbols	
A,B,C,D	points in the servo loop at which signals are continuous functions of time (Fig. 21)
A(s) to D(s)	signals at points A, B, C and D respectively as functions of complex frequency
a(t) to d(t)	— ditto — as functions of time
f_s	sampling frequency
H	gain; subscripts indicate points between which the gain applies
j	$\sqrt{-1}$
K	multiplication constant in expressions where gain is expressed in terms of poles and zeros
k	integer
L	$H_{XY}(j\omega)\sum_{k=0}^{m}\xi_k e^{jkT\omega}$
m	integer; also highest power in general polynominal expressions
M	highest power of z in numerator and denominator polynomials of $H_{UY}(z)$
n	sample number
p(t)	sampling waveform
s	complex frequency
T	sampling interval
t	time
U,V,X,Y	points in the servo loop carrying sampled-data signals (Fig. 21)
U(z) to Y(z)	z-transforms of signals at U, V, X and Y
u(n) to y(n)	sample values at U, V, X and Y
z	e^{Ts}
α	hold- circuit proportionality constant
β_k	coefficient of z^k in numerator polynomial of $H_{VX}(z)$
γ_k	coefficient of z^k in denominator polynomial of $H_{VX}(z)$
$\delta(t)$	Dirac function
$\Delta\tau$	time delay between A and B (Fig. 21)
ζ_k	coefficient of z^k in numerator polynomial of $H_{UY}(z)$
η_k	coefficient of z^k in denominator polynomial of $H_{UY}(z)$
$\lambda_1, \lambda_2, \ldots$	zeros of $H_{XD}(s)$
$\mu_1, \mu_2, \ldots$	poles of $H_{XD}(s)$
ν_k	coefficient of z^k in numerator polynomial of $H_{XY}(z)$
ξ_k	coefficient of z^k in denominator polynomial of $H_{XY}(z)$
$\psi_1, \psi_2, \ldots$	poles of $H_{XY}(z)$
ω	angular frequency
φ	phase angle

The modulus and phase angle of this function are plotted in Fig.17.

In the zero-order case where $\alpha = 0$ this last equation reduces to

$$H_0(j\omega) = \frac{1-e^{-jT\omega}}{jT\omega}$$

and using equations 2.1 and $T = 2\pi/\omega_s$ this becomes

$$H_0(j\omega) = e^{-j\frac{\omega}{\omega_s}\pi}\,\frac{\sin\frac{\omega}{\omega_s}\pi}{\frac{\omega}{\omega_s}\pi}\,. \quad \ldots 3.3$$

APPENDIX

Effect of using unit impulses in sampling waveform

To keep the mathematical expression as simple as possible, it has been assumed in the main text and in the programs, that the sampling waveform consists of impulses of weight T (part 2), and that on conversion back from a sampled-data signal to a continuous signal, the output immediately following a sample of weight T has unit value. In practically all the published literature, however, sampling is assumed to be done with unit-weight impulses. Therefore to relate the material presented here to other publications, the principal equations for unit-weight sampling pulses are given. The equations are numbered as in the main body of the text but with the prefix U to indicate unit-weight impulses.

Gain of first-order hold circuit:

$$H_1(s) = \frac{1-e^{-Ts}}{s}\left\{1+\alpha\left[\frac{1-e^{-Ts}}{Ts} - e^{-Ts}\right]\right\} \quad \ldots U3.1$$

Gain of zero-order hold circuit:

$$H_0(s) = e^{-j\frac{\omega}{\omega_s}\pi}\, T\,\frac{\sin\frac{\omega}{\omega_s}\pi}{\frac{\omega}{\omega_s}\pi}\,. \quad \ldots U3.3$$

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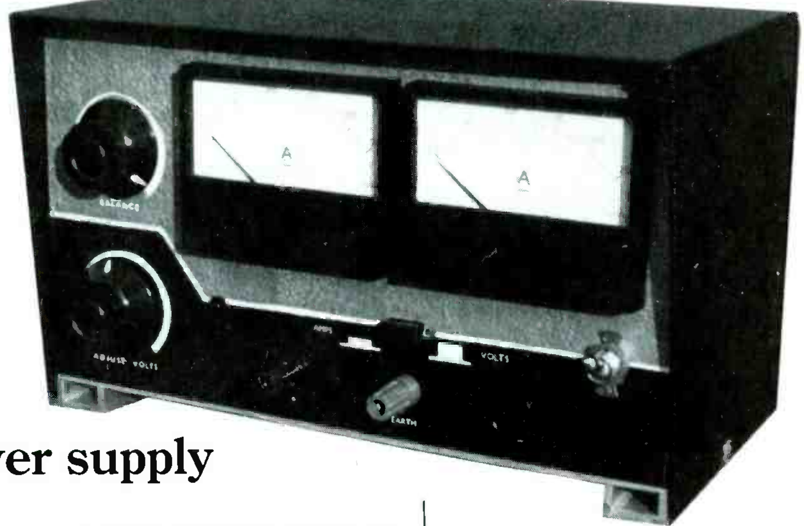
D.c. supplies from a.c. sources — 4



Constructing a stabilized power supply

by K.L Smith Ph.D.*

An important step in studying a topic is when the experimenter puts theory into practice. And as lab. or bench type power supply designs seem to be unendingly popular, here is another, which can supply some 80 watts at 13.8V.

There is a "chicken and egg" situation in such designs as that shown in block form in Fig. 1. For example, what transformer rating (in VA) is required, when we do not yet know the r.m.s. secondary currents? These currents through the rectifiers are known and these depend on the source resistance R_i. R_i will only become known when the size, and therefore wire gauge and turns on the transformer windings, are known. . . !

'From experience' (an expression nearly as famous as 'it can be shown') an R_i of about one ohm is common for such power levels as used here.

$$R_L \text{ will be } \frac{21 \text{ volts}}{6 \text{ amps}} = 3.5\Omega$$

on full load. Therefore τ_c will be about 5.6ms from Fig. 3 (part 3). Equation 11 (part 3) then yields $I_{rms} = 6.3$A for one half, therefore the total r.m.s. current is $\sqrt{2} \times 6.3 = 9$ amps. This, together with the total r.m.s. voltage of 40V across the secondary gives a required rating for the transformer amounting to 360 VA. (Equation 10 would give this directly, because from the transformer's point of view, it is feeding a bridge rectifier).

Now the d.c. power in the load plus dissipative pass elements is 40V × 6A = 240 watts. Therefore the transformer utilisation factor is 360/240 = 1.5, meaning that it has to be about one and a half times bigger than you'd think. The iron in the transformer used for the practical design had a centre limb area of 2.9 square inches, so that it can handle $(2.9 \times 6.9)^2 = 395$VA, which is comfortably within the requirements.

You would expect the peak voltage (no load) across the smoothing capacitors with a 20 volt half winding secondary to be 20 × 1.414 = 28 volts. With $R_i \sim 1$ ohm we would lose about 6 volts at full load, so the mean d.c. level at the input to the series regulators would be ~ 22V. Then we have the peak ripple voltage to consider. Using equation 12 (part 3)

$$\hat{V}_r = \frac{6(10 - 5.6)\times 10^{-3}}{2 \times 10^{-2}}$$

$$= 1.32 \text{ volts}$$

This shows that the troughs in the supply to the regulators will reach a low of 22 − 1.32 = 20 volts, say. Therefore with the 20—0—20 r.m.s. transformer we will not be able to reach the full ± 20V output on full load of 6A. Hence the 'spec.' judiciously says 'reduced load at the top end'.

The completed unit yielded transformer secondary voltages of 20.3V and rectified d.c. voltages on the smoothing capacitors of 27.3V with no output load current drawn. When 6A was taken, the capacitor voltages dropped to 21.2V and the peak ripple voltage was measured as 1.25 volts.

There are many integrated blocks from the i.c. designers that give excellent performance, including thermal shut down and current limiting. The three-terminal adjustable type, such as the 317, are particularly versatile. The 317 is already dated, but is still very popular.

The design shown in Fig. 2 uses it to control the positive supply, together with shunt booster transistors to up the current to 5-6 amps. The common 2N3055 is used for this. In effect, the 2N3047 plus the 2N3055 act as one much larger p.n.p. device — but is overall cheaper for the power handling capability. The 'current division' resistors (1ohm and 0.25ohm) at the input share out the current to the 317/2N3055 in the ratio 1:4. The 317 limits at just over an amp, so the whole control leg limits at approx 5 to 6 amps if the output is short circuited.

The single variable resistor (4.7k) on the 'var' terminal of the 317 can reduce the output to 1.4 volts minimum. To reduce the output to zero requires a bias of −1.4 volts on its tail end. This −1.4 volts is obtained across the two forward biased silicon diodes as shown in Fig. 2. The 6A diode gives one junction drop to compensate for the base-emitter drop in the 2N3047, and is generously rated. The other components around the 317 comply with the maker's recommendations (1).

Once the positive line is stabilised, it can be used as a reference level for the negative line. Any change in this line's output voltage is divided down and tapped off the wiper of the lk 'balance' potentiometer, amplified, inverted by the operational amplifier and (with lots of current gain) fed back via the compound emitter follower to 'cancel' most of the original change.

By the time we have 6 amps going through the 2N3055s, the h_{FE} is reducing. This point was offered as criticism to E.J. Hatch with his very high demand on the 2N3055. I agree with this and the result is an increasing demand on the driver transistor, the 2N3054

* University of Kent at Canterbury

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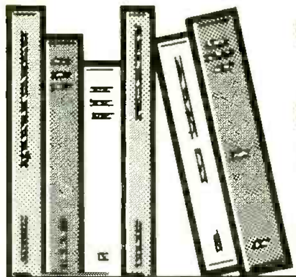

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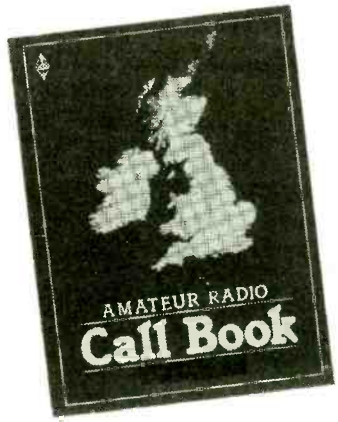

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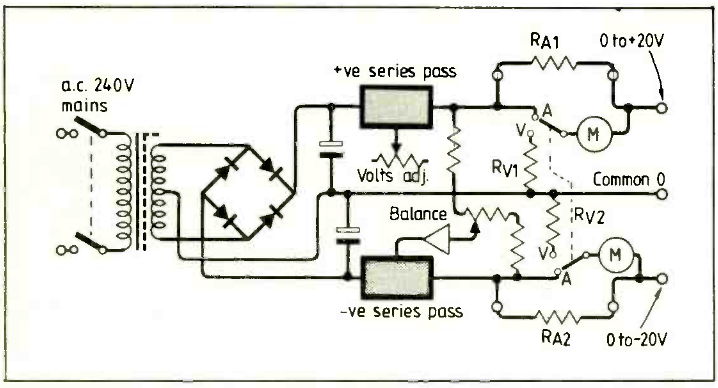


Fig. 1. **The diagram shows how positive and negative lines can be obtained from a centre tapped transformer secondary in conjunction with a bridge rectifier. The negative line is referenced to the stabilised positive supply. Simple volt-amp meter switching to monitor the output is illustrated.**

Fig. 2. **the practical circuit shows all the design points discussed in the text.**

here. If the h_{FE} drops to ~ 10 (as it might with I_c ~ 10A) — then the poor old 2N3054 could be called on to deliver more than an amp! (Therefore this could be the device to fail first). The circuit will manage 6A fairly well, as the h_{FE} for the 2N3055 is still well over 20 and the base drive therefore ~ 300mA. The 2N3054 can supply this and its own h_{FE} should be ~ 70. Therefore the base drive from the BC177 collector is required to be about 4mA — well within the capability. Finally there is no difficulty driving the BC177 from the 741.

One other point is that we fall into the habit of saying 'an on silicon junction drops about 0.7 volts'. This is not necessarily true for the power devices used here. For example, the V_{be} given for a 2N3055 at I_c = 6A is 1.7 volts. The 2N3054 might very well drop a further 0.9 volts at ~ 300mA. Finally there is the $V_{ce(sat)}$ for the BC177, which is about 0.6 volts. There is one more junction drop at 6 amps — that across the resistor labelled 'R' on Fig. 2. At 6 amps, 'R' is chosen to drop just one small signal silicon 'on' voltage to turn on the BC109 current limited transistor. Therefore the minimum voltage differential from source to output terminal must be, 1.7 + 0.9 + 0.6 + 0.7 ~ 4 volts at 6 amps. The differential available in the practical design operating at 13.8 volts output is 21.2 − 13.8 = 7.4 volts. Which, on the above argument, is sufficient.

When the current limit transistor turns on, current is shunted away from the base of the 2N3054. The output voltage rapidly collapses and the op-amp rapidly saturates. The current remains at 6A. However, all the available supply voltage is across the 2N3055, whose resistance has been raised, and maximum dissipation is occurring in it. In fact the thermal lag will safeguard the devices for a time, but the dissipation is actually greater than $P_{c(max)}$ for them, so prolonged shorting would probably result in failure. . .

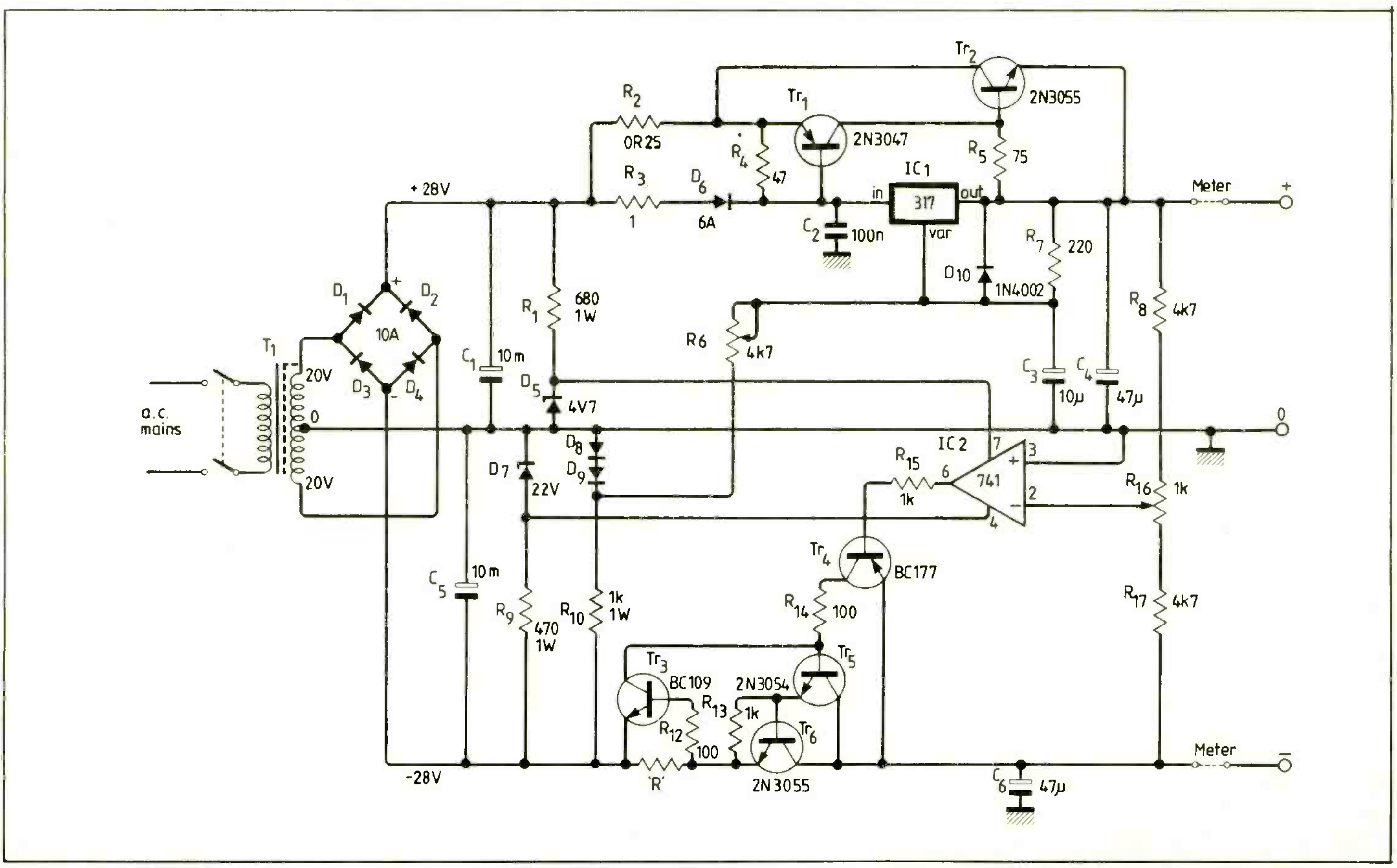
Power dissipation and heat sinking

As I stated in article 1, the series regulator is a dissipator of surplus power and plenty of heat will be generated. The 2N3055 can dissipate 117 watts absolute maximum, but the mounting base temperature T_{mb}, for this must be 25°C. In practice, the mounting base temperature will be greater and power derating must be applied. The derating must reduce the dissipation to zero at a junction temperature T_j of 200°c. This is the absolute maximum junction temperature allowable.

In order to remove the heat from the base-collector junction, it has to flow through the thermal resistance of the path, junction to mounting base. The IEC 148 symbol convention for this is $R_{th\ j\text{-}mb}$ which is rather heavy on subscript use, but descriptive. . .

The mounting base (which is in effect, the case) then warms up. Further heat removal must be arranged from the mounting base to the heat sink. This has a resistance, $R_{th\ mb\text{-}h}$. Finally, the heat sink must dissipate the heat arriving, into the ambient surroundings. This resistance is written $R_{th\ h\text{-}amb}$.

Thus the total thermal resistance from the junction to ambient is,



$$R_{th\ j\text{-}amb} = R_{th\ j\text{-}mb} + R_{th\ mb\text{-}h} + R_{th\ h\text{-}amb}$$

The direct heat loss from the mounting base to the surroundings has been ignored in my argument, so has the (much smaller) contribution to the heat production by the dissipation at emitter-base junction-

The TO3 package 2N3055 has an $R_{th\ j\text{-}mb}$ of 1.5°C per watt. If a mica washer with thermal grease is used between it and the heatsink, then an $R_{th\ mb\text{-}h}$ of 0.5°C per watt should be obtainedc. It only remains to establish a value of $R_{th\ h\text{-}a}$ for a suitable heatsink to be chosen, by an argument like the following.

If you remember your basic physics, then a TO3 case on a mica washer and heat sink is simply a Lee's disc situation, except that the shape is far from a disc. If P_{tot} is the power dissipated by the 2N3055, then the temperature of the mounting base, the junction and the thermal resistance is related by

$$R_{th\ j\text{-}mb} = \frac{T_j - T_{mb}}{P_{tot}}$$

Similarly the flow of heat to the ambient surroundings is given by

$$R_{th\ j\text{-}mb} + R_{th\ mb\text{-}h} + R_{th\ h\text{-}amb} = \frac{T_j - T_{amb}}{P_{tot}}$$

Therefore as all the numbers are, known except $R_{th\ h\text{-}amb}$, this can be calculated. As an example, if the present power supply is intended to operate continuously at 13.8 volts at 6 amps output (although in a communications system there will be an "on/off" diversity factor), then the 2N3055 on that side must dissipate (21.3-13.8)×6 = 45 watts. Therefore

$$R_{th\ h\text{-}amb} = \frac{200 - 20}{45} - 2$$
$$= 2°C \text{ per watt}$$

I chose a 110mm length of extrusion 30D. The thermal resistance of this sink is 1.3°C per watt at 45 watts dissipation. Therefore the T_{mb} and T_j values reached at a T_{amb} of 20°C are 100°C and 168°C respectively. On a 6A at 13.8V soak test, the case of the 'negative' 2N3055 reached ~ 90°C.

The above calculation does show up the fact that the heat dissipation is not sufficient for sustained short-circuit conditions — or a continous maximum current drain at low output voltages (less than 8 volts. . .). A larger heat sink would alleviate these limitations.

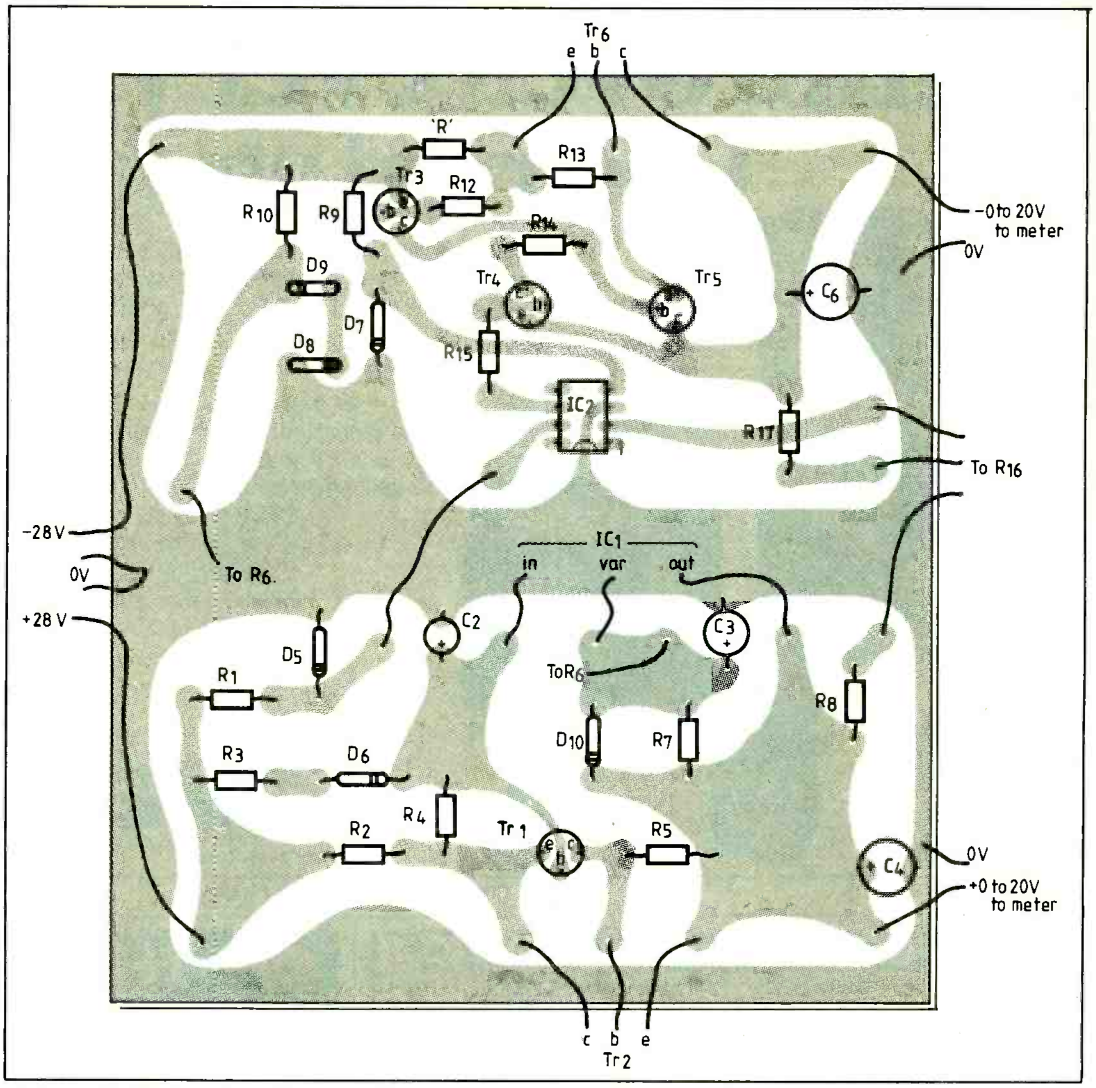


Fig. 3. **The printed circuit design is show at (a), with component layout at (b).**

Construction

The circuit details and printed-circuit layout are shown in Fig. 2 and Fig. 3 (a) and (b). Each heat sink has the dimensions mentioned above. In my unit, simple voltmeter and ammeter switching was incorporated to indicate the output quantities, (see Fig. 1).

Performance

Figure 4 shows the results obtained under load for the two outputs. The ranges over which good stability is obtained is clearly seen. The limitations predicted for the high output (20V) shows up. The negative line regulation (given a constant positive line) is

$$\text{Load regulation} = \frac{\Delta V_o}{V_o \Delta I_o} \times 100$$
$$= \frac{13.86 - 13.79}{13.8 \times 6}$$
$$= 0.08\%$$

This is better than the positive side, which is 0.57%. For the test "to extremum" the current limit resistor 'R' was shorted.

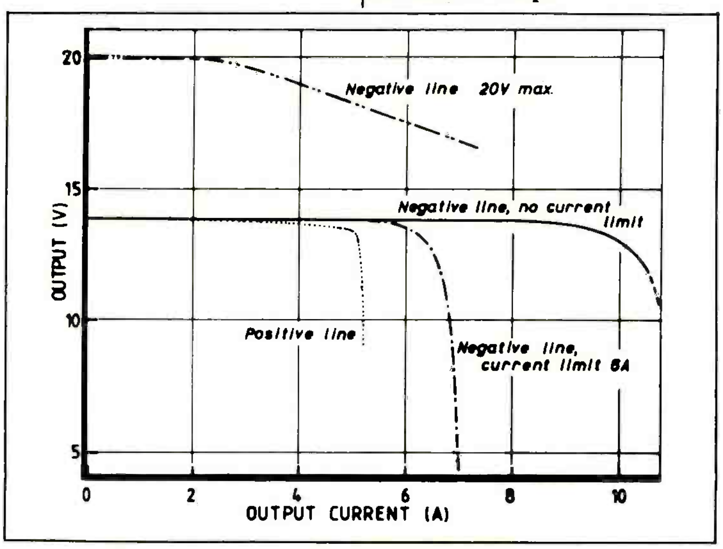
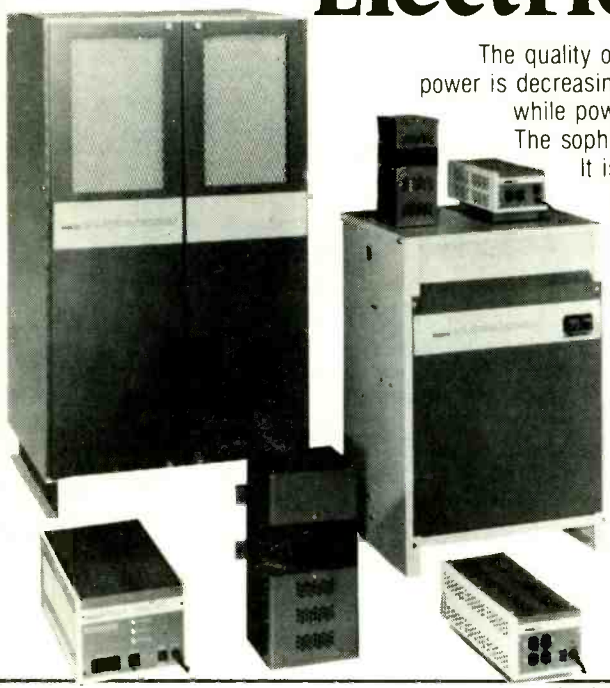


Fig. 4. **The test results on the bench are shown here. The sharp drop-off in the positive output shows the capability of the 317 chip.**

Electronic technology improves every year. Electrical power does not.



The quality of electronic equipment is increasing every year, but the quality of electrical power is decreasing. Computer technology is continuously experiencing a high rate of growth while power utilities in the U.S. are already failing to meet peak demands for power. The sophistication of electronic equipment requires clean power to operate smoothly. It is the user's responsibility to protect his equipment against these problems.

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1000	55.65	4.70
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4	2	5.15	1.70
6	3	8.07	1.76
8	4	9.43	1.82
10	5	10.31	2.05
12	6	11.43	2.15
16	8	13.62	2.33
20	10	18.33	2.66
30	15	22.79	2.85
60	30	46.67	4.50
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1	2	5.28	1.50
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5	10	20.11	2.36
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8-9×2	.5×2	3.53	1.30
8-9×2	1A×2	4.48	2.31
15×2	.2×2	2.53	.96
12-0-12	.05	3.11	.96
20×2	.15×2	3.55	1.30
20×12			
15-20×2	.9A	4.34	1.70
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2	4	7.34	1.69
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6	12	14.20	2.30
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3000	75.22	5.10
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1000	35.43	3.97
2000	63.49	4.76
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CIRCLE 23 FOR FURTHER DETAILS.

Power supplies

Our brief introduction to supply technology is followed by information on a wide range of current bench supplies.

On hearing the words power supply, one immediately forms an image of a box containing a mains transformer, bridge cell and capacitor. After all, the majority of instruments and appliances still use this well-worked formula albeit with a few enhancements like a three-terminal regulator i.c. — the conventional linear power supply.

But a power supply need not necessarily supply d.c. More importantly, other techinques for converting mains power have progressed significantly in recent years because of the need for smaller units and higher efficiency. These efficient power supplies vary considerably in design, but they all use power switching of one kind or another. Despite what some designers might say to obscure the issue, being regulated by switching circuits they are all switch-regulated supplies.

The two basic types of switching regulator are primary switching types, in which mains voltage to the primary winding of a transformer is switched, and secondary types which switch output from a transformer secondary winding. Unlike linear regulators, which are essentially power dividers, a switching circuit designed as a power converter can give an output voltage which is higher than its input voltage.

Primary switch-regulated supplies are smaller and more efficient than secondary types, mainly because they only need a small high-frequency isolating transformer. Their drawbacks are the need for high-voltage medium-frequency switching power transistors and the fact that a large part of the circuit is at mains potential. Regulation is obtained by feeding back output voltage to the mains switching circuit so mains isolation is required between the transformer primary and secondary and in the feedback circuit.

Switching regulators are not a new concept, but they have not been common until recently. Component prices have had something to do with this but the components concerned are now widely available and reasonably priced. Good switching regulators require fast power transistors and diodes, high-quality smoothing inductors and high-frequency capacitors. The main reason for the switching regulator's slow appearance is probably complexity. A reliable, electrically quiet switch-regulator is difficult to design.

Television sets have had switching regulators in them for some years now. Our tv-repair expert calls them 'the service engineer's nightmare', which helps to confirm their complexity. They took over from a most inefficient power source — a potential divider — and power consumption in large colour tv sets has quartered. Obviously using semiconductors instead of valves has allowed this power reduction, but comparing like with like, a potential divider supplying 12V at 1A in a modern set would waste more power than one supplying 200V at 1A in an older valve tv. Efficiencies of around 90% are possible using switching regulators.

There are applications though where switching regulators will not be seen for a few years yet. High-fidelity power amplifiers are possibly the best argument for linear power supplies. A switching regulator here would cause switching noise directly in the amplifier, it could cause r.f. noise problems, and its regulation would be worse than that of a linear supply because of the amplifier's widely varying current demand, especially during music transients.

Linear supplies have a wide dynamic range and their inefficiency is not so much of a problem with modern push-pull power amplifiers. They are also more able to withstand abuse than switching regulators and there are numerous ways of protecting linear supplies against short circuits.

When a switching regulator starts up, extremely high currents must be switched by the

Further reading

Regulated Power Supplies by Irving M. Gottlieb, Sams, £18.50. The third edition of this book contains information about switching and linear supplies and includes plenty of applications ideas.

power device until the output filter capacitor is charged. At switch on, input to the switching circuit climbs from zero and the pass transistor can cope with charging the output capacitor (some switching regulators have a 'soft-start' circuit which allows the capacitor to charge slowly at switch on). If the output is shorted however and the pass transistor survives, it will almost surely fail when the short is removed as the power circuit has to charge the output capacitor from zero with a fully-on input voltage. Any protection circuit included must be very fast as the switching rate of most supplies is between 20 and 40kHz.

Linear regulated power supplies are also more practical in applications requiring variable voltage and current, such as a low-voltage bench power supply. Switch-regulators, although tolerant of input fluctuations, do not lend themselves to variable output. Efficiency in a switch-regulated supply can fall rapidly when the load falls outside design parameters or when one circuit is used to give different output voltages.

So far only linear and switching power supplies have been mentioned. An often overlooked form of power supply (possibly because of its price) is the ferroresonant transformer, which has been around for 50 years. It offers around 1% regulation, between 80 and 90% efficiency, inherent short-circuit protection and transient filtering, and an almost square-wave output which requires little smoothing when rectified. The so-called constant-voltage transformer makes for a low component-count supply and lends itself to computer power applications because of its rejection of mains faults.

Basically, this type of transformer has a secondary or tertiary winding (or combination of the two) which, in conjunction with a

Characteristics of bench power supplies available on the UK market.

MAKE	TYPE	O/PV	O/PI	RIPPLE	R-LOAD%	R-LINE%	O/P R	FL	CL	CV	CC	V	I	C	PRICE	REMARKS
Bang &	SN16A	30	1	100µV	0.05	0.15	0,005	*	*	*	*	*	*			overload protected
Olufsen		30	1	100µV	0.05	0,15	0.005	*	*	*	*	*	*			"
		5	3	50µV	0.15		0.003	*	*	*	*	*	*			
	SN17	30	2	<100µV	0,015	0,01	0,002	*	*	*	*			*		
	SN18	60	1	<100µV	0.015	0.01	0.002	*	*	*	*			*		
Beha	N6303	30	3	<10%	<2	<1	0.005	*	*	*	*	digital				Dvm may be used separately
	N6306		Double version of above													
Bertan	214	1000	15mA	15mV	0.005	0.001		*						*		Programmable
	215	3000	5mA	15mV	0.005	0,001		*						*		". O/ps switchable + or-.
	205A-01R	1000	30mA	10mV	0.005	0.001								*		"
	205A-50PN	50000	0.3mA	2V	0.005	0.001								*		Programmed. Analogue, binary or GPIB
Coutant	LC60	30	2	2mV	<0.05	<0.01	0.01	*		*	*	digital			145	Dvm can be used externally
				1mA	<1mA	<0.01	>30k									
	LCT60			Dual version of LC60											290	Outputs track
Daren	DPM4	3000	6mA	<10mV	0.01	0.001						*				Remote control. For photomultipliers.
Elcanic	212	25	3	5mV	0.01	0.01								*		A.c. outputs 4-24V at 5A
	215	25	5	5mV	0.01	0.01								*		"
	301	25	10	5mV	0.01	0.01								*		"
	2302	30	2	1mV	0.01	0.01								*		A.c o/ps. 1Hz t.t.l. pulse gen
		30	2													
		5(fixed)	1													
	300	25	10									*				
		500	0.1									*				
		6a.c														
		12a.c.														
Delta	SM3540	35	40	10mV	5mV	5mV	<0.05	*		*	*	*	*			Soft start. Remote sensing.
				25mA	25mA	25mA										OV protected. Programmable.
	SM6020	60	10	10mV	5mV	5mV	0.01	*		*	*	*	*			Soft start. Remote sense.
		or														Programmed by 0-5V.
		30	20	50mA	70mA	70mA										
	EK30-10	30	10	1mV	10mV	1mV		*		*	*	*	*			Programmable. Protected.
				5mA	10mA	3mA										
	E015-2	15	2	0.1	2mV	1mV	0.1	*		*	*			*		
	E030-1	30	1	0.1	4mV	2mV	0.1	*		*	*			*		
	E0303	30	3	0.1	4mV	2mV	0.1	*		*	*			*		
	E060-0.6	60	0.6	0.1	8mV	4mV	0.1	*		*	*			*		
	E0300-0.1	300	0.1	0.5mV	20mV	10mV	0.01	*		*	*			*		
	E018-0.6D	+/-18	+/-0.6	0.1mV	5mV	5mV	0.1	*		*	*			*		For op-amps. Tracked.
Electronic Measurements	HCC7.5-30	7.5	30	100mV	0.1	0.1		*		*	*	*	*			Soft start.Programmable.S.c.r.
			Other models up to:													
	HCR300-0.9	300	0.9	650mV				*		*	*	*	*			
Farnell	E30/1	30	0,5	<1mV	<0.03%	<0.02%	0.04	*						*	89	Switch-selected V range.
		or														
		15	1													Overload protected
	E30/2	30	1												102	
		or														
		15	1													
	ET30/2	30	1												191	Dual outputs
		30	1													
		or														
		15	2													
		15	2													
	L50/05	50	0.5	<1mV	<0.01%+2mV		0.1			*	*			*	121	
			Other models to:													
	L12/10C	12	10	"	"	"	"			*	*			*	260	Crowbar protected.
	D30/2	30	2	<2mV	<0.01%+2mV 0.01%+1mA		0.002			*	*digital				145	Digital meter usable externally
	D30-2T	30	2							*	*digital				281	Dual unit
		30	2													
	D30-4	30	4							*	*digital				265	
	D100-1	100	1							*	*digital				260	
	TOPS 1	4-6	1	<2mV	0.1%+5mV	.05%+2mV	<0.05			*					104	Overload protected.
		12-17	0.2													No meters-cal. pots.
		12-17	0,2		0.05%+2mV											
	TOPS 2	4-6	5							*					176	"
		12-17	1													
		12-17	1													
	TOPS 3	4-6	4	<2mV	0.02%+5mV	.05%+2mV			*		digital				219	Digital metering. Over-voltage protection.
		5-17	1													
		5-17	1													

MAKE	TYPE	O/PV	O/PI	RIPPLE	R-LOAD%	R-LINE%	O/P R	FL	CL	CV	CC	V	I	C	PRICE	REMARKS
	TSV 70	70	5	<1mV	0.01%+1mV	.01%+1mV	.05		*			*	*		530	Switch-selected output.
		or														
		35	10													Remote sensing.
	E350	350	0.2	<5mV	<0.5%	<0.1%		*	*	*		*	*		333	Overload protected.
HEWLETT PACKARD	Much too large a range to accommodate here. From 30W to several kW. Single and multiple outputs. simple bench types and complex, programmable instruments. Small part of range as follows															
	6214B	10	0.1	200µV	4mV 500µA	4mV 750µA	.005	*		*	*			*		6200 & 6209 autoseries, auto-parallel,autotracking, programmable.
	6200B	20 or 40	1.5 0.75	"	4mV 250µA	4mV 250µA	.02	*		*	*			*		Single, dual range
	6216B	25	0,4	"	4mV/.5mA	4mV/.5mA	.02	*		*	*			*		
	6206B	30 or 60	1 0.5	"	4mV	4mV	.04	*	*	*				*		
	6218B	50	0.2	"	4mV	4mV/500µA	.04	*		*	*			*		Single.dual range output
print	6212B	100	0.1	"	8MV	"	.08	*		*	*			*		
	6209B	320	0.1	1mV	2mV	2mV/200µA	.02	*		*	*			*		
	6205C	20 or 40 and 20 or 40	0.6 0.3 0.6 0.3	200µV	4mV	4mV	.025		*	*				*		Programmable, autotracked
	6234A	25 25	0.2 0.2	200µV	1mV	1mV		*	*	*				*		
Hunting Hivolt	Series650 6 models	1-10k to 5-50k	0.025 0.005	<0.05%	<0.05%	<0.02%						*	*		1789 to 2025	Switched mode,high voltage remote control, monitor.
	Series 4000	50k to 150k	0.08 0.024	<0.05%	1%	0.02%						*	*		8590 to 11661	External high voltage discs.
	Series 2000	2.5-25k to 20-200k	0.08 0.01	<0.02%	0.05%	0.02%									4467 to 8824	Separate h.v.system
Keithley	Several programmable current and voltage sources, plus:															
	247	3k	0.006	3.5mV	0.005%	0.001%						*				Overload protected.
Kepco	Very large range of instruments--summarized only															
	BOP50-2M 12models	+/-50 to	+/-2	1mV	0.001% 0.5mA	0.0005% 0.002%	0.0005 50k	*		*	*	*	*			GPIB programmable. 4-quadrant volts/current stabilized
	BOP1004M	+/-100	+/-4	"	"	"	"	*		*	*	*	*			
	MPS620M	6	5	0.1mV	0.01%	0.01%		*				*	*			Remote sensing.
		20	1	"	"	0.05%		*	*			*	*			20V ouputs track.
		20	1	"	"	"		*	*			*	*			
Kikusui	PADL/LP	8	20	0.5mV 5mA	.005%+1mV 3mA	.005%+1mV 1mA		*		*	*	*	*		634 to	Overload protected. Remote programming. Series or parallel.
	48 models	to														
	PAD1k-0.2	1k	0.2	0.5mV 0.05mA	,002%+5mV 0.1mA	.002%+5mV 0.1mA		*							1865	
	PAE35-10	35	10	0.2mV 1mA	1mV 2mA	1mV 0.5mA				*	*	*	*		875	Programming speed up to 35V/µs
	3 models	to													to	
	PAE35-30	35	30	0.4mV 5mA	1mV 3mA	2mV 1mA		*		*	*	*	*		1575	
	PAC7-10	7	10	0.5mV 1mA	0.03%	.005%+1mV 1mA		*		*	*	*	*		428	
	8 models	to													to	
	PAC110-1	110	1	"	"	"		*		*	*	*	*		400	
	PAB8-2.5	8	2.5	0.5mV	.02%+2mV	.02%+2mV		*		*	*	*	*		143	Simple bench supplies.
	17 models	to													to	
	PAB350-0.2	350	0.2	"	"	"		*		*	*	*	*		184	
	PDM18-2.5	+18 -18	2.5	0.5mV	.005%+2mV	.005%+1mV		*		*	*	*	*			Dual tracking,+and- can be set
	5 models	to														
	7034	+60 -60	0.5	0.5mV	3mV	3mV		*		*	*	*	*			
Lambda	LA-200-V	16.5	4	60mV	20mV	20mV			*			*	*		149	T.t.l. on/off. Protected.
	LA-300-V	16.5	7	"	"	"			*			*	*		173	
	LA-250-V	32.5	2	"	"	"			*			*	*		149	
	LA-350-V	32.5	3.5	"	"	"			*			*	*		173	
	LB 701	7.5	270	15mV <1/V%	.1%+10mV 1%+10mA	.5%+6mV 1%+6mA				*	*	*	*		4450	Programmable. Rack or bench

capacitor, acts as a tank circuit. The core is separated magnetically into two sections by a magnetic shunt; the section with the tank circuit is resonant at the mains frequency and saturates, but the primary section does not. Energy is transferred between the two sections proportionally with input level and output load to provide constant voltage. The resonantor is not strictly an LC one as it involves magnetism in the core, hence the term ferroresonance.

Glossary

Automatic recovery. Some supplies need resetting after being overloaded. One which returns to normal output when the overload is removed has automatic recovery.

Bipolar supply. Usually used to describe a supply whose output can travel from positive to negative and vice-versa, rather than one with separate positive and negative outputs or one with transistor drivers.

Bridge circuit. This term not only used to describe a diode configuration in a rectifier circuit but also a bridge driver circuit in switch-regulated supplies.

Brown-out. This is an input voltage level at which the supply still functions, but not necessarily within its specification. Derived from the American term for the practice of dropping mains voltage to reduce demand.

Common-mode output. Current through an impedance connected between the ground terminal to which the supply output is returned and a separate ground terminal.

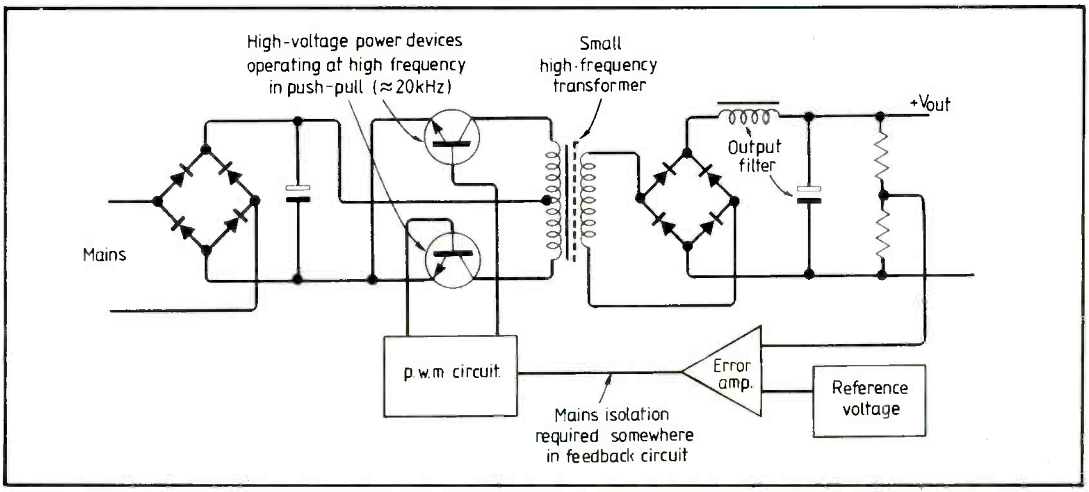
Complementary tracking. Some supplies may be connected together so that the output of one tracks the output of the other.

Converter. In some applications, a d.c. supply higher than the one availabe is required. Rather than use a separate power supply, a d.c.-to-d.c. converter is used to step up voltage from the existing supply.

Crowbar protection. For expensive circuits sensitive to overvoltage, such as found in a computer, crowbar protection is often used to sense an overvoltage condition and drag down the supply using a shunt element like a thyristor to blow the fuse. It is a cheap means of protection for situations where overvoltages might occur. If overvoltage will occur, a less terminal means of shutdown is preferred.

Current mode. Some supplies have linear and adjustable current limiting and are designed to run indefinitely with the current limiting on. As load increases, voltage drops proportionally while the current-limit point is exceeded. This mode has numerous applications like zener-diode, led and diode testing, and can even be used to estimate the size of a large capacitor. Such a supply can also be used as a constant-current load for experimentation.

Primary-type switching regulator using p.w.m. and push-pull driving transistors. Being high-frequency components, the mains transformer and filtering elements are much smaller than usual. This type of regulator is highly efficient but mains isolation is required both in the transformer and feedback loop. Some primary switching regulators use a single-ended drive stage.



CVT, constant-voltage transformer, see text.

Digital control. Many supplies are now capable of being controlled digitally either by a dedicated controller or by a computer through say a GPIB interface or a slower RS232 serial link. Digital control is used in automatic testing, process control and in laboratories. Much of the power-control circuit may be digital, even though the supply may act in the same way as a conventional linear one. In this case analogue-to-digital and digital-to-analogue converters are used.

Dual tracking supply. A supply with interdependent positive and negative output voltages.

EMI. Electromagnetic interference is generated by switching supplies. Without adequate screening and filtering, this can affect surrounding circuits, the mains supply and the power supply output.

Ferroresonance (see text)

Foldback limiting. Protection circuit which actively reduces current supply as overload increases. This avoids overheating the supply and damaging any circuit connected to it during overload, but unless the supply has a separate linear current regulator, it cannot be used in constant-current applications.

GPIB (IEEE488, IEC625-1, HPIB, etc.,). More and more supplies designed for computer control are becoming available. GPIB — for general-purpose interface bus — is a widely used standard means of connecting instruments to a computer and most manufacturers use it. Its drawbacks are that it is quite expensive to implement and that the standard does not define how the control software should be written (see our March issue).

Inverter. An apparatus for converting d.c. into a.c. Often used for providing mains voltage from a car battery either in remote areas or locally for battery back-up. Unlike the uninterruptible power source, an inverter does not necessarily switch in automatically, and even if it does, at least a few mains cycles will be lost.

Line regulation. Expression of a supply's tolerance to input-voltage fluctuation. Assuming constant load conditions, line regulation is the output-voltage maximum deviation measured while varying the load from

MAKE	TYPE	O/PV	O/PI	RIPPLE	R-LOAD%	R-LINE%	O/P R	FL	CL	CV	CC	V	I	C	PRICE	REMARKS
		Other models in 701 series up to 300V at 9A													4600	
	LES	7.5	57	10mV	.02%+2mV	.02%+2mV			*	*	*	digital			1175	Remote sense. Switched mode.
					0.5%	.5%+50mA										
		Other models in LES range up to 60V at 14A													1500	
	LK	20	7.2	500µV	0.15%	0.15%			*	*	*	*	*		980	Programmable
					10mA	10mA										
		Other models in LK range up to 60V at 22.5A													2740	
	LP	20	17	500µV	0.1%+1mV				*	*	*	*	*		745	Single, dual and triple.
		20	17													Programmable
		to													to	
		250	0.13	0.2%											840	
		250	0.13	5mA												
		10	18												395	
		to													to	
		250	72												685	
	LA	!0	!8		0>05%+0.5mV			*	*	*	*	digital			505	Programmable. Single and dual.
		to													to	LA !0 Auto series/parallel.
		250	0.072		2.5mA	1mA									570	
		10	12.6												770	
		to													to	
		120	1.5												885	
		20	1.36												850	
		20	1.36													
		to													to	
		250	0.1												940	
		250	0.1													
	LT	7	135	10µV	.02%+2mV	.02%+2mV									1725	Programmable. Switched mode.
		to		to	or	or									to	
		60	19.3	15µV	0.3%	0.3%			*	*	*	digital			1825	
		7	270												3360	
		to													to	
		60	45												3420	
Linstead	S 10	30	2	<300µV		<0.01&	<0.005	*	*					*	306	Remote sensing.
		30	2													
	S 14	5	1	<5mV	< 0 . 3 %				*						67	
Philips	PE1535	40	0.5	<1.5mV	<40mV	<0.05%	0.02	*	*	*	*			*	137	Remote programming and sense.
				<1mA	<4mA	<2.5mA										
	PE1536	20	2	<1mV	<10mA	<0.01%	'	*	*	*	*			*	239	
				<2mA	<3mA	<0.05%										
	PE1537	40	1	<1mV	<15mV	<0.01%	'	*	*	*	*			*	239	
				<1mA	<3mA	<0.05%										
	PE1538	75	0.5	<1mV	<25mV	<0.01%	'	*	*	*	*					
				<1mA	<3mA	<0.05%										
	PE1539	20	6	<!Mv	<!2Mv	<0.01%	'	*	*	*	*				373	
				<2mA	<4mA	<0.05%										
	PE1540	40	3	<1mV	<18mV	<0.01%	'	*	*	*	*				373	
				<1mA	<4mA	<0.05%										
	PE1541	75	1.6	<1mV	<30mV	<0.01%	'	*	*	*	*				373	
				<1mA	<4mA	<0.05%										
	PE1542	7	3	<0.5mV	<7.5mV	<0.05%	'	*	*	*	*				411	
				<1.5mA	<4mA	<0.5%										
		20	1	<1mV	<20mV	<0.05%	'	*	*	*	*					
		20	!	<0.5mA	<4mA	<0.5%										

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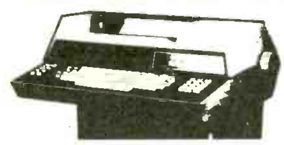

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Pro S100 system with dual 5" floppy drives, software, manuals etc.
£850.00 Call sales office for details

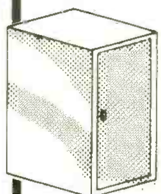
ULTRA COMPACT 300 BAUD ACCOUSTIC MODEM — COUPLER

A Major manufacturer's over production and a bulk buy special enables us to offer this **BRAND NEW TRANSDATA 307A** ultra compact, **BT APPROVED**, 300 baud full duplex accoustic modem at a fraction of manufacturer's list price. The unit operates on the standard **CCITT V21** frequencies with **RS232** interface via 25 way 'D' skt.

Combine the adjustable cup system, which fits almost any phone with the benefit of "No jacks or phone cables" and a light weight of only 1.2 Kg and you have a truly portable modem!! Supplied complete with data, 90 day guarantee and ready to use.

ONLY £49.95 + £3.00 pp

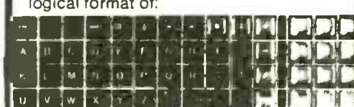
PROFESSIONAL 6 FOOT 19" RACK CABINETS



LARGE 19" equipment cabinet. Totally enclosed with locking front and rear doors. An internal sub fram 63" high is pre drilled for standard 19" equipment etc. Other features include internal 12" cooling fan, two-tone blue and grey finish with alloy trims. Mounted on 4 heavy duty castors, mains panel etc. And at a current cost from **IMHOFS** of over **£500** A snip at **ONLY £125**. Supplied In **NEW** or little used condition. Carriage £22.00.
Ext. Dim 72.5"h x 23.5"w x 26"d

LOGICAL KEYBOARD

Heavy duty unit in attractive satin alloy case. 55 full travel keys are laid out in a logical format of:



Making a very useful keyboard, ideal for persons unfamiliar with or confused by the standard **QWERTY** layout. All keys generate the equivalent **ASCII** outputs and various control codes shown in data. A 7 bit latched parallel **TTL** output with strobe enables direct connection to any similar micro port etc. Many other features such as Internal 240v to 5v PSU, MAINS ON/OFF switch. **Supplied In NEW** or little used condition with data.
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CIRCLE 76 FOR FURTHER DETAILS.

maximum to minimum. It is expressed as a percentage.

Operating area. Supplies with wide output-voltage ranges can often supply more current at higher voltages because dissipation in the linear regulating circuit is lowest. Rather than giving a fixed rating of, say 0-30V at 5A, some manufacturers provide an operating area graph of current versus voltage.

Regulation, see load/line regulation.

Remote sensing. Specifications for power supplies don't take into account the leads connecting the supply to the load. With long leads and high currents, voltage drop can be significant and output impedance of the supply increases. Remote sensing is used to minimize these effects. Normally, voltage is sensed at the supply output terminals and fed back to the control amplifier which provides regulation. Remote sensing involves taking the voltage sensing lines out directly to the load.

Resolution. Smallest voltage or current increment which an adjustable supply can repeatably be set to.

Response time. When subjected to a step or transient load, a supply takes time to respond. It is likely that response times in current and voltage modes will be different.

Ripple rejection. In a regulating circuit, ripple rejection is the ratio of r.m.s. input ripple voltage to r.m.s. output ripple voltage.

Shunt regulation. A shunt regulator, a good example of which is a zener diode, stabilizes voltage by acting as a load whose impedance rises rapidly as voltage falls below a certain level and vice-versa. With no load, a shunt regulator draws high current, and with full load draws very little current. Unless load is constant, shunt regulators are inefficient. Their advantage is that they are unaffected by output short-circuits.

Suppressor. This term is used for any device used to filter out unwanted noise or transients. These include LC mains filters, metal-oxide voltage dependent resistors, which can be found over the mains input or d.c. output, high-speed silicon suppressors, which are like a zener diode but able to withstand extremely high currents in short bursts, and simple capacitor suppressors, which may be found almost anywhere in a supply circuit.

Settling effect. When load on a supply changes, it takes time for the supply to reach thermal equilibrium. This is the settling effect.

Transient response. Like power amplifiers, power supplies take time to respond to transient load variations. A supply's transient response is difficult to quantify and is probably best expressed in an oscillograph. Some manufacturers express transient response in terms of time taken for output voltage to recover to within a certain tolerance for a given step load change.

Zero-crossing switch. Some supplies only allow the mains to switch on at the voltage zero crossing point.

MAKE	TYPE	O/PV	O/PI	RIPPLE	R-LOAD%	R-LINE%	O/P R	FL	CL	CV	CC	V	I	C	PRICE	REMARKS
Powerbox	2000	4-6	3	10mV	10mV	2mV	0.004	*	*	*	*			*		
		40	1.25	3mV	0.05%	0.05%										
	3000	4-6	3													
		40	1.25	As 2000 but with 20V output												
		20	2.5													
	3535	+/-11-16	1		0.1%	0.2%	0.02	*	*					*		11-16V outputs track.
		4-6	3		25mV	2mV										
	3525	4-6	3	3mV	0.25%	0.15%	0.002		*					*		25V outputs track.
		25	1	3mV	0.25%	0.05%	0.003									
		25	1	"	"	"	"									
	SB15-20	15	20	50mV	0.05	0.05	<0.001					*	*			Switched mode.
	to															
	SB2501.25	250	1.25	"	"	"	"					*	*			"
Powerline	LAB501	30	1	1mV	0.05%	0.05%	<0.015	*		*	*	*				Programmable. Analogue or digital
				500μA	0.5%	0.5%	3-70k									
			Models with common characteristics:													
	LAB502	30	2					*		*	*	*	*			
	LAB505	30	5					*		*	*	*	*			
	LAB515	15	10					*		*	*	*	*			
	LAB510	30	10					*		*	*	*	*			
	LAB702	70	2					*		*	*	*	*			
	LAB521	30	1							*	*			*		
		30	1													
	LAB522	30	2							*	*			*		
		30	2													
	LAB532	30	2							*	*			*		
		12-15	0.5						*	*						
		12-15	0.5						*	*						
		4.5-5.5	5						*	*						
	IC	20	0.5							*	*			*		
		20	0.5							*	*			*		
		4.5-5.5	5						*	*						
	LAB520	30	20							*	*	*	*			
	LAB530	30	30							*	*	*	*			
	LAB610	60	10									*	*			
	LC3021	30	2	2mV	0.1%	0.1%	<0.015	*			*			*		For educational use.
	LC1541	15	4	"	"	"	"	*			*			*		
	LC3012	30	1	"	"	"	"	*			*			*		
	LC1522	15	2	"	"	"	"	*			*			*		
	LC6011	60	1	"	"	"	"	*			*			*		
	LC1513	15	1	"	"	"	"	*			*			*		
Racal-Dana	9231	31	1.1	<1mV	<0.01%	<0.01%	0.005	*	*			digital				Remote sensing. Protected.
	9231Q	Dual 9231														
	K unit	5	3.5	Can be combined with other units												
	9232	31	2.2													
	9232Q	Dual 9232														
Radford	N14	6000	3mA	0.05%	High source Z		2.2M	*				*			130	E.h.t. supply
	Hipack	12a.c.	3A		unstabilized											
	LAB59	25	8						*						100	Nuffield instrument. variable
		300	0.1		unstabilized											
		25a.c	8													
		6.3a.c.	3													
		12a.c.	6													
	N59	25	8		unstab.				*						90	Nuffield instrument. Step variable
		25a.c.	8													
	N59C	25	10						*			*			130	Continuous
		25	10													
Takasago	GP07-10	7	10	<500μV	<0.005%	<0.005%		*		*	*	*	*			
		Models from above to 1000V at 0,5A (GP01000-05) with common characteristics. Must be ordered with 220V input if needed														
Thurlby	PL310	30	1	<1mV	<0.01%	<0.01%	<0.005	*	*	*	*	digital				Remote sensing
	PL320	30	2	"	"	"	"	*	*	*	*	"				
	PL154	15	4	"	"	"	"	*	*	*	*	"				Outputs can be combined in series or parallel
		Range of dual and triple units based on above														
	PL320GP	30	2													GPIB controlled. Based on PL320
Time	9810	33	1	<2mV	0.05%	0.05%	0.005					*	*		595	GPIB remote and local
Electronics	9809	66 or +/-33	1.1	<2mV	0.05%	0.05%	0.005		*			*	*		825	"
Weir	4000-30-1	30	1	2mV	0.05%	0.01%	<0.01	*	*	*	*	digital			115	
				1mA	1mA	0.1%	>30k									
	4000-30-2	30	2	"	"	"	"	*	*	*	*	digital			150	
		Twinpack versions of these available, including mixed types														

DEWSBURY G4CLX ELECTRONICS

POCOMTOR AFR 2000
RTTY ALL MODE

- Special narrow band quadrature discriminator for all used LF shifts from 50 to 1000 Hz
- Simple and quick tuning with 16 line LED bar indication
- Extremely simple operating
- Current-saving 8 bit C-Mos microprocessor
- Development and manufactured in Switzerland

SPECIAL FEATURES:

- Fully automatic recognizing of ARO, FEC Collective and FEC Selective (SITOR/AMTOR)
- Fully automatic searching and synchronizing in Baudot mode according to Baud rate and phase; indication of baud rate and phase
- Manual preselecting of all Baudot and ASCII speeds
- Optimum microprocessor controlled signal reception with 16'000 (sixteen thousand) samples per second and steady re-phasing on forward and backward run of signal

FEATURES AND APPLICATION:

The **POCOMTOR AFR-2000 RTTY ALL MODE DECODER** allows the simple and easy writing of the usual teletype codes as BAUDOT, ASCII (including 200 baud press service), ARO, FEC-Collective, FEC-Selective (SITOR/AMTOR) and the FEC procedure used for secret services, which differs from the usual CCIR recommendation 476-2. The **POCOMTOR AFR-2000** is a complete teletype decoder with built-in new quadrature discriminator for automatic adapting and processing of the normal shift offsets of 50Hz to 1000 Hz. The **POCOMTOR AFR-2000** is the first RTTY reception device on the consume area that fully automatically determines the received baud rate and synchronizes thereon, without being necessary as yet usual to test the baud rates and phase (Normal/Reverse) in question in a troublesome way. It is now only required to call up the automatique-routine and after a short time for the signal reception of about 10 to 15 seconds the synchronization is reached and the text can be written.

In the mode ARQ/FEC, i.e. during synchronous character transfer (without start and stop bit) the built in intelligency finds out by itself whether it is an ARQ or FEC signal, whereby it is additionally differentiated between FEC-Collective and FEC-Selective. To balance signal phase moves there is a steady adaption of the microprocessor controlled sampling, as to pre-running characters and to after-running characters.

The technology of the POCOMTOR AFR-2000 RTTY ALL MODE DECODER corresponds to the highest requirements. Its extraordinary prize/performance ratio will not be reached in near future on the easy way. Choosing the POCOMTOR AFR-2000 you take the most modern receiving device on the market. Its for that you receive more and have to tune less. It has never been thus easy to receive radio teletype.

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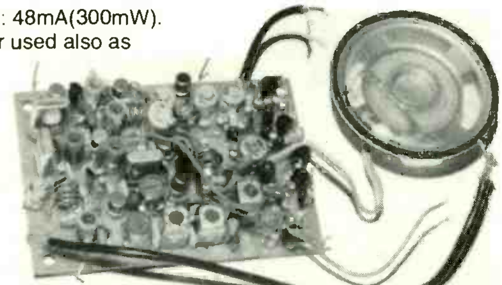
CIRCLE 53 FOR FURTHER DETAILS.

C & A ELECTRONIC

1 CHANNEL
VHF WALKIE TALKIE 250mW/9v
KIT No 626

Specification
RECEIVER
Sensitivity: 0,25uV
First IF: 10,7Mhz
Second IF: 455khz
Crystals used: carrier: 3 — 10,7=crystal frequency.
Audio out: 300mW
Power consumpt.:15mA (sq.open).
TRANSMITTER
RF out: 250mW (can be increased to 1W)
Crystals used: osc.frequency ×2=carrier.
Power cons.: 48mA(300mW).
32R speaker used also as micro.

Description
A lightweight, small handie talkie with main advantage its VERY LOW comsumption...
A typical 9v battery will last for several hours. Can be used between 140 to 165Mhz just changing crystals or trimming a few coils. P.c. board dimentions: 80×55mm.
All transisters used are bipolar for low cons. Also, two special IC's, the one in flat pack version for limited space.



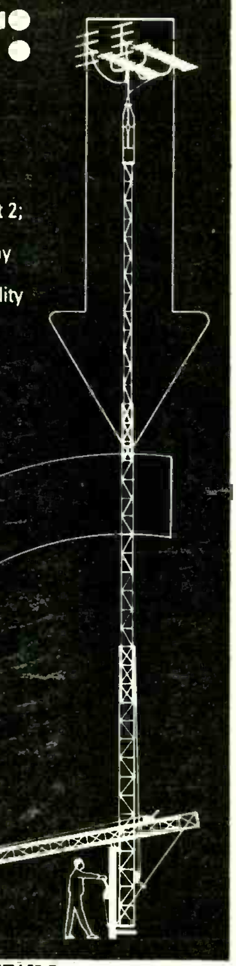
C & A ELECTRONIC O.E.
PO Box 25070 Athens 10026
GREECE Tel:5242867. Tlx:210798 CAGR

CIRCLE 65 FOR FURTHER DETAILS.

Versatower:

A range of telescopic towers in static and mobile models from 7.5 to 36 metres with tilt-over facility enabling all maintenance to be at ground level.

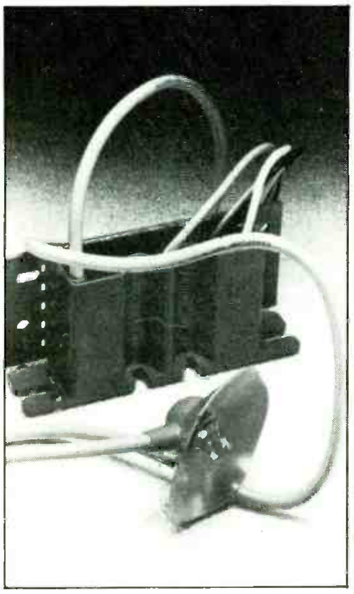
Designed in accordance with CP3 Chapter V; part 2; 1972 **for a minimum wind speed of 140 kph in conditions of maximum exposure** and specified by professionals world-wide where hostile environments demand the ultimate in design, quality and reliability.
Suitable for mounting equipment in the fields of:
Communications
Security surveillance — CCTV
Meteorology
Environmental monitoring
Geographical survey
Defence range-finding
Marine and aero navigation
Floodlighting
Airport approach lighting
Further details available on request.



STRUMECH ENGINEERING LIMITED
Portland House, Coppice Side, Brownhills
Walsall, West Midlands WS8 7EX, England
Telephone: Brownhills (05433) 4321
Telex: 335243 SEL.G.

CIRCLE 38 FOR FURTHER DETAILS.

E.h.t. multiplier



A new design for high-voltage multiplier provides an e.h.t. supply up to 30kV for c.r.ts from an input voltage of between 5 and 5kV. The unit uses single-cell silicon diodes and is claimed to provide improved regulation when compared with split diode systems. They will operate over a wide temperature range and are rated for continuous operation at an ambient temperature of 55°C. It is housed in a flame-retardent plastic case with epoxy resin seals and is approved to BS415. Edicron Ltd., 1 Wesley Avenue, London NW10 7BZ. EWW213

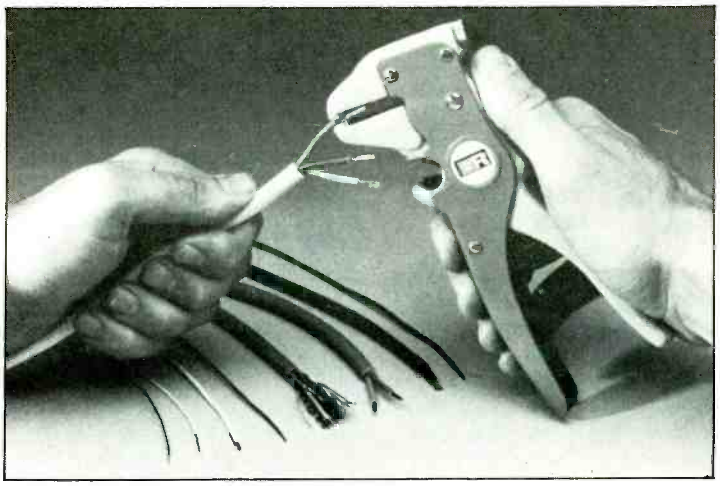
Static locator

A pocket sized static electricity locator is designed and made in the UK. The EVL9 has three ranges; 1kV, 5 and 25kV and uses leds to indicate the presence and polarity of static. A simple conversion table is provided to calculate the field strength. The battery powered instrument may be used in such static-sensitive environments as computer rooms, electronic component assembly areas, hospitals, laboratories etc. It costs £109.75 inclusive from Technotrend Ltd., The Town House, High Street, Chobham, Surrey GU24 8AF. EWW218

Low-cost wire stripper

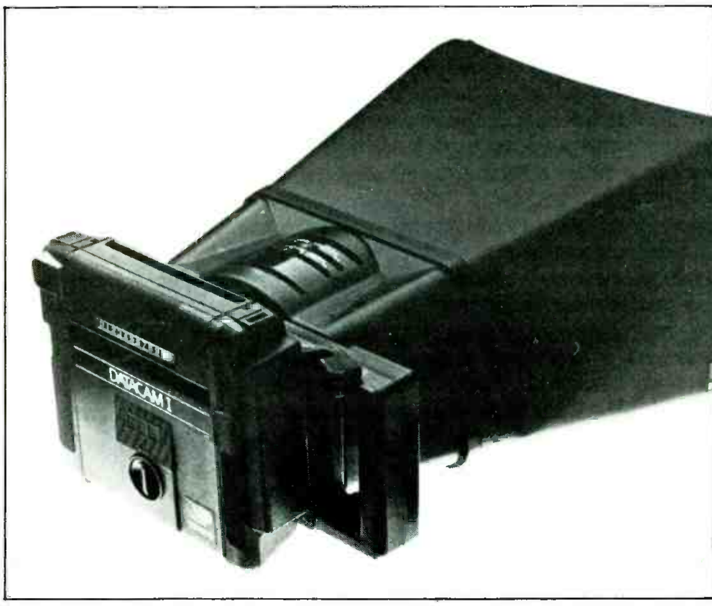
At a price claimed to about a third of any comparable tool, the TC1017 is a self-adjusting wire stripper and cutter suitable for most types of wire of diameters from 0.5 to 5mm. The tool operates in one continuous action by griping the wire and then cutting and removing the insulation by the sliding action of the blades. A pressure adjustment is provided for wires with particularly tough or soft insulation but in practice there is little need to use this.

Incorporated into the tool is a pair of cutting blades so that cables may be cut to length and trimmed before stripping. Graduations along the jaw of the stripper enable measured lengths to be stripped. Trade price £4.30 from B&R Electrical Products Ltd., Temple Fields, Harlow, Essex CM20 2BG. EWW219



Camera for screen graphics

Computer graphics displays as well as tv images can be easily and quickly reproduced with the Datacam 35 colour recording camera. It uses 35mm Polachrome film and an Autoprocessor can be used to produce and mount slides without the need for any darkroom facilities, or they can be processed normally. Another camera, the Datacam 1, produces 3 by 4in colour prints instantly by using Kodamatic Trimprint colour film. Two versions are available of each camera suitable for use with a 12 to 13in screen or a 19 to 21in. Dicoll Data Systems Ltd., Bond Close, Kingsland Estate, Basingstoke, Hants RG24 0QB. EWW222



Lowest-cost modem

The cheapest multi-standard modem yet is the Demon, which for a v.a.t.-exclusive price of £49.95 gives access to dial-up databases on both the 300 baud and viewdata standards. And a front-panel push-button allows selection of the corresponding American modes.

Most other controls, however, are implemented in software to avoid the cost of switches. At present the Demon, which was first announced last autumn as the Unicom modem, is available only in a version for the BBC Micro. The software is supplied in eprom at an extra £20. The data connection to the computer is via the serial port, which doubles as a control line: mode selection is carried out by keying the RTS line.

The software offers a number of attractive facilities: Prestel telesoftware downloading, user-to-user file transfer with the so-called CP/M protocol, auto-dialling, auto-answer and auto-scanning mode selection. One feature of its design is that all functions are controlled by means of 'star' commands. Users can incorporate these in their own software to make do-it-yourself computer bulletin boards.

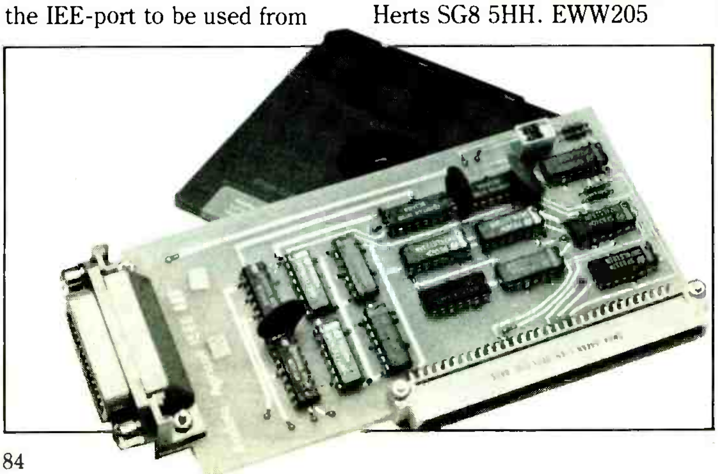
But a drawback of the software control is that there is no quick way of discovering the status of the modem. And the user cannot check whether a call has succeeded, since the unit has no telephone extension socket. Another problem is that although the rom is said to use 'legal' system calls only, it seems to conflict with certain other packages — for example, Addcomm and the Computer Concepts graphics extension rom.

Versions of the Demon are planned for several other computers, including the Amstrad CPC464, Apple II, ZX Spectrum and Commordore 64. The Demon Modem has not yet received BABT approval.

Demon Electronics Ltd., 182 Royal College Street, London NW1 9NN.
EWW210

GPIB for Apricot

A plug-in card together with a disc library of driver subroutines provides a full implementation of the IEEE-488 interface bus for the ACT Apricot personal computer. The card enables users of the computer to program and access data from such sources as automatic test stations, test and measurement equipment and signal interfaces such as Microlink. The software allows the IEE-port to be used from Microsoft controller functions, which include: secondary addressing, parallel data transfer in eight bits, serial and parallel polling, status tests from software, remote line control and data transfer at 20Kb/s. The p.c.b. plugs directly into the backplane of the computer or may be connected through a lead if required. Electroplan Ltd., PO Box 19, Orchard Road, Royston Herts SG8 5HH. EWW205



Terminal software for Spectrum

A cassette program, Spacenet, will allow Sinclair Spectrum owners to use their VTX5000 Prestel modems with ASCII services such as Bulletin boards and commercial databases which are not accessed through Prestel. The modem speed is still fixed at 1200/75 but most databases and an increasing number of bulletin boards are providing services at this data rate. Once connected to a service all control characters can be sent for editing or cancelling various functions. Program transfer is possible in both directions using Xmodem principles. Copies of the screen can be saved and reloaded into the computer as can any software received by the system. Local echo is provided as an option.

Another program, Specterm, provides similar functions and allows all known Spectrum RS232 interfaces to be used with a modem and will communicate even with Spectrum-incompatible computers. The software manufacturer tells us that BBC, Tandy and CP/M computers, amongst others, have been used to store Spectrum data. Each program cost £5.95 from Stephen Adams, 1 Leswin Road, London N16 7NL.
EWW207

Comal for the BBC

Latest in a flurry of recent language releases from Acornsoft is a version of Comal for the BBC Micro. Comal, which has been described as a half-way house between Basic and Pascal, is widely used in educational computing in Scandinavia (where it originated) and the Netherlands. It has also won official approval in Scotland and the Irish republic as the recommended language for secondary schools.

Comal is an interpreted language. For the beginner it is as easy to pick up at the keyboard as Basic, yet it does not share that language's tendency to engender untidy programming habits.

On paper, a Comal listing looks much like its Basic equivalent: most of the key-words are the same (though the tokens used for program storage differ), there are the same variable types and the program lines are numbered.

Comal's practical advantage lies in its powerful control structures. For example, in addition to the Repeat-Until loop (which is executed at least once) it has the useful While-do loop, which is not executed at all if on entry the exit conditions are already met. For decision-making, Comal has Case-when for use where the course to be taken depends on the value of a variable: a neat alternative to complicated If-then statements.

String-handling is made exceptionally easy by the sub-string specifier, a simple yet strikingly effective device which by-passes the cumbersome Left$, Mid$ and Right$. Filing commands are comprehensive, yet plainer in their meanings than their Basic counterparts.

Each program line entered at the keyboard is checked for syntax errors by the editor, which echoes any faulty line with the error marked. When the program is listed, loops and other features are indented automatically to emphasise the structure, making the flow of control easy to follow. Keywords are displayed in upper case letters, variables and procedure names in lower-case, and the editor inserts certain formal details of syntax where they have been omitted.

Execution speed is a little slower than BBC Basic — by about 15% according to Acorn — though that still makes it faster than most other eight-bit Basics. However, Comal's special features make it possible to write compact code which is also much simpler to de-bug.

Acornsoft's Comal conforms to the Comal-80 standard published in 1982. It includes many extensions specific to the Electron and BBC Micro such as sound and graphics commands, which have the same syntax as their BBC Basic equivalents. The language is supplied in a 16K rom for £49.85 including v.a.t., together with a clear and well-written 440-page manual, also available separately at £10. Acornsoft Ltd., Betjeman House, 104 Hills Road, Cambridge CB2 1LQ. EWW211

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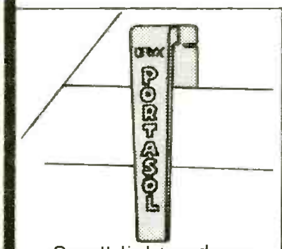
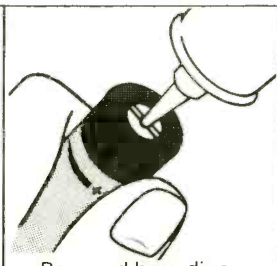
CIRCLE 21 FOR FURTHER DETAILS.

New from ORYX -PORTASOL
Portable Gas Soldering Iron

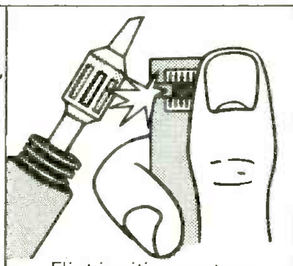
ORYX – market leaders in soldering irons and accessories introduce the revolutionary PORTASOL. This new approach to catalylic soldering iron technology is truly pocket portable (173 mm) and independent of any external energy source. PORTASOL is powered by ordinary cigarette fuel and one filling lasts for 60 minutes continuous use.



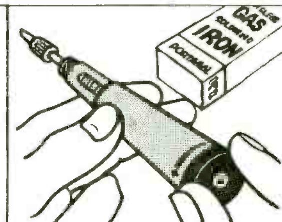
Small, light and can be carried in the top pocket.



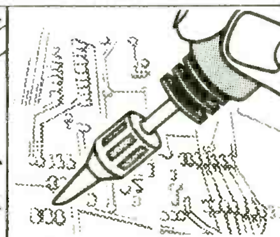
Powered by ordinary cigarette lighter fuel.



Flint ignition system built into the cap.



Adjustable temperature equivalent to electric soldering irons 10 to 60 Watt.



Ease of soldering for engineers, hobbyists, repair men etc.

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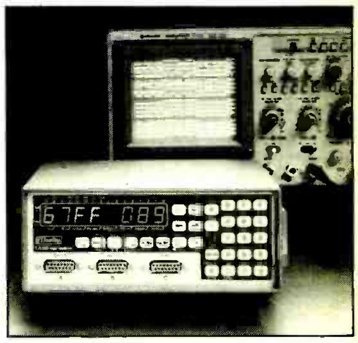
Low-cost logic analyser

Claimed to be by far the best in price to performance ratio, the Thurlby LA-160 at £395 offers 16 data channels, expandable to 32, and a 2000-word acquisition memory. The state domain display shows the data in any of five formats: binary, octal, decimal, hex or mixed. A full 16-channel timing display is available by connection to any conventional oscilloscope. The maximum clock rate is 10MHz for the LA-160A or 20MHz for the LA-160B.

Comprehensive trigger facilities include 230bit trigger width, the ability to set the trigger word in any display format, selectable trigger hold-off and a trigger arm input with variable delay. Data can be capture synchronously or asynchronously using the clock of the circuit under test or an internal clock with 16 selectable frequencies. Two clock qualifiers enable data to be captured selectively, e.g. on the read cycle of a processor bus.

The instrument is microprocessor controlled through a front-panel keyboard with all the set-up information being stored in permanent memory. A non-volatile reference memory is also included. This can be loaded from the acquisition memory and allows reference data to be stored for comparison. Extensive software facilities include word search, block memory compare, word-by-word comparison and stop on equality or non-equality acquisition modes. A built-in RS232 interface enables the



contents of the acquisition memory to be dumped to a computer and printed. Options include high impedance input modules, expansion units, an IEEE488 bus analysis connector and a direct printer interface. The LA-160 is truly portable, weighing less than 1.8kg.

Thurlby believe that its low cost makes it suitable for each engineer to be allocated one, rather than the usual queue to use the lab's only instrument. The low cost also makes it available to educational establishments and service departments who hitherto have been unable to afford a logic analyser. Thurlby Electronics Ltd., New Road, St. Ives, Huntingdon, PE17 4BG. EWW215

THURLBY LA160

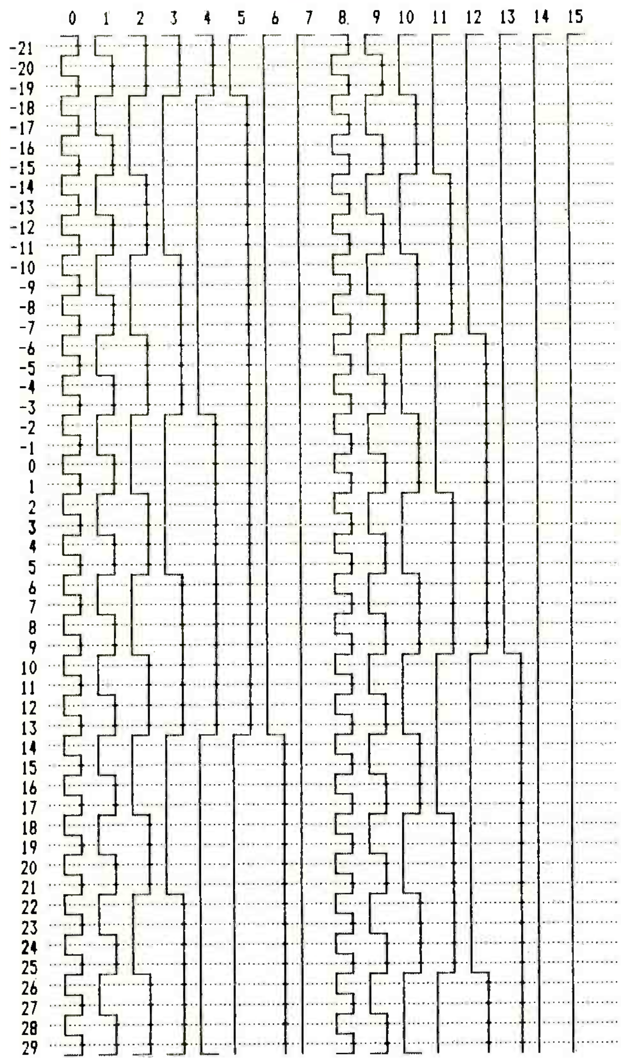
CLOCK= EXT   CLOCK POLARITY= POSITIVE   TRIGGER BIN= XXXX XXXX 0011 0010   HEX= XX32

CLOCK ENABLES= 11   TRIGGER ENABLES= 1101   TRIGGER ARM= 1

ARM DELAY= ON   TRIG HOLD-OFF= OFF

LOGIC= NEGATIVE   MEMORY= AQU

LOC   DATA

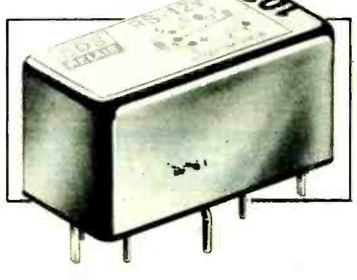


LOC	BINARY D15 … D0	HEX	ASCII
-21	0000 0001 0001 1101	011D	..
-20	0000 0010 0001 1110	021E	..
-19	0000 0011 0001 1111	031F	..
-18	0000 0100 0010 0000	0420	.
-17	0000 0101 0010 0001	0521	.!
-16	0000 0110 0010 0010	0622	."
-15	0000 0111 0010 0011	0723	.£
-14	0000 1000 0010 0100	0824	.$
-13	0000 1001 0010 0101	0925	.%
-12	0000 1010 0010 0110	0A26	.&
-11	0000 1011 0010 0111	0B27	.'
-10	0000 1100 0010 1000	0C28	.(
-9	0000 1101 0010 1001	0D29	.)
-8	0000 1110 0010 1010	0E2A	.*
-7	0000 1111 0010 1011	0F2B	.+
-6	0001 0000 0010 1100	102C	.,
-5	0001 0001 0010 1101	112D	.-
-4	0001 0010 0010 1110	122E	..
-3	0001 0011 0010 1111	132F	./
-2	0001 0100 0011 0000	1430	.0
-1	0001 0101 0011 0001	1531	.1
0	**0001 0110 0011 0010**	**1632**	**.2**
1	0001 0111 0011 0011	1733	.3
2	0001 1000 0011 0100	1834	.4
CURS	0001 1001 0011 0101	1935	.5
4	0001 1010 0011 0110	1A36	.6
5	0001 1011 0011 0111	1B37	.7
6	0001 1100 0011 1000	1C38	.8
7	0001 1101 0011 1001	1D39	.9
8	0001 1110 0011 1010	1E3A	.:
9	0001 1111 0011 1011	1F3B	.;
10	0010 0000 0011 1100	203C	<
11	0010 0001 0011 1101	213D	!=
12	0010 0010 0011 1110	223E	">
13	0010 0011 0011 1111	233F	£?
14	0010 0100 0100 0000	2440	$@
15	0010 0101 0100 0001	2541	%A
16	0010 0110 0100 0010	2642	&B
17	0010 0111 0100 0011	2743	'C
18	0010 1000 0100 0100	2844	(D
19	0010 1001 0100 0101	2945	)E
20	0010 1010 0100 0110	2A46	*F
21	0010 1011 0100 0111	2B47	+G
22	0010 1100 0100 1000	2C48	,H
23	0010 1101 0100 1001	2D49	-I
24	0010 1110 0100 1010	2E4A	.J
25	0010 1111 0100 1011	2F4B	/K
26	0011 0000 0100 1100	304C	0L
27	0011 0001 0100 1101	314D	1M
28	0011 0010 0100 1110	324E	2N
29	0011 0011 0100 1111	334F	3O

Glass-less relay

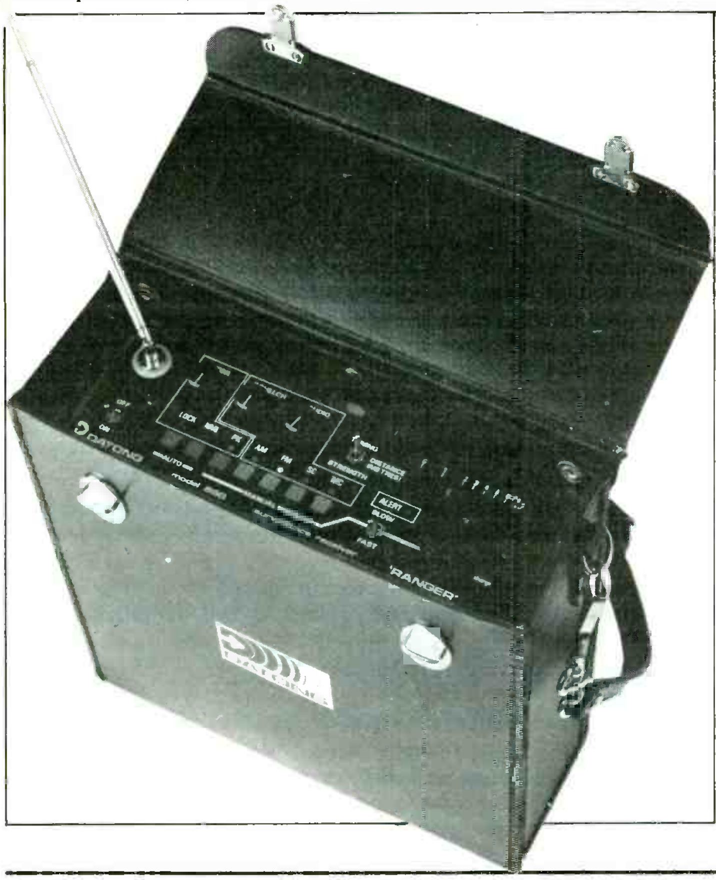
The changeover contacts on the SDS RS family of reed relays can switch 240V, 1A and up to 40VA. The relay does not use the conventional glass envelope for the reed element, but instead uses the coil body which is encapsulated inside the relay housing. The coils are polarized and 160mW of power is sufficient to achieve high contact pressure.

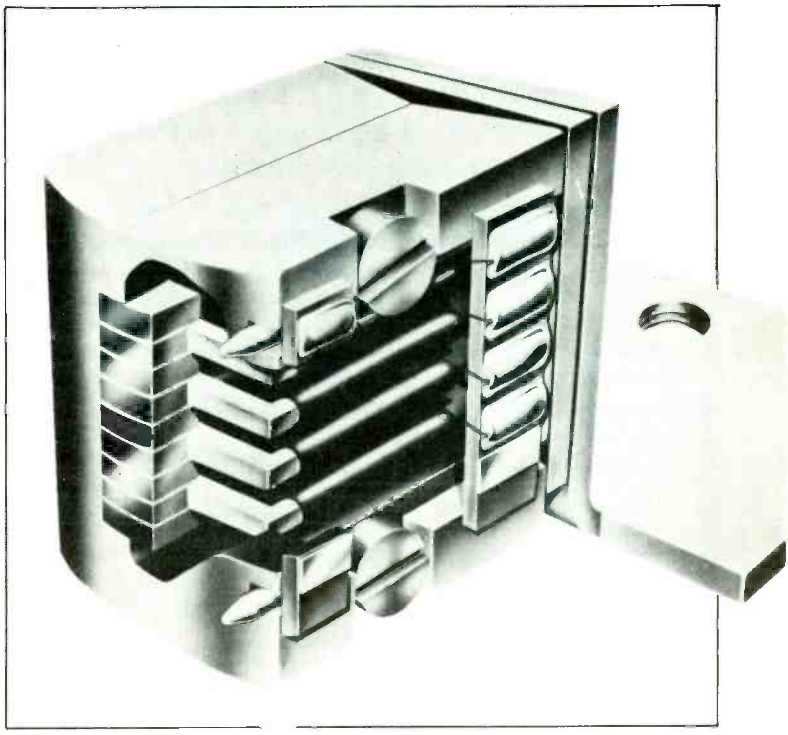
Polarizing also enables latching relays with one or two coils to be produced in a package only 20 by 10 by 10.2mm. For use in telecommunications, telemetry, instrumentation and control systems. They are sealed and magnetically screened. SDS Relais Ltd., 17 Poters Lane, Kiln Farm, Milton Keynes MK11 3HF. EWW221



Bug hunter

A device for detecting and locating clandestine radio microphones is the Ranger surveillance receiver. It improves over earlier systems by being able to operate in the presence of strong local radio signals, it can detect power line bugs without being connected to the power line, it can locate a bug to within a few centimetres and needs no specialist operator skills. An average room can be 'swept' in about two minutes and the sweep covers a frequency range from v.l.f. to several GHz. It also checks all likely modulation methods. The device is portable and operates from rechargeable batteries. Datong Electronics Ltd., Spence Mills Lane, Bramley, Leeds LS13 3HE. EWW217



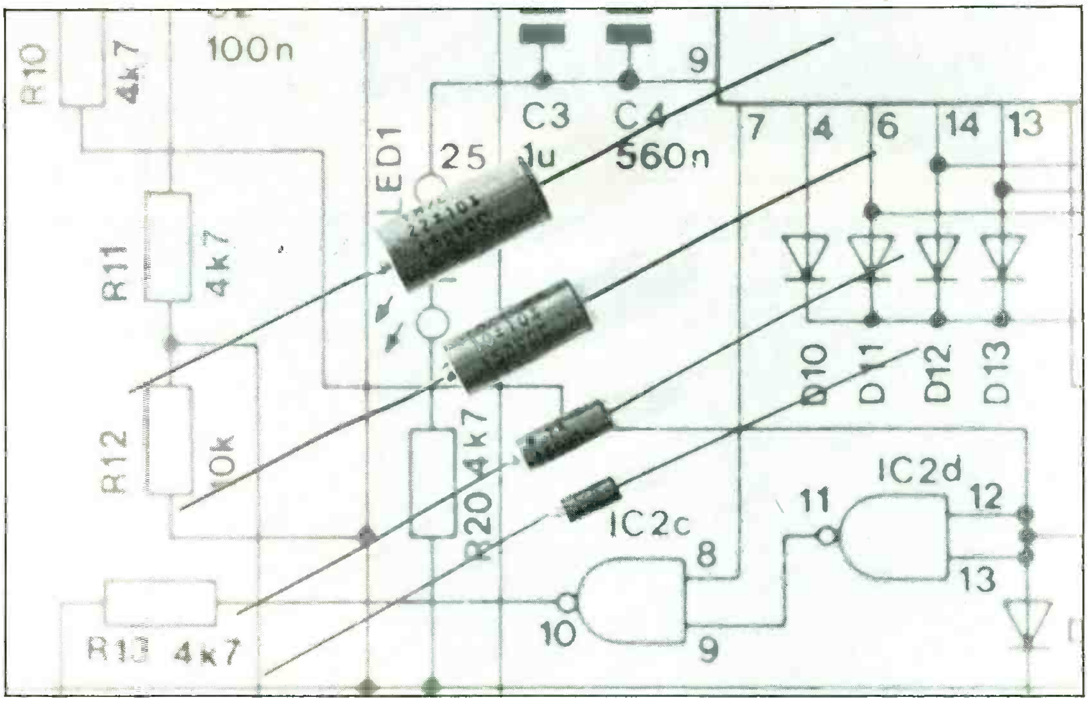


Nine-channel tape head

Designed for high speed data storage on 0.25in tape, the D99RW01 has nine channels designed for eight-bit words and a parity bit. The manufacturers point out that this method eliminated the need to buffer incoming signals before writing to the tape in serial format for subsequent reconversion to parallel on read output. There are also audio applications with the use of NAB audio cartridges and could be used, for example for the 'jingles' in popular radio The volume production version has a head gap of 100microns, a nominal inductance of 2.7mH providing an output of up to 4mV with a tape speed of 15ips and a data rate of 3200Hz. Other versions can be built to meet customer specification. Monolith Electronics Ltd., 5 Church Street, Crewkerne, Somerset TA18 7HR. EWW223

Tantalum capacitors

Of particular use in timing circuits where high stability, high reliability and low dissipation are important, the Mepco Electra range of metal cased solid tantalum capacitors is available. The 40SS range can also be used in decoupling, blocking, bypass and filtering applications. They are manufactured using porous sintered tantalum anodes with tantalum oxide dielectric. They feature very low d.c. leakage. Voltage ranges are from 6 to 100V in preferred capacitance values from 0.1 to 330µF, at 10% tolerance. Greenwood Electronics, Portman Road, Reading, Berks RG3 1NE. EWW216



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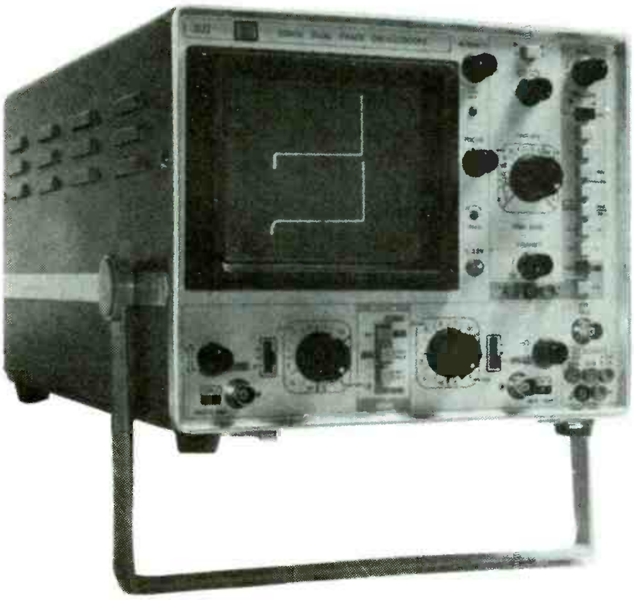

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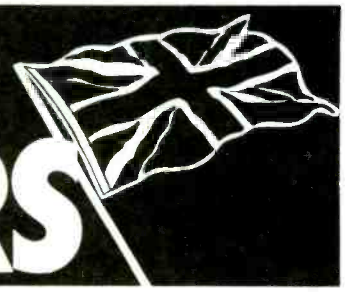

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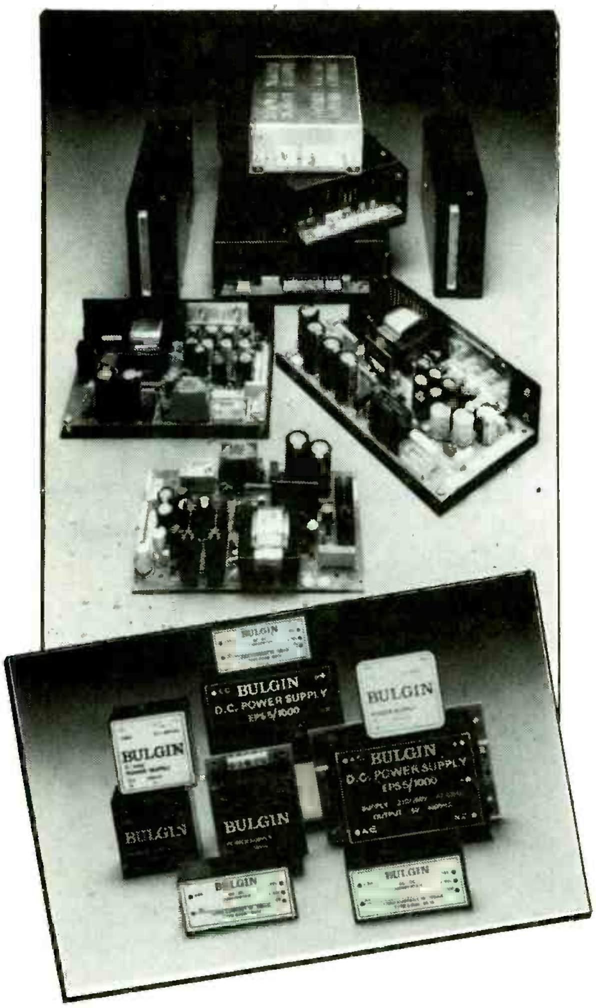

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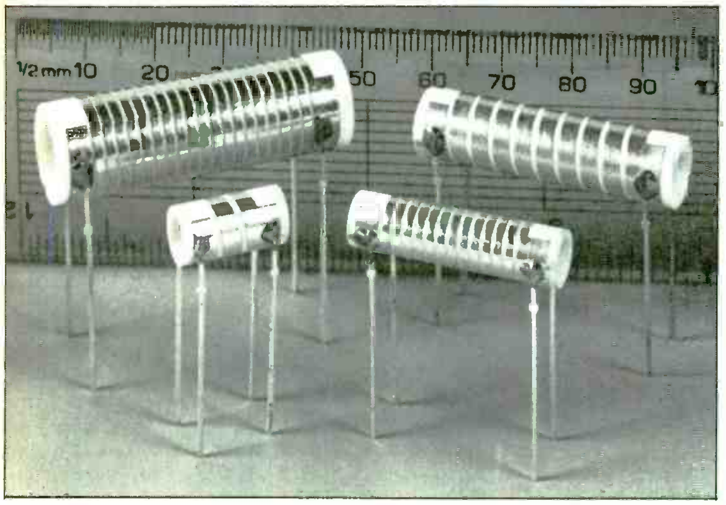

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The RB2 computer input tracker ball is now available with improved speed and temperature specification. Known as the RB2/CAD controller, it is available as a standard model, with enhanced specifications or it can be 'customized' with various options for quantity users. The standard tracker ball comes in a case with three user-definable function keys making it ideal for positional control applications such as c.a.d. word processing, robotics, graphics etc. A version is available with a standard RS232 interface communications module. The one-off price for the RB2/CAD from Marconi starts at about £70. MEDL Power Division, Carholme Road, Lincoln LN1 1SG. EWW227

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TDA2571	3.50
TDA2581	2.25
TDA2593	2.95
TDA2600	5.50
TDA2610	2.50
TDA2611A	1.95
TDA2640	3.50
TDA2680A	2.75
TDA2690	2.45
TDA3310	2.95
TDA3560	5.50
UPC566H	2.95
UPC575C2	2.75
UPC1025H	1.95
UPC1028H	1.95
UPC1032H	1.50
UPC1156H	2.75
UPC1158H	0.75
UPC1167C2	1.15
UPC1181H	1.25
UPC1182H	2.95
UPC1185H	3.95
UPC1191V	1.50
UPC1350C	2.95
UPC1353C	2.45
UPC1365C	3.95
UPC2002H	1.95
555	0.35
556	0.42
723	0.50
741	0.35
747	0.50
748	0.35
7805	0.65
7808	0.60
7815	0.65

SEMICONDUCTORS

AAY12	0.25
AC126	0.45
AC127	0.20
AC128	0.28
AC128K	0.32
AC141	0.28
AC141K	0.34
AC142K	0.30
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
AD142	0.79
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF106	0.50
AF114	1.95
AF121	0.60
AF124	0.65
AF125	0.35
AF126	0.32
AF127	0.65
AF139	0.40
AF150	0.60
AF178	1.95
AF239	0.42
AU106	4.50
AU107	3.50
AU110	3.50
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147A	0.12
BC147B	0.12
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.12
BC158	0.09
BC159	0.09
BC174	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC182LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.10
BC550	0.14
BC557	0.08
BC557B	0.08
BC558	0.10
BCY33A	1.60
BD115	0.30
BD124P	0.59
BD131	0.42
BD132	0.42
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10
BD150C	0.29
BD159	0.65
BD160	1.50
BD166	0.55
BD179	0.72
BD182	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.59
BD225	0.48
BC232	0.35
BD233	0.35
BD234	0.35
BD236	0.49
BD237	0.40
BD238	0.40
BD242	0.65
BD246	0.75
BD376	0.32
BD410	0.65
BD434	0.65
BD437	0.75
BD438	0.75
BD520	0.65
BD538	0.65
BD597	0.95
BD701	1.25
BD702	1.25
BD707	0.90
BDX32	1.50
BF115	0.35
BF119	0.65
BF127	0.39
BF154	0.20
BF158	0.22
BF160	0.27
BF167	0.27
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.18
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37
BF362	0.38
BF363	0.65
BF371	0.25
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.36
BF459	0.36
BF467	0.68
BF595	0.23
BF597	0.25
BFR39	0.23
BFR40	0.23
BFR81	0.25
BFR88	0.30
BFR90	1.50
BFR91	1.75
BFT42	0.35
BFT43	0.35
BFW92	0.85
BFX29	0.30
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BLY48	1.75
BRY39	0.45
BR100	0.26
BR101	0.49
BR103	0.55
BRC4443	1.15
BT100A/02	0.85
BT106	1.49
BT116	1.20
BT119	3.15
BT120	1.65
BU105	1.95
BU108	1.69
BU124	1.25
BU125	1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
BU208A	1.52
BU208D	1.85
BU326	1.20
BU407	1.24
BU500	2.25
BU508A	1.95
BU526	1.90
BU80Y	2.25
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA13	0.29
MPSA92	0.30
MRF237	4.95
MRF450A	13.95
MRF453	17.50
MRF454	23.50
MRF455	17.50
MRF475	2.50
MRF477	10.00
OC16W	2.50
OC23	1.50
OC42	0.75
OC44	0.75
OC45	0.55
OC70	0.45
OC71	0.55
OC81	0.50
R2008B	1.45
R2010B	1.45
R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.55
TIP32C	0.42
TIP33B	0.95
TIP34B	0.95
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP161	2.95
TIP2955	0.80
TIP3055	0.55
TIS91	0.20
TV106/2	1.50
2N1308	1.35
2N2219	0.28
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.12
2N3706	0.12
2M3708	0.12
2N3733	9.50
2N3773	2.75
2N3792	1.35
2N4427	1.95
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5485	0.45
2N5496	0.95
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1106	2.50
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.00
2SC1307	1.50
2SC1364	0.50
2SC1449	0.80
2SC1678	1.25
2SC1909	1.45
2SC1945	2.65
2SC1953	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2098	2.95
2SC2166	1.95
2SC2314	0.80
2SC2371	0.36
2SD234	0.50
3N211	1.95
3SK88	0.95

DIODES

AA119	0.08
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	1.10
BZY95C30	0.35
CS4B	4.50
CS10B	8.45
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00
IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.10

ZENER DIODES

BZX61 Series	0.15
BZY88 Series	0.10

NEW BRANDED CATHODE RAY TUBES

PLEASE ALLOW ADDITIONAL £3 PER TUBE FOR CARRIAGE.

A1865/20	65.00
AW36.11	25.00
CME822W	19.00
CME822GH	25.00
CME1428GH	45.00
CME1428W	39.00
CME1523GA	39.00
CME1523W	39.00
CME1431GH	39.00
CME1431W	39.00
CME202GH	45.00
CME2024W	45.00
CME2325W	45.00
CME3126GH	45.00
CME3128GH	45.00
CME3128W	45.00
CME3132GH	45.00
CME3155W	45.00
CRE1400	25.00
CV429	89.00
CV1450	35.00
CV1526	19.00
CV2185	15.00
CV2191	19.00
CV2193	15.00
CV5119	85.00
CV5320	85.00
CVX389	55.00
D9-110GH	39.50
D9-120	45.00
D10-210GH	45.00
D10-210GH68B	65.00
D10-210GH72	65.00
D10-230GH	35.00
D10-230GM	35.00
D10-293GY/90	55.00
D13-30GH	49.50
D13-33GM	49.00
D13-47GH/26	55.00
D13-47GH/34	55.00
D13-51GL/26	85.00
D13-51GM/26	85.00
D13-450GH/01	55.00
D13-471GH/26	55.00
D13-550GH	65.00
D13-600GM	59.00
D13-610GH	59.00
D13-610GM	59.00
D13-611GH	59.00
D13-611GM	59.00
D13-630GH	59.00
D14-120GH08	65.00
D14-150GH	75.00
D14-150GM	75.00
D14-172GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/62	65.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
D14-182GM/98	65.00
D14-200BE	89.00
D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH/50	75.00
D14-310W	110.00
D14-320GH	85.00
D14-320GH/82	85.00
D14-340GH/KM	45.00
D14-340KA	45.00
D16-100GH	65.00
D16-100GH/65	69.00
D16-100GH/67	65.00
D16-100GH67A	75.00
D16-100GH/79	69.00
D16-100GH/79A	75.00
D16-100GH97	65.00
D18-160GH	69.00
D21-10GH	65.00
D21-10GJ	69.00
D21-10LD	69.00
DG7-5	55.00
DB7.6	35.00
DB7-36	55.00
DG7.32	45.00
DG13.2	45.00
DH3-91	55.00
DH7 91	45.00
DP7.5	35.00
DP7.6	35.00
DN13.78	35.00
F15.101LC	49.00
F16-101GM	55.00
F16-101LD	55.00
F21-130GR	55.00
F21-130LC	55.00
F21-131GR	79.00
F31-10GM	65.00
F31-10GR	65.00
F31-10LC	65.00
F31.10LD	65.00
F31-12LC	65.00
F31-12LD	65.00
F31-13GR	65.00
F31.13LD	65.00
F31-13LG	65.00
F41-123LC	160.00
F41-141LG	160.00
F41-142LC	185.00
M7-120W	19.00
M14-100GM	45.00
M14-100KA	55.00
M14-100LC	45.00
M17-151GVR	175.00
M17-151GR	175.00
M19-100GY	55.00
M19-100W	45.00
M19-101GR	55.00
M19-103W	55.00
M23-110GH	55.00
M23-111W	55.00
M23-111GH	55.00
M23-111LD	55.00
M23-112GM	55.00
M23-112GV	55.00
M23-112GW	55.00
M23-112KA	55.00
M23-112LD	55.00
M23-112W	55.00
M24-120GM	59.00
M24-120GR	59.00
M24-120LC	59.00
M24-120WAR	59.00
M24-121GH	55.00
M24-121LC	59.00
M24-121WA	59.00
M28-12GH	55.00
M28-12LC	55.00
M28-13LC	49.00
M28-13LG	49.00
M28-13GR	49.00
M28-131GR	55.00
M28-132GM	55.00
M28-133GH	55.00
M31-100GH	55.00
M31-101GH	55.00
M31-182GR	55.00
M31-182GV	53.00
M31-183W	55.00
M31-184W	65.00
M31-184GH	65.00
M31-184P31	65.00
M31-185GH/VR	69.00
M31-186W	69.00
M31-190GH	55.00
M31-190GR	55.00
M31-190LA	55.00
M31-190W	59.00
M31-191GH	59.00
M31-191GR	59.00
M31-191GV	55.00
M31-191W	59.00
M31-192W	59.00
M31-195GH	59.00
M31-210GH	59.00
M31-220W	59.00
M31-270GY	65.00
M31-271P31	65.00
M31-271GW	65.00
M31-271W	65.00
M36-12W	75.00
M36-141LA	75.00
M36-141LG	75.00
M36-141W	75.00
M36-170LG	75.00
M38-100GR	65.00
M38-101GH	65.00
M38-103GR	65.00
M38-120W	65.00
M38-120WA	65.00
M38-121GR	65.00
M38-121GHR	65.00
M38-121LA	65.00
M38-121WA	65.00
M38-122GW	65.00
M38-140LA	65.00
M38-141LA	65.00
M38-142GR	65.00
M38-142LA	65.00
M38-340P31	65.00
M38-341GR	65.00
M38-341P31	65.00
M38-344P39	65.00
M40-120W	59.00
M43-12GM/01	65.00
M43-12LG/01	65.00
M44-120LC	65.00
M44-120GR	65.00
M47-25GR/22	65.00
M50-120GH	65.00
M50-120GR	65.00
M50-120GV	65.00
M50-120LC	65.00
M61-120LC	75.00
M61-120W	75.00
S6AB	45.00
SE4/D/P7	45.00
SE42BP31AL	55.00
SE42BP31	55.00
SE52AP31AL	55.00
SE5FP31	55.00
T937	65.00
T948N	65.00
T948H	65.00
V3191	59.00
V4150LC	55.00
V4254B	65.00
V4274GH	65.00
V4283W	65.00
V5002LD	65.00
V5004GR	59.00
V5004LD	59.00
V6001GH	65.00
V6006GH	65.00
V6007DP31	59.00
V6007GW	65.00
V6008GW	59.00
V6008W	65.00
V6034WA	59.00
V6048CLA	59.00
V6048F	65.00
V6048J	49.00
V6052GH	65.00
V6052GR	65.00
V6064BLA	65.00
V6064BP31	55.00
V6064CLA	55.00
V6069GH	55.00
V6070P31	49.00
V7016A	65.00
V7030	59.00
V7031GH	59.00
V7031/67A	59.00
V7035A	49.00
V7037GH	45.00
V8004GR	65.00
V8006GH	65.00
V8010A	65.00
2BP1	9.00
3BP1	13.50
4EP1	30.00
3WP1	18.50
3H/0BM	55.00
5BP1	9.00
5BHP1	30.00
5BHP1FF	30.00
5BHP31	30.00
5CP1	10.00
6EP7/S	39.00
13BP1	13.50
13BP4	17.50
17DWP4	25.00
32J/1085	69.00
88D/89B/89D/89L	15.00
1273	39.00
1564	39.00
1844	45.00
9442E1	80.00
95447GM	75.00
95449GM	75.00
7709631	78.50

TAPE HEADS

MONO HEAD	1.50
AUTO REVERSE	3.50
STEREO HEAD	2.95

ELECTRO-OPTICAL

9524H	25.00
9677M	22.00
P4231BAM	19.00

WIREWOUND RESISTORS

4 Watt	2R4-10K	0.20
7 Watt	R47-22K	0.20
11 Watt	1R5-15K	0.25
17 Watt	1R-15K	0.30

VALVE AND CRT BASES

B5D	5.50	B13B	0.50
B7G	0.25	B14A	3.00
B7G SKTD	0.25	12PIN CRT	0.95
B8G	1.50	NUVISTOR	2.95
B8H	0.70	OCTAL	0.35
B9A	0.35	SK610	35.00
B9A SKT	0.40	UX5	1.75
B9G	0.75	UX7	1.75
B10B	0.20	CANS	0.30

LINE OUTPUT TRANSFORMERS

DECCA 100	7.95
DECCA 1700 MONO	9.95
DECCA 1730	8.95
DECCA 2230	8.25
GEC 2040	8.95
GRUNDIG 1500	15.45
GRUNDIG 5010-6010, 2222.5011-6011	13.45
ITT CVC20	8.20
ITT CVC30	8.25
PHILIPS G8	8.50
PHILIPS G9	8.99
PHILIPS G11	13.39
PYE 725	10.95
RBM T20A	12.40
TANDBERGE 90°	11.15
TELEFUNKEN 711A	11.15
THORN 1590	9.50
THORN 8000	9.20
THORN 9000	9.95
THORN 9800	22.40
THORN MAIN TRANSFORMER 3000/3500	9.70

EHT MULTIPLIERS

ITT CVC20	6.35
ITT CVC30	6.35
PHILIPS G8 550	6.96
RANK T20A	6.91
THORN 3000/3500	7.57
THORN 8500	5.80
THORN 9000	8.00
UNIVERSAL TRIPLER	5.45

REPLACEMENT ELECTROLYTIC CAPACITORS

DECCA 30 (400-400/350V)	2.85
DECCA 80/100 (400/350V)	2.99
DECCA 1700 (200-200-400-350V)	3.55
GEC 2110 (600/300V)	2.25
ITT CVC20 (200/400V)	1.80
PHILIPS G8 (600/300V)	2.25
PHILIPS G9 (2200/63V)	1.19
PHILIPS G11 (470/250V)	2.35

VARICAP TUNERS

ELC1043/05 MULLARD	8.65
ELC1043/06 MULLARD	8.65
U321	8.25
U322	8.25

POTENTIOMETERS

STANDARD VERTICAL POTS	0.12
MIN. VERTICAL POTS	0.12
SANDARD HORIZONTAL POTS	0.12
MIN. HORIZONTAL POTS	0.12
CONVERGENCE PRE-SETS	0.30
SLIDERS LOG	0.48
SLIDERS LINEAR	0.48

PUSH BUTTON UNITS

DECCA, ITT, CVC20 6WAY	7.95
ITT CVC5 7 WAY	10.19
PHILIPS G8 (550) 6 WAY	14.49

20MM QUICK BLOW FUSES

100MA	8p each
200MA — 5AMP	5p each

20MM ANTI SURGE FUSES

100MA — 800MA	15p each
1A — 5AMP	12p each

SPARES & AIDS

FOAM CLEANSER	0.79
FREEZE IT	0.82
SOLDA MOP	0.64
SWITCH CLEANER	0.79
WD40	1.25
PUSH PULL MAINS SWITCH (DECCA, GFC, RANK, THORN ETC.)	1.02
PYE IF GAIN MODULE	6.99
ANODE CAP (27kV)	0.69

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3 LINES

P. M. COMPONENTS LTD

SELECTRON HOUSE, WROTHAM ROAD
MEOPHAM GREEN, MEOPHAM, KENT DA13 0QY

TELEX
966371
PM COMP

A SELECTION FROM OUR STOCK OF BRANDED VALVES

A1714	18.50
A1834	7.50
A1998	11.50
A2087	11.50
A2134	14.95
A2293	6.50
A2599	37.50
A2792	27.50
A2900	11.50
A3042	24.00
A3283	24.00
AC/HL/DD	4.00
AC/THI	4.00
ACT22	59.75
AH221	39.00
AH238	39.00
AL60	6.00
AN1	14.00
ARP12	0.70
ARP34	1.25
ARP35	2.00
ATP4	2.50
AX50	5.50
AZ11	4.50
AZ31	2.50
BL63	2.00
BS450	67.00
BS810	55.00
BS814	55.00
CIK	19.00
C3JA	21.00
C6A	9.00
C1108	54.95
C112G	70.00
C1134	32.00
C1148A	115.00
C1149/1	130.00
C1150/1	135.00
C1534	32.00
CCA	2.60
CC3L	0.90
CL33	2.00
CV Nos Prices on request	
D63	1.20
DA41	22.50
DA42	17.50
DA90	4.50
DA100	125.00
DAF91	0.70
DAF96	0.65
DC70	1.75
DC90	1.20
DCX4-1000	12.00
DCX4-5000	25.00
DET16	28.50
DET18	28.50
DET23	35.00
DET24	39.00
DET25	22.00
DET29	32.00
DF91	0.70
DF92	0.60
DF96	0.65
DF97	1.00
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	0.90
DK92	1.20
DK96	2.50
DL35	2.50
DL63	1.00
DL70	2.50
DL73	2.50
DL91	1.50
DL92	0.95
DL93	1.10
DL94	2.50
DL96	2.50
DLS10	13.50
DLS16	10.00
DM70	1.95
DM160	2.75
DY51	1.50
DY86/87	0.65
DY802	0.72
E81L	12.00
E82CC	3.50
E83CC	3.50
E83F	5.50
E86C	9.50
E88C	7.95
E88CC	3.50
E88CC Siemens Special	6.95
E90CC	7.95
E90F	7.95
E91H	4.50
E92CC	3.95
E99F	6.99
E130L	19.95
E180CC	6.50
E182CC	9.00
E180F	6.50
E186F	8.50
E188CC	7.50
E1T	15.00
E280F	19.50
E283CC	10.00
E288CC	13.50
E810F	25.00
E1148	1.00
E1524	6.95
EA50	1.00
EA76	1.95
EA79	1.95
EABC80	0.70
EAC91	2.50
EAF42	1.20
EAF801	2.00
EB34	1.50
EB41	3.95
EB91	0.85
EBC33	2.50
EBC41	1.95
EBC81	1.50
EBC90	0.90
EBC91	0.90

EBF80	0.65
EBF83	0.65
EBF85	0.95
EBF89	0.70
EBF93	0.95
EBL1	2.50
EBL21	2.00
EC52	0.75
EC70	1.75
EC80	9.50
EC81	7.95
EC86	1.00
EC88	1.00
EC90	1.10
EC91	5.50
EC92	1.75
EC93	1.50
EC95	7.00
EC97	1.10
EC8010	12.00
ECC32	3.50
ECC33	3.50
ECC35	3.50
ECC81	1.15
ECC81 Special Quality	1.95
ECC82	0.55
ECC82 Philips	1.95
ECC83	0.65
ECC83 Brimar	1.35
ECC83 Philips	1.95
ECC84	0.50
ECC85	0.60
ECC86	2.75
ECC88	0.95
ECC91	2.00
ECC180	0.72
ECC189	0.78
ECC801S	3.50
ECC803S	3.50
ECC804	0.60
ECC2000	12.00
ECF80	1.15
ECF82	1.15
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF804	6.00
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	3.50
ECH42	1.00
ECH81	0.65
ECH83	0.78
ECH84	0.69
ECH2000	1.50
ECL80	0.60
ECL82	0.65
ECL83	2.50
ECL84	0.74
ECL85	0.69
ECL86	0.80
ECL805	0.69
EF37A	2.00
EF39	1.10
EF41	3.50
EF42	3.50
EF50	2.50
EF55	4.95
EF70	1.20
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.50
EF85	0.50
EF86	2.25
EF86 Special Quality	3.15
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.95
EF95	1.50
EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF730	1.80
EF731	3.50
EF732	3.50
EF800	11.00
EF805S	13.50
EF806S	14.50
EF812	0.65
EFL200	1.50
EH90	0.72
EK90	0.72
EL32	0.95
EL33	4.00
EL34	2.25
EL34 Mullard/Philips	4.50
EL36	1.95
EL37	9.00
EL38	4.75
EL41	3.50
EL42	2.00
EL81	6.95
EL83	5.95
EL84	0.75
EL85	4.50
EL86	0.85
EL90	1.75
EL91	6.00
EL95	0.70
EL153	12.15
EL183E	3.50
EL18P	3.50
EL360	6.75
EL500	1.40
EL504	1.40
EL509	5.25
EL519	6.95
EL802	3.65
EL821	8.50

EL822	12.95
EM1	9.00
EM4	9.00
EM80	0.70
EM81	0.70
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
EN91	1.10
EN92	4.50
ESU150	14.95
ESU872	25.00
EY51	0.80
EY81	2.35
EY83	1.50
EY84	5.95
EY86/87	0.50
EY88	0.55
EY91	5.50
EY500A	2.50
EY802	0.70
EZ35	0.75
EZ40	2.75
EZ41	2.75
EZ80	0.75
EZ81	0.75
EZ90	1.50
F6064	2.95
FW4/800	2.95
G55/1K	9.00
G180/2M	9.00
G240/2D	9.00
GC10B	17.50
GC10D	17.50
GC10/4B	17.50
GC10/4E	17.50
GC12/4B	17.50
GD86W	6.00
GDT120M	5.00
GE10	9.00
GN4	6.00
GN10	15.00
GR10G	4.00
GS10C	16.50
GS10H	12.00
GS12D	12.00
GT1C	14.00
GT1C S/S	13.00
GTE175M	8.00
GTR150W	1.00
GU20	35.00
GU50	17.50
GXU1	13.50
GXU3	24.00
GXU50SS	14.50
GY501	1.20
GY802	1.00
GZ30	1.00
GZ31	1.00
GZ32	1.00
GZ33	4.50
GZ34	2.15
GZ34 U L	3.95
GZ37	4.50
HAA91	1.00
HABC80	0.90
HBC90	0.75
HBC91	0.80
HF93	0.75
HF94	1.50
HK90	1.05
HL2K	3.50
HL23DD	4.00
HL41	3.50
HL42DD	3.50
HL90	0.70
HL92	1.50
HL133/DD	3.50
HR2	4.00
HY90	1.00
HVR2	3.00
JP9-7A	60.00
K3118	85.00
KR6/3	45.00
KT8C	7.00
KT33C	3.50
KT36	2.00
KT44	4.00
KT45	4.00
KT61	4.00
KT63	2.00
KT66 OSRAM	15.00
KT66 USA	9.95
KT66 GEC	14.95
KT77 Gold Lion	10.95
KT81	7.00
KT88 USA	10.95
KT88 G Lion	18.95
KT67	9.00
KTW61	2.50
KTW62	2.50
KTW63	2.00
KTZ63	2.50
L63	1.50
L102/2K	6.95
L120/2K	12.00
LB7-20	95.00
LS9B	6.95
M502A	60.00
	85.00
M537A	60.00
M5143	155.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	5.50
M8099	5.00
M8100	5.50
M8136	7.00
M8137	5.50
M8161	6.50
M8162	5.50
M8163	5.50
M8190	4.50
M8195	6.50
M8196	5.50
M8204	5.50

M8223	4.50
M8224	2.00
M8225	3.50
ME1401	29.50
ME1402	29.50
ME1501	14.00
MH4	3.50
MHLD6	4.00
ML4	4.50
MS4B	5.50
MU14	1.50
MZI-100	125.00
N37	12.50
N78	9.85
OA2	0.85
OA2WA	1.50
OA3	2.50
OB2	0.85
OB2WA	1.25
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
QRP93	12.00
P61	2.50
P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL800	0.80
PCL805	0.90
PD500	3.50
PD510	3.65
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PEO6-40N	42.00
PFL200	0.95
PL21	2.50
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802	5.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	54.95
QE03-10	3.50
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE03-12	6.50
QQE03-20	27.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV03-20B	32.00
QQV06-40A	27.50
QQV07-50	63.50
QQZ03-20	42.50
QS75-20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95

QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	4.95
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-2500	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	76.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
S30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.95
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/2000	9.00
SD6000M	45.00
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3/2000	
TBL-2-300	275.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT15	34.95
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4-400	70.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.95
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	0.65
UCL82	1.75
UF41	1.15
UF42	1.15
UF80	0.80
UF85	1.20
UF89	2.50
UL41	4.50
UL44	3.50

UL84	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V240C/2K	225.00
V241C/1K	195.00
V2464A/2K	315.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
VR105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	1.00
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG2-6400	135.00
XG5-500	22.50
XL1-5V	1.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
Y503	25.00
Y65	6.95
Y602	12.00
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1005	8.00
ZM1020	8.95
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1B3GT	1.95
1B22	10.00
1B24	14.95
1B35A	29.50
1BC2A	2.50
1C1	2.50
1C5GT	2.50
1D5	2.50
1FD1	2.50
1G3GT	2.50
1K3GT	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1T4	0.70
1U5	1.00
1X28	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
2C21	1.00
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C51	0.75
2C53	32.00
2CY5	1.50
2D21	1.50
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	24.95
2K25 Raytheon	75.00
2K26	95.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95

3AT2	3.35
3B2	3.00
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3D22	19.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4687A	9.50
4-125A	55.00
4-250A	65.00
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B EIMAC	49.00
4CX250BM EIMAC	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4D26	75.00
4GS7	2.25
4GV7	2.25
4J52	75.00
4JC6A	2.95
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AMB	2.15
5ANB	1.20
5AR4	2.00
5AU4	1.50
5B8	2.50
5B.110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	9.00
5B-257M	9.00
5B-258M	14.50
5C22	125-00
5R4GB	3.50
5R4GY	3.50
5T4	5.95
5U4G	2.50
5U4GB	2.50
5V4G	1.25
5Y3GT	1.95
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AF4A	2.50
6AF9	4.15
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.50
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.50
6AN5	2.65
6AN8A	2.65
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AR8	3.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AZ8	5.95
6B7	2.80
6B8G	1.50
6BA6	0.95
6BA7	4.50
6BA8A	3.50

6BC8	1.00
6BD4	1.50
6BD6	2.50
6BE6	0.72
6BF5	1.60
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BL8	1.15
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	3.95
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
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6BZ7	2.95
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6F17	2.75
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6F25	1.25
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6SG7	1.35
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
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6SN7GT	1.35
6SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U8	1.15
6U8A	1.50
6V6GT	1.15
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7C6	2.50
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RESEARCH OFFICER IN ELECTRONICS
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The appointment will be made on the Research Officer grade **(£6483-8492)** or Senior Research Officer grade **(£8574-10,938)**. The MRC has a pension scheme and generous leave allowances.

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Opportunities exist for Engineers to work with a wide variety of equipment, including Multimeters, Oscilloscopes, Navigation Systems and Electronic Counter Measure Systems. Ability to trace, diagnose and rectify faults in these complex equipments is essential. Education to a minimum of C&G/TEC or equivalent is required, together with considerable practical knowledge and experience in electronic testing, servicing of radar, and telecommunications equipment. Experience of this nature gained in the Services will be of particular value.

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For full details please call our Personnel Manager, Roger Loughney, on 01-450 7811. Or write to him at Bradley Electronics Limited, Electral House, Neasden Lane, London NW10 1RR.

Bradley Electronics

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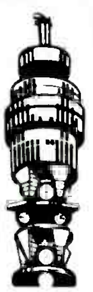

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Project and test engineers are required to work in the Systems Engineering Group which primarily deals with the custom design, manufacture and test of studio talkback and intercom systems.

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For fuller discussion, please contact Gavin Rendall, on 01-578 0081 during office hours up until 6.00 pm. Alternatively, write to him with full CV, quoting reference 85/01 to Dowty Electronics Limited, Communications Division, 419 Bridport Road, Greenford, Middlesex UB6 8UA.

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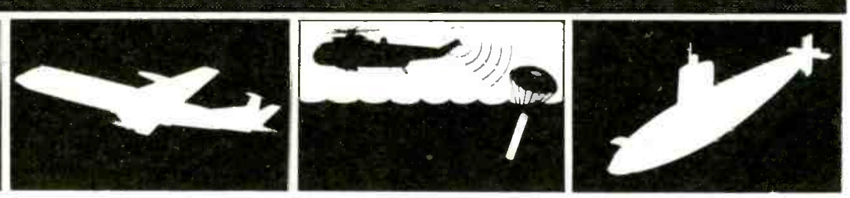

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Appointments

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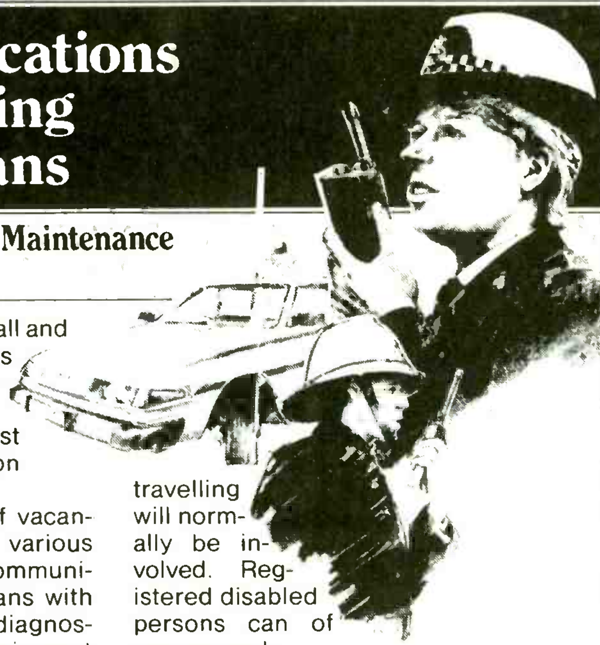

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Home Office Directorate of Telecommunications

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A valid UK driving licence is essential.

Application forms and further information are obtainable from Scottish Office, Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (Quote Ref PM PTS) 1/4/85 (031-556 8400, Ext. 4317 or 5028).

Closing date for receipt of completed application forms is 10 May, 1985.

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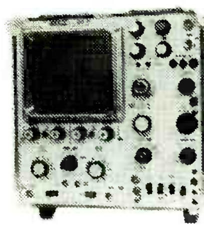

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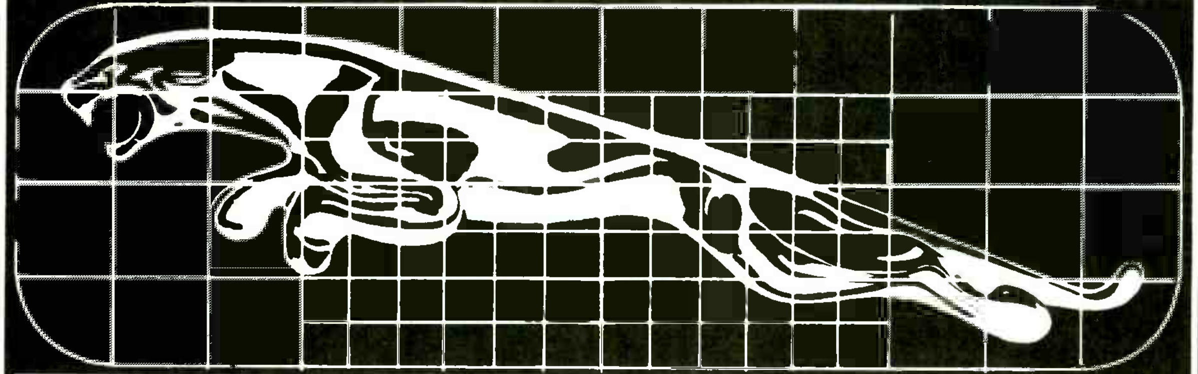

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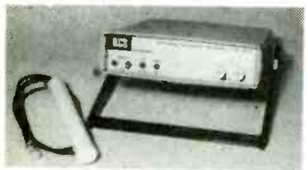

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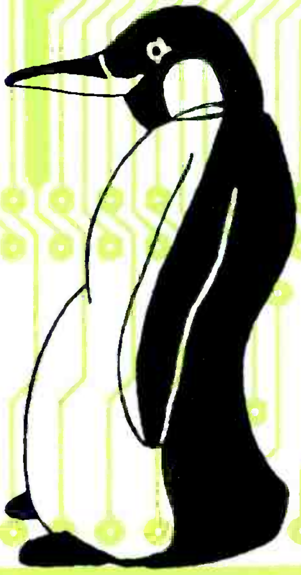
CIRCUIT BOARD DESIGN WITHOUT THE TEDIUM

smARTWORK lets the design engineer create and revise printed-circuit-board artwork on the IBM PC or compatibles.

Forget tape. Forget ruling. Forget waiting for a technician, draftsman, or the CAD department to get to your project. smARTWORK software turns your IBM PC or compatible into a professional, high quality drafting tool. It gives you complete control over your circuit-board-design — from start to finish.

What makes smARTWORK so smart is that it understands electrical connections. Conductor spacing is always correct, lines do not become too narrow, and connecting lines do not intersect other conductors. smARTWORK can automatically find and draw the shortest route between two conductors. Or you can specify the route.



smARTWORK is the only lowcost printed-circuit-board artwork editor with all these important advantages:

- Complete interactive control over placement and routing
- Quick correction and revision
- Production-quality 2× artwork from pen-and-ink plotter
- Prototype-quality 2× artwork from dot-matrix printer
- Easy to learn and operate, yet capable of sophisticated layouts
- Single-sided and double-sided printed-circuit boards up to 10×16 inches
- Multicolour or black and white display
- 32 user selectable colour combinations; coincident points may be displayed in contrasting colours
- Can use optional Microsoft Mouse as pointing device

System Requirements

- IBM PC, XT or compatible with 192K RAM, 2 disk drives and DOS 2.0
- IBM Colour/Graphics Adapter with RGB monitor or B& W monitor
- Epson MX-80/MX-100 or FX-80/FX-100 dot-matrix printer
- Houston Instruments DMP-41 pen-and-ink plotter (optional)
- Microsoft Mouse (optional)

The Smart Buy

At £895 (+VAT) smARTWORK is exceptional value, particularly when compared to conventional engineering workstation costs.

Write to the address below or use the enquiry card for more information on smARTWORK. Or call Richard Lambert on 0524 381423 to arrange a FREE demonstration or to discuss your requirements.

Starter kit comprising of: SAM 2001 PC, monochrome monitor, FX-100 dot matrix printer, DOS-2.0, smARTWORK, 1 Year on-site maintenance and much more £3995.00

Starter kit plus 10M hard disk drive £4995.00

Colour monitor £395.00

Microsoft Mouse £149.00

Pen and ink plotters from £1795.00

smARTWORK £895.00

smARTWORK Demo disk.... £10.00

10% Discount on all Orders processed and paid for before 28th February 1985.

Note: All prices exclude VAT and are subject to change without notice.

Terms: Strictly CASH WITH ORDER.

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Phone: 0524 381423 CIRCLE 2 FOR FURTHER INFORMATION