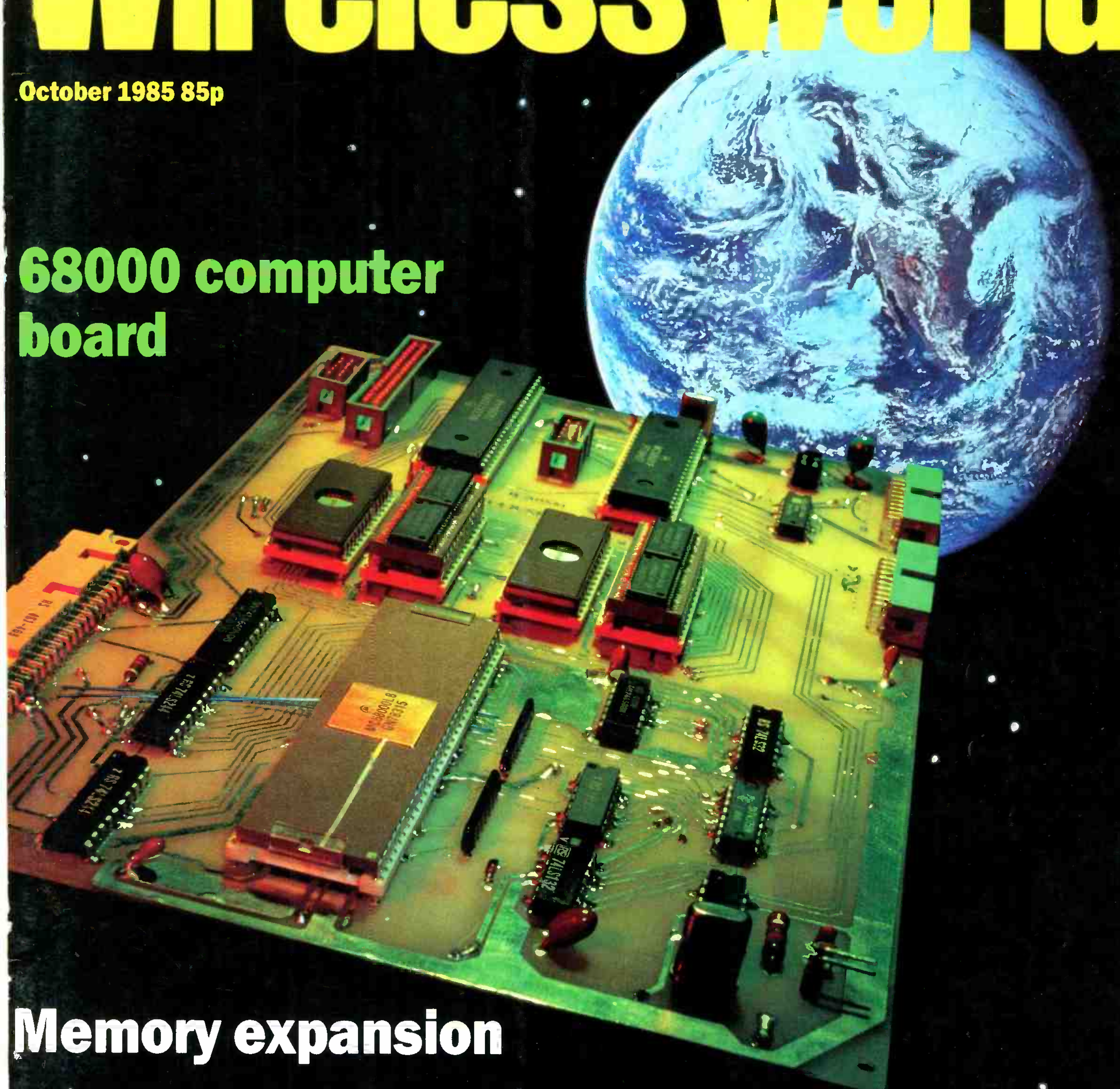
ELECTRONICS & Wireless world

October 1985 85p

68000 computer board



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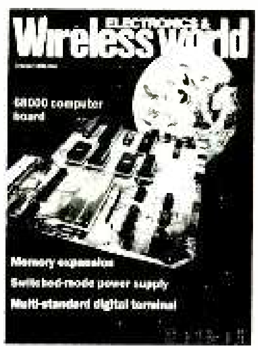
FEATURES

REGULARS



Phil Brooker's cover shows Bob Coates' 68000 board which links to hundreds of peripheral cards in the outside world through its G64 interface.

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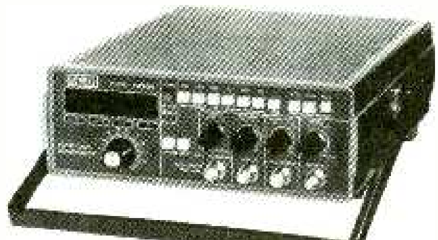

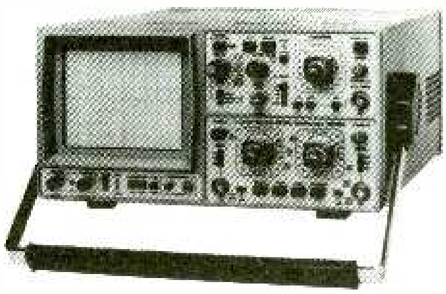

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CIRCLE 14 FOR FURTHER DETAILS.

Swings and swings

It's ironic that the electronics industry, which has contributed so much to advanced control technology — giving us such things as automatic blind landing of aircraft and multi-variable process control using microprocessor—can do so little to control its own business. Companies in this field have recently experienced the whole gamut of instability, from uncomfortable fluctuation in profitability to complete bankcruptcy. And the semiconductor manufacturing sector is notoriously vulnerable to fluctuations in trading.

Yet the basic parameters of business stability are few, traditional and well understood. If you can optimize profit, operating costs and cash flow, you are a business-man, my son. Unfortunately, the big unpredictable parameter, the highly independent variable in the control system equation, is the external one of market demand. Here, electronics is perhaps more vulnerable than many industries. Relying as it does on 'high' or 'leading-edge' technology, it is converting knowledge about Nature, some of it very new, into industrial and domestic products at an extremly fast rate. And because the gently dozing public is inevitably unaware of the new possibilities offered by these products it has to be woken up be advertising and promotion.

There is nothing wrong with advertising as a means of letting people know what is available on the market. But when it over-persuades a public which necessarily has no criteria to judge the usefulness or otherwise of entirely new kinds of products, it is doing a bad service to everyone. The hyperbole even goes to the heads of the manufacturers themselves. But *hubris* is followed by *nemesis*. We saw it with the over-selling of main-frame computers in the 1960s, the over-selling of pocket calculators in the late 1970s and we see it in the over-production of home computers now. At the worst the public feels it has been conned. At the best it signals by passive resistance that the rate at which it can consume and digest the new kinds of products is strictly limited.

If all this only resulted in a few financiers, shareholders and company directors getting their fingers burnt it wouldn't matter very much. But the worst effect is social. The flight of capital, whether in reduction of manufacturing capacity or complete shut-down of a plant, brings social havoc in its wake. According to an American study, the resulting unemployment brings"... psychosomatic illness, anxiety, worry, tension, impaired interpersonal relationships and an increased sense of powerlessness... As self-esteem decreases problems of alcoholism, child and spouse abuse, and aggression increase." Europeans know this too.

Capital mobility is regarded as a technical necessity for a free-market economy. The alternative is often stated to be the rigid bureaucracy and lack of enterprise of a centrally-planned economy, as in certain communist countries. But this is not so.

All electronics engineers know that the answer to instability in a closed-loop control system is damping. It slows down the response of an over-reactive chain of cause and effect. Precise control is achieved by a careful combination of proportional, integral and differential (PID) terms in the control system equation. If one could apply this analogy to an economic system it would mean making adjustments to achieve equilibrium rather than growth. We already have enough evidence before our eyes to show that the drive for perpetual economic growth is potentially disastrous, socially and ecologically. It cannot be sustained and is as unrealistic as perpetual motion. It will either result in some kind of breakdown in civilisation or, perhaps more likely, in an unrelievedly painful self-limiting condition.

An economic system is not a 'natural' order or God-given. It is man-made, like a servomechanism. It is therefore capable of being stabilized.

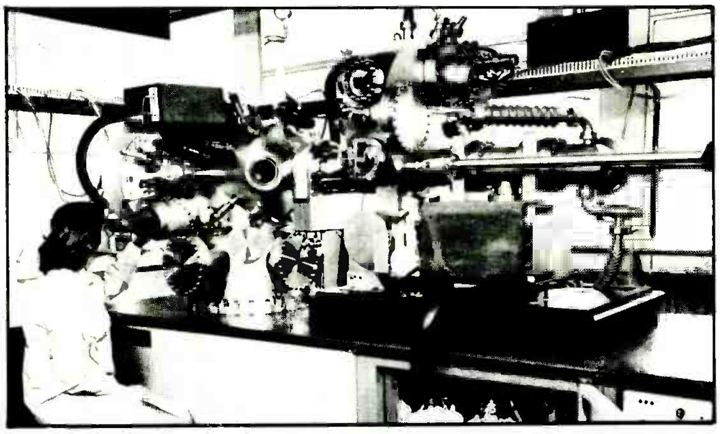
Molecular beam epitaxy

Gallium arenside semiconductor materials are produced, like silicon, by the growth of cylindrical crystals sliced into thin wafers. Unlike silicon, though, GaAs devices are not made directly from these wafers; they are used as a substrate for the growth of very thin layers of gallium arsenide or related alloys. The orientation of the layers is determined by that of the substrate, a phenomenon known as epitaxy.

Molecular beam epitaxy, just emerging from the research stage, may be used to grow layers with the depth of one atom. Molecular beams of the constituent elements, produced from effusion cells, impinge on the surface of the heated substrate to produce the required epitaxial layer.

The growth rate and composition of the layer can be controlled by the intensity of the beam, which is dependant on the temperature of the cells. The beams can be turned on an off by the use of shutters and the whole system can be automated with computer control of the cell temperatures and the shutter operation. Abrupt changes in the composition of a layer are possible and multilayer devices can be made. Thickness and composition of the layer can be closely monitored by observing the diffraction patterns produced by a high-energy electron beam directed at a grazing angle across the surface of the layer.

One of the first practical products to be produced this way has been the short-wavelength semiconductor laser used in optical recording and playback systems. Philips Research Laboratories at Redhill have produced lasers that can operate at wavelengths as short as 707nm, using inter-band layers as thin as 13nm. The chief advantage is that these lasers give visible light whereas normal GaAs lasers operate in the infra-red. The advantage of GaAs over silicon is the higher mobility of electrons, enabling the production of much faster devices. This has been increased even further, using molecular beam techniques, by the growth of a layer of AlGaAs onto the surface of a high-purity crystal of GaAs. At the intersection of the materials, a two-dimensional cloud of electrons is found in the gallium arsenide. This has even greater mobility than in normally doped GaAs, and could lead to the production of transistor structures able to operate at extremely high frequencies, up to 100GHz.



An ultra-high vacuum chamber is needed in this machine for gallium arsenide molecular beam epitaxy. Philips Research Labs, Redhill.

Canon's new T80 autofocusing camera brings the 'point and shoot' photography of compact cameras to single-lens reflex (SLR) cameras, with the benefit of being able to use interchangeable lenses. Its liquid crystal 'picture selector system' allows press-button selection if an appropriate program for exposure, sharpness detection and autofocusing. The camera has over 28,000 active elements in its i.c. complement, including a c-mos 8 bit microcomputer, and costs £395.

Eftpos comes to the High Street

Credit or charge-card sales can now be processed on-line in just a couple of seconds using Britain's first Eftpos system. Eftpos stands for 'electronic funds transfer at the point of sale', and a system is now available from Cresta Communications and British Telecom, initially in the London area.

The shopkeeper keys in brief details of each transaction on a small data terminal and wipes the customer's card through a built-in magnetic reader. The information is immediately transferred to a British Telecom computer which checks it against data supplied by the card companies and authorizes the purchase (or not) on the spot. A receipt is automatically printed out by the terminal.

Cresta's Teletran terminal makes use of voice-over-data techniques to exchange signals over the merchant's existing telephone line. Ordinary use of the line is unrestricted, but it remains available continuously for direct communication with the central computer and so avoids the need for time-consuming dialling. The data does not reach the local telephone exchange and is therefore presumably hacker-proof: a high degree of security is essential where money is concerned.

Cost to the retailer is £72 per month to rent the terminal, plus 2p per transaction. Cresta, who have licensed the system to BT, see a potential market of a quarter of a million terminals; a figure which they expect to increase with the growing use of plastic money. By next year the service is due to be available nationally.

In brief...

Freefone numbers have only been available by asking exchange operators for the number. Now, direct dialling is introduced by the use of dialling codes 0800 and 0345. The difference between the two is that 0800 numbers are free to the caller; 0345 numbers charge the cost of a local call from anywhere in the UK. BT, who seem to have an inexhaustible supply of catchy names have called this service LinkLine. It is most likely to be used by those service companies who gain much of their business from incoming calls, such as catalogue companies, travel agents, vehicle hirers, hotels, repair and maintenance companies and parts suppliers.

Professor Carsberg of Oftel is taking seriously the report in the Daily Mail that out of 200 public telephone kiosks visited, 120 of them were out of order. He commissioned a survey from NOP which found that 50% of call box users had difficulty in finding one that worked last time they tried and is having another to see how long specific boxes are out of action. He points out that BT's licence includes provision for a "reasonable public telephone service", and if necessary he could issue an order to enforce BT to meet its obligations.

The Director-General of Telecommunications has also been called in to arbitrate on the proposed switch from System X (GEC and Plessey) to System Y (Thorn Ericsson) digital telephone exchanges. Taking into account the possible loss of jobs at GEC and Plessey, and the possible gain in employment at Thorn Ericsson in Scunthorpe (where about 70% of the System Y exchanges will be made); and looking at the possible harm to the export prospects of System X, Carsberg has come to the conclusion that any further shifts of orders from X to Y should be gradual, over a period of three years, and give system X manufacturers the chance to meet reasonable cost and delivery requirements in the meantime.

The Monopolies and Mergers Commission has been asked by the Office of Fair Trading to investigate the possibility of a monopoly in the supply in the UK of marine radio navigation receivers compatible with he Decca Navigator system. Anyone with an interest in the investigation is invited to give their views or information to he the Commission, at 48 Carey Street, London WC2.

Although the technical papers are an important part of Montreux, (our report starts on page 14) the exhibition floor is where visitors spend most of their time.

The emphasis in the exhibition was firmly on the production and programme side of television. Of the over 200 exhibitors only about a dozen or so were showing broadcast transmitters.

Digital techniques are playing an ever increasing role in programme production. The French programme company SFP showed a four-minute tv clip which was the world's first demonstration of tv material in which the production and post-production were done entirely by digital means.

Although exhibitors and visitors regularly complain about the cramped facilities at Montreux, the picturesque lakeside location of the TV Symposium and Exhibition will continue to ensure that one of the world's most important tv events remains where it has been for the last 20 years!

Spark hazards

Dr Peter Excell, whose work on hazards associated with radio induced explosions is wellknown, is one of two academic staff members (the other is Dr Alfred Keller) of the University of Bradford who have received a £33,572 grant from SERC to investigate the possibilty that explosions on oil rigs and other major chemical installations could be accidentally triggered by radio waves. Although safety standards already exist they tend to be unduly restrictive they assume a number of conditions existing simultaneously, including a spark gap in the presence of a concentrated flammable mixture. They believe that probability factors could safely be taken into account to free radio systems from unnecessary restrictions.

The study will extend to related hazards, such as the likelihood of radio signals from low power transmitters setting off electro-explosive detonators or, interfering with aircraft guidance systems.

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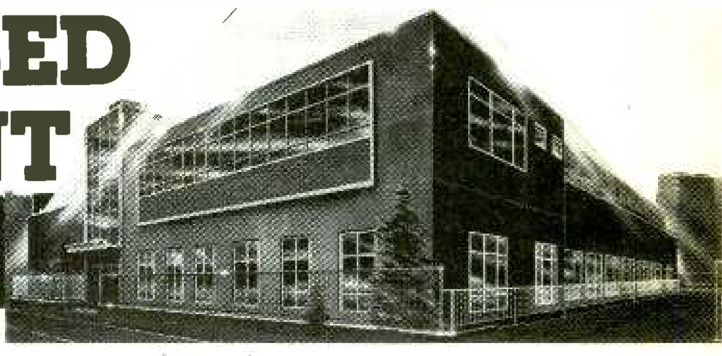

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PG502	Pulse Generator	£1650
PG505	Pulse Generator	£450
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CIRCLE 42 FOR FURTHER DETAILS.

British URSI research topics

The 1985 one-day "National Radio Science (URSI) Colloquium" held in London under the auspices of The Royal Society provided an opportunity to catch up with the many university, Rutherford Appleton Laboratory and British Antarctic Survey studies in the subjects covered by nine URSI commissions: electromagnetic metrology; fields and waves; signals and systems; electronic and optical devices and applications; electromagnetic noise and interference; remote sensing and wave propagation; ionospheric radio and propagation; waves in plasmas; and radio astronomy.

The presentations included wide-ranging surveys, plus informal talks by young scientists on particular projects, including a lively presentation by Dr Lorna Robertson of Glasgow University on the so-far unseccussful attempt to detect gravitational waves which may, if ever detected, finally prove or disprove Einstein's theories to the chagrin of so many writers of letters to the editor of this journal!

P. Wells (RSRE) described military work on compact, transportable satellite terminals for digital slow-scan tv. Dr P. Cudd (Sheffield University) described efforts to direct microwave energy further into the body to permit the use of hyperthermia techniques for deeper-seated malignant tumours with the aifd of phased arrays.

Dr Peter Bradley (RAL) reviewed the many research projects in the field of ionospheric propagation, though it is clear that the $64,000 question of predicting the time and shape of future sun-spot cycles remains essentially unsolved.

Prof. E.D.R. Shearman and Dr Lucy Watt of Birmingham University reported on the work on h.f. sea-state radar. This has now abandoned the use of pulsed emissions at 1.9MHz in favour of f.m. — c.w. emissions between 6.7 and 40MHz that do not spread over more than about 20kHz of spectrum. Although this project is presented as a tool for studying oceanography it is difficult to dispel the suspicion that the objective could be to locate submarines from the disturbances they create at the surface.

The idea of these URSI symposia seems excellent, but they do tend to highlight the tendency of British universities and establishments to ignore work carried on elsewhere in the world — the old "not invented here" syndrome. This is markedly different from the intense Japanese interest in what is happening in Europe and the USA. This has now led to American industry seeking more engineers versed in the Japanese language in order better to monitor Japanese science and engineering publications of which only about a fifth are currently translated into English.

Flying tape

The recent IEE 50th anniverssary of radar seminar was only one aspect of the increasingly serious interest in the history of electronics technology. The 25th anniversary (May 15, 1985) of the first demonstration at Hughes Research Laboratories, Malibu, California by T.H. Maiman of a working laser did not go unnoticed, although what was once "a solution awaiting a problem" is now increasingly regarded as a solution to military rather than civilian problems.

A detailed paper by Claud Powell in the IERE Journal (June 1985) traces the early history, from its conception in 1937, of the Decca Navigator system based on the work of William O'Brien and Harvey Schwarz. They had great difficulties in getting the system adopted in the USA. This led to its important but largely unrecorded role (as "QM") in the Normandy landings of June 1944, following secret trials between Anglesey and the Isle of Man.

An SMPTE historical paper by William Lafferty "The use of steel tape magnetic recording media in broadcasting" similarly shows that while the Blattnerphone and Marconi-Stille machines, both stemming from the work of Curt Stille, were widely used in Europe throughout the nineteen-thirties and early nineteen-forties, American broadcasters depended on direct-disc recording.

There are broadcast engineers still working who recall using the Marconi-Stille machines with large spools containing up to 2700 metres of special Swedish steel tape that sped by the heads at 1.5m/sec.

Lafferty points out: "Editing the recorded tapes could be accomplished through the tedious and cumberous process of cutting the tape with tin shears, then soldering or spot-welding the tapes together. Edited tapes could be dangerous, since if a splice broke during transmission the operator risked being slashed by the flying steel tape as it spun."

The BBC adopted the bulky Blattnerphone machines at the start of the Empire Service in 1932 when "time-shift" became essential. Blattner's company went into liquidation in 1933 after their failure to interest the film industry. The later Marconi-Stille machines were smaller, more reliable and provided better quality.

The BBC also adopted the Philips-Miller film system of sound recording, mechanically cutting away an opaque coating on the film, later using a photo-electric cell for high-quality reproduction. However both steel tape and film recorders were expensive to operate so that use was also made of direct-disc recorders, including the portable machines used by the war reporters. German work on plastics-backed tape, leading to the modern tape recorder, came about to avoid having to import the special Swedish steel.

Interference aggro

The decision of the Department of Trade and Industry to discontinue its free service to viewers who complain of radio and television reception problems, and instead to concentrate its diminished resources of the Radio Investigation Service on "pirate" operation and spectrum abuse, it a logical, though in some ways regrettable, move. It was made essential because of the many members of RIS who were unwilling to accept the relatively poor terms of employment offered by the DTI when the service was transferred from British Telecom. Even after some fresh recruitment the present staff is only about 240 compared with 340 under BT.

There is little doubt that domestic interference investigation has been difficult to justify in terms of cost-benefit. A high proportion of all complaints have been due to ineffective aerials, receiver faults, or so infrequent that the investigation teams have been unable to observe, let alone trace, the interference. The introduction of c.b. into the UK significantly increased the number of viewer complaints, though in practice such interference, when involving "legal" c.b. operation, reflected the poor immunity of many television sets, and could usually be cured by a simple filter fitted to the receiver. It could be claimed that the existence of the free-services provided by RIS encouraged set-makers to pay little heed to immunity. Retailers have tended to leave it to the specialist skills of the RIS teams or simply to tell customers that interference problems are the fault of the transmitter or appliance. British regulations are also very lax in regard to spectrum pollution by industrial equipment, home computers and the like.

The DTI are, in effect, now copying the FCC approach in the provision of a detailed free booklet providing good explanatory advice to viewers/listeners together with technical guidance for dealers (it is questionable whether these fit well into a single booklet).

The DTI also intend to incorporate BS905, Part 2 of which provides recommended minimum immunity standards for television sets, into legally-binding regulations. This is good news for amateurs, c.b.-ers and anyone operating transmitters in residential areas. Unfortunately, BS905 Part 2 currently stipulates immunity tests to be carried out only on signals between 26-30MHz, though it is to be hoped that a set which shows good immunity to such signals will be reasonably immune to signals on other frequencies (though not necessarily for 144MHz and above). A real

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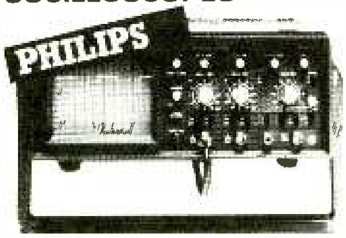

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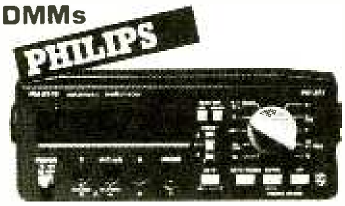

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Fluke JF 25 **£193**
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Fluke JF 27 **£216**
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Thandar TG 102 **£160**
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Thandar TG 105 **£105**
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Thurlby PL 310 **£125**
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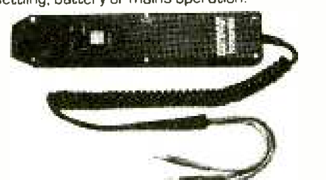
Thurlby multiplexer expands any oscilloscope to 8 channels, displays analogue or digital signals, triggering from any channel, band width 35MHz, precision calibrated attenuator.

Thurlby CM 200 **£89**
Thurlby digital capacitance meter, 4½ digit LCD, 1pF to 2500µF range, accuracy 0.2%, fast settling, battery or mains operation.



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CIRCLE 43 FOR FURTHER DETAILS.

problem, however, will continue to exist in the case of wideband r.f. amplifiers that are fitted to devices intended for use in countries with both v.h.f. and u.h.f. television and particularly susceptible to strong local amateur signals on 70, 144 and 430MHz or broadcast signals on 95MHz.

The real loss both to amateurs and broadcasters is that of the diplomacy of the RIS teams in settling fairly the disputes and social problems that arise. While the new booklet does emphasise that it is usually the receiving installation that is at fault it is often virtually impossible for an amateur or c.b. operator to convince an irate neighbour that this is the case. It could prove an expensive business for a viewer to call in a dealer to trace and cure some of the more intractable interference problems, and pressure will be put on the amateurs and c.b. operators to close down.

C^4I — Costly CCCI

The Americans, over the past two decades, have spent billions of dollars on strategic command, control, communications and information (C^3I) systems designed to provide instant and secure access to military commanders throughout the world. Yet today, it is increasingly recognized that many of the projects have turned sour primarily because of the pursuit of ideal rather than practical systems. The crucial world-wide military command and control system (WWMCS) comprises more than 60 different communications systems linking 27 command centres under the control of 20 million lines of Cobol software and 35 ageing Honeywell Series 6000 computers. American journals suggest that the system suffers extensively from down-time and has failed badly on several occasions, including the putting out of a nuclear attack alert when a war-games program got into the main Colarado neclear warning centre, and a record of dismal failures during real crises in the 1960s and 1970s. Currently three main up-grading projects are under way for WWMCCS, for the slightly less ambitious "minimum essential emergency communications network" and for the new "Milstar" network which is intended to be proof against neclear electromagnetic pulses (NEMP) and on which the US is spending some $400-million per year. Even EMP-protection however will not necessarily prevent disruption of communications over an extended period in the event of a nuclear attack or the use of anti-satellite weaponry.

Amateur Radio

SSB on 10.1MHz?

As a morse enthusiast initially, I welcomed the idea of keeping the narrow 10.1 to 10.15MHz band free not only of contest operation but also of s.s.b. This form of bandplanning to which the RSGB became committed at an early stage, was later endorsed by the IARU Region 1 Bureau but depends on voluntary restraint as, at least in Europe, it is not written into the licence regulations.

There has, however, always been a valid case for using a small segment of this band, which has interesting "chordal hop" propagation along the twilight "grey-line" paths as a result of ionospheric tilts as the F1 and F2 layers combine at dawn and dusk. The belief that c.w./r.t.t.y. operation with its high average power duty cycle causes *less* interference to commercial point-to-point communications is hardly a tenable theory. The s.s.b. enthusiasts claim that telephony, with good operating discipline, enables experimental data to be obtained rapidly. It is also the case that the absence of s.s.b. has tended to keep amateur activity on the band low.

There are signs that the IARU restriction is breaking down in several countries, including the UK — although the s.s.b. operators are subject to abuse. Is it not time that this subject should be reconsidered with a view to providing an s.s.b. segment? The alternative may prove to be a loss of confidence in the concept of "voluntary" band plans drawn up by largely self-perpetuating committees. Voluntary band-planning is too valuable an asset to be lost, yet is an area where manifestly it must be seen to be fair to all.

RAE attacked

Richard Harris, G3ZWH, head of physics at Harrogate College, has delivered a strong attack on the Radio Amateurs' Examination run by City & Guilds of London Institute. He complains in particular of the refusal of CGL1 to allow actual examination papers to be published or even taken out of the examination room and the unsuitability of many of the questions which often concentrate on basic theory rather than the principles and practice of amateur radio. He suggests that the RAE should recognize that fewer candidates have prior experience as short-wave listeners and need to ben encouraged to learn more about the practical aspects of two-way radio communication. He objects to the absence of a fixed "pass mark" and strongly believes that "the present situation must not be allowed to continue" — reflecting comments that have been made over several years in *E&WW*.

In brief

Good two-way voice contacts were made from the UK with Dr Tony England, WOORE on board the August Challenger space-shuttle flight. It has also been claimed that the RSGB headquarters station at Potters Bar was the first amateur station in Europe to receive frames of slow-scan television pictures from the shuttle.

October 27 marks the 50th anniversary of the day in 1935 when Nell Corry, G2YL made radio history by working all six continents on 28MHz in a single day. Transatlantic contacts on this band had been made in 1928-29 but the declining sun-spot cycle then resulted in several years when virtually no long-distance stations were contacted, until sun-spot activity began to increase again.

At 9 a.m. she contacted VU2LJ, Assam; 10.30 a.m. VK4BB Queensland, Australia; 11 a.m. CX1CG Uruguay; followed by Europe, Africa and the USA all before 3.30 p.m.

Less than half of American "novice" licence holders renew or upgrade their licences and many never reach the stage of coming on air. It is uncertain whether this is due to the cost of equipment, restriction to morse only, or the crowded state of the novice segments of h.f. bands. American amateurs holding higher grades of licence are being urged to do more to provide encouragement and guidance to the "novices".

An RSGB "National HF Convention" is being held on Sunday, September 29 at the Belfry Hotel, Milton Common, Oxford with a crowded programme of lectures, demonstrations, talk-in stations, "car boot sale" etc. It will also be possible to take, by prior appointment, the official morse test. . . RSGB president for 1986 is to be W.J. McClintock, G3VPK. . . Welsh Amateur Radio Convention is on October 6 at Oakdale Community College, Blackwood, Gwent. . . The second Yeovil QRP (Low Power) convention is on October 13 at The Preston Centre, Monks Dale, Yeovil. . . A large numer of RAE courses began in September at adult education centres. . .

The Radio Amateur Old Timers Association (RAOTA) and the Dutch Old Timers Club are holding activity mornings (0830 to 1130 GMT) on October 6 and 7 on 3.5 and 7MHz (initial contacts on 3600kHz). . . The worldwide Jamboree-on-the-Air takes place on October 19 and 20. . . The Royal Navy Amateur Radio Society celebrates its 25th anniversary and will operate GB4KRN throughout October from Tonbridge, Kent. . . The RSGB Midlands VHF Convention is at Madeley Court, Centre, Telford, on October 12. . .

In a letter to *The Lancet*, J. Seager of the Arrowe Park Hospital, Upton, Wirral has commented on the leukaemia risks that have been linked with non-ionizing electromagnetic radiation in such occupational groups as electronic assemblers, television repairmen and radio amateurs. He points to the need for more precise analysis of the apparent risk factors and their relation to the fluuxes and tin/lead alloy used in soldering or the fumes given off during soldering by the overheating of synthetic materials.

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74 SERIES	
7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	1.00
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.10
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.55
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.80
74154	1.40
74155	0.80
74156	0.90
74157	0.80
74159	1.75
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	3.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.10
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
7474221	1.10
74251	1.00
74259	1.50
74265	0.80
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74742	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74368A	0.70
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES	
74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS12	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.24
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS47	0.80
74LS48	0.90
74LS49	1.00
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS91	0.90
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	0.80
74LS124	1.40
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.50
74LS136	0.45
74LS138	0.55
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.40
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.65
74LS160A	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166A	1.50
74LS168	1.30
74LS169	1.00
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS193	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.80
74LS245	1.10
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS2457A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS261	1.20
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	9.00
74LS293	0.80
74LS295	1.40
74LS297	9.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.90
74LS374	0.90
74LS375	0.75
74LS377	1.30
74LS378	0.95
74LS379	1.30
74LS381	4.50
74LS385	3.25
74LS390	0.60
74LS393	1.00
74LS395A	1.00
74LS399	1.40
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	19.00
74LS612	19.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.25
74LS640	2.00
74LS640-1	3.00
74LS641	1.50
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS45-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.70
74LS682	2.50
74LS683	3.00
74LS684	3.50
74LS687	3.50
74LS688	3.50
74LS783	21.00

74S SERIES	
74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	0.50
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.60
74S40	0.50
74S51	0.60
74S64	0.45
74S74	0.70
74S85	3.00
74S86	1.00
74S112	1.50
74S113	1.20
74S114	1.20
74S124	3.00
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.00
74S158	2.00
74S163	3.00
74S169	5.50
74S174	3.00
74S175	3.20
74S188	1.80
74S189	1.80
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	4.00
74S241	4.00
74S244	4.50
74S251	2.50
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	4.50
74S373	4.00
74S374	4.00
74S387	2.25

74C SERIES	
74C00	0.70
74C04	0.50/ 4069
74C08	0.70
74C10	0.70
74C14	0.50/ 40106 4584
74C20	0.70
74C32	1.00
74C42	1.50
74C48	1.50
74C73	1.00
74C74	1.20
74C76	1.00
74C83	2.00
74C85	2.25
74C86	0.50
74C90	1.90
74C93	1.50
74C95	1.60
74C107	1.00
74C150	5.00
74C151	2.00
74C157	2.50
74C160	1.80
74C161	1.80
74C162	1.80
74C163	1.80
74C173	1.00
74C174	1.50
74C175	1.50
74C192	1.50
74C193	1.50
74C194	1.50
74C195	1.50
74C221	2.50
74C244	2.00
74C245	2.25
74C373	2.25
74C374	2.25
74C902	1.20
74C911	9.00
74C912	4.50
74C922	6.00
74C923	6.50
74C925	6.50
74C926	7.50

[illegible]	
74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.45
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

4000 SERIES	
4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0.45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
3014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.80
4021	0.60
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.80
4055	0.80
4056	0.85
4059	4.00
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.90
4095	0.90
4096	0.90
4097	2.70
4098	0.75
4099	0.90
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.75
4541	0.90
4543	0.70
4551	1.00
4553	2.40
4555	0.36
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.60
14490	4.20
14495	4.50
145000	6.50
14599	2.00
22100	3.50
22101	7.00
22102	7.00
40D14	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.30
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	0.80
40110	2.25
40114	2.25
40147	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

LINEAR ICs

AD7581	12.00
ADC0808	11.90
AM7910DC	25.00
AN-1-5050	1.00
AY-3-1350	3.50
AY 3-8910	4.90
AY 3-8912	5.00
CA3019A	1.00
CA3020	3.50
CA3028A	1.10
CA3046	0.70
CA3059	3.25
CA3060	3.50
CA3080E	0.70
CA3085	1.50
CA3086	0.60
CA3089E	2.50
CA3090AQ	3.75
CA3130E	0.90
CA3130T	1.30
CA3140E	0.45
CA3140T	1.00
CA3146	2.25
CA3160E	1.50
CA3161E	2.00
CA3162E	6.00
CA3189E	2.70
CA3240E	1.50
CA3280G	3.00
D7002	6.00
DAC1408-8	3.00
DAC0800	3.00
DAC0808	3.25
DG308	3.00
HA1366	1.90
ICL7106	6.75
ICL7611	0.95
ICL7650	4.00
ICL7660	2.50
ICL8038	4.00
ICM7216B	22.00
ICM7217	7.50
ICM7555	0.90
ICM7556	1.40
LC7120	3.00
LC7130	3.00
LC7131	3.50
LC7137	3.50
LF347	1.20
LF351	0.60
LF353	0.90
LF355	0.90
LF356N	1.10
LF357	1.00
LM10CLH	4.50
LM301A	0.30
LM307	0.45
LM308CN	0.75
LM310	2.25
LM311	0.60
LM318	1.50
LM319	1.80
LM324	0.45
LM334Z	1.15
LM335Z	1.30
LM336	1.60
LM339	0.40
LM343	0.60
LM358P	0.50
LM377	3.00
LM380N-8	1.50
LM380N	1.50
LM381AN	1.70
MC1496	0.70
LM383	3.25
LM384	2.20
LM386N-1	1.00
LM387	2.70
LM389	1.80
LM391	1.80
LM392N	1.10
LM393	0.85
LM394CH	4.00
LM709	0.35
LM710	0.48
LM711	1.00
LM723	0.60
LM725CN	3.00
LM733	0.65
LM741	0.22
LM7747	0.70
LM748	0.30
LM1011	4.80
LM1014	1.50
LM1801	3.00
LM1830	2.50
LM1871	3.00
LM1872	3.00
LM1886	6.00
LM1889	4.50
LM2917	3.00
LM3302	0.90
LM3900	0.80
LM3909	1.00
LM3911	1.80
LM3914	3.50
LM3915	3.40
LM3916	3.40
LM13600	1.50
M51513L	2.30
M51516L	4.50
MB3712	2.00
MC1310P	1.50
MC1413	0.75
MC1458	0.45
MC1495	3.00
MC1496	0.70
MC3340P	2.00
MC3401	0.70
MC3403	0.65
MF10CN	4.10
MK50240	9.00
MK50398	11.00
ML920	5.00
ML922	4.00
MM6221A	3.00
NE529	2.20
NE531	1.20
NE544	1.90
NE555	0.22
NE556	0.60
NE564	4.00
NE565	1.20
NE566	1.50
NE567	1.25
NE570	4.00
NE571	3.00
NE592	0.90
NE5532P	1.50
NE5533P	1.60
NE5534P	1.20
NE5534AP	1.50
OP-07EP	3.50
PLL02A	5.00
RC4136	0.55
RC4151	2.00
RC4195	1.50
RC4558	0.55
S566B	2.20
S50240	9.00
SAA1900	16.00
SFF96364	8.00
SL490	3.00
SN76013N	3.00
SN76023N	3.00
SN76033N	3.00
SN76115N	2.15
SN76489	4.00
SN76495	4.00
SN76660	1.20
SPO256-AL2	7.00
SP8515	7.50
TA7120	1.20
TA7130	1.40
TA7204	1.50
TA7205	0.90
TA7222	1.50
TA7310	1.50
TBA641-BX1	4.00
TBA231	1.20
TBA800	0.80
TBA810	0.90
TBA20	0.80
TBA820M	0.75
TBA920	2.00
TBA950	2.25
TC9109	5.00
TCA210	3.50
TCA220	3.50
TCA270	3.50
TCA940	1.75
TDA1004A	5.00
TDA1010	2.25
TDA1022	4.50
TDA1024	1.10
TDA1170S	3.00
TDA2002	3.25
TDA2003	1.90
TDA2004	3.20
TDA2006	3.20
TDA2020	3.20
TDA2030	2.50
TDA2593	5.00
TDA2653	7.00
TDA3560	7.50
TDA3810	7.50
TDA7000	3.50
TEA1002	7.00
TL061CP	0.40
TL062	0.60
TL064	0.90
TL071	0.40
TL072	0.70
TL074	1.10
TL081	0.35
TL082	0.55
TL083	0.75
TL084	1.00
TL094	2.00
TL170	0.50
TL430C	1.20
UAA1003-3	9.35
UA759	3.20
UA2240	1.20
UAA170	1.70
UCN4801A	4.00
ULN2001A	0.75
ULN2002A	0.75
ULN2003A	0.75
ULN2004A	0.75
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
UPC575	2.75
UPC592H	2.00
UPC1156H	3.00
UPC1185H	5.00
XR210	4.00
XR2206	4.50
XR2207	3.75
XR2211	5.75
XR2216	6.75
XR2240	1.20
ZN404	1.00
ZN414	0.80
ZN419P	1.75
ZN423E	1.30
ZN424E	1.30
ZN425E8	3.50
ZN426E8	3.00
ZN427E8	6.00
ZN428E8	4.50
ZN429E8	2.25
ZN447E	9.00
ZN449E	3.00
ZN450E	7.50
ZN459CP	3.00
ZN1034E	2.00
ZNA1040	6.60
ZNA134J	23.00
ZNA234E	9.50

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Only current prime grade components stocked.

We also stock a wide range of Transistors, Diodes, Triacs Plastic, Bridge Rectifiers, Thyristors and Zeners.

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CPU	
1802CE	6.50
2650A	10.50
6502	4.50
65C02 2MHz	12.00
6502A	6.50
6502B	8.00
6800	2.50
6802	3.00
6803-2	12.00
6809	6.50
6809E	10.00
68B09	10.00
68B09E	12.00
68000-L8	36.00
8035	3.50
80C35	6.00
8039	4.20
80C39	7.00
8080A	4.20
8085A	3.00
80C85A	7.50
8086	22.00
8088	17.50
8741	15.00
8748	16.00
TMS1601	12.00
TMS9980	14.50
TMS9995	12.00
Z80	2.50
Z80A	2.90
Z80B	5.50
Z80H	7.50
TMS4500	14.00
TMS9901	5.00
TMS9902	5.00
TMS9911	18.00
TMS9914	14.00
Z80PIO	2.50
Z80APIO	2.75
Z80CTC	2.50
Z80ACTC	2.75
Z80DART	6.50
Z80ADART	7.00
Z80DMA	7.00
Z80ADMA	7.50
Z80ASIO /0/2/9	7.00
Z80BPIO	5.00
Z80BCTC	5.00
Z80BDART	9.00

SUPPORT DEVICES	
2651	12.00
3242	8.00
3245	4.50
6520	3.00
6522	3.50
6522A	5.50
6532	4.80
6551A	6.00
6821	1.50
68B21	2.50
6829	12.50
6840	3.75
68B40	6.00
6850	1.60
68B50	2.50
6852	2.50
6854	6.50
68B54	8.00
6875	5.00
8154	8.50
8155	3.80
8156	3.80
8205	2.25
8212	2.00
8216	1.60
8224	P.O.A
8226	4.25
8228	5.50
8243	2.60
8250	9.50
8251A	3.25
8253C-5	3.50
8255AC-5	3.20
8256	18.00
8257C-5	4.00
8259C-5	4.00
8271	P.O.A.
8275	29.00
8279C-5	4.80
8282	4.00
8284	4.60
8287	3.80
8288D	9.50
8755A	16.00

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CIRCLE 51 FOR FURTHER DETAILS.

Television at Montreux

by Nigel Cawthorne

Satellite dishes are now as much a part of broadcasting as studio cameras and tv transmitters.

Satellite broadcasting, high-definition and the future of terrestrial television discussed at biennial symposium

This year's Montreux TV Symposium, the 14th in the series, brought together over 200 exhibitors from 16 countries. There was an international programme of 67 presented and 35 supporting papers covering both tv broadcast and c.a.tv topics. On the transmission side, d.b.s. and h.d.tv were front-line topics.

Chinese DBS

China Broadcast Satellite Corporation president, Mr Hsu Chung-ming, outlined the necessity for establishing d.b.s. as the key to the realization of national tv and radio coverage for the whole of China. He announced that some important technical decisions for China's new satellite tv services had been taken.

China plans to have two co-located satellites in orbit operating in Ku-band. Reasons given for the selection of Ku-band (11-14GHz) as opposed to C-band (4-6GHz) included the protection of microwave links, the eventual requirement for provincial beams, and C-band orbit congestion, which, with two-degree orbital spacing limits the use of small receiving antennas.

East satellite will have "5-for-2" transposer redundancy. The transposer power will be 230-250W at the orbital position of 92 degrees East, which is one of the three (62°E, 80°E and 92°E) WARC-77 positions allocated to China. The earliest eclipse time at this position is at 01.09 Beijing Time: tv transmissions will not take place because of the power requirements of the transponders.

One satellite will act as a spare, but it will operate on a different pair of channels to the main, so that in-orbit-testing of the spare can be made without interfering with the main satellite. If necessary, all four channels could be switched on at the same time.

China's current terrestrial tv transmission network consists of 455 main transmitter stations and over 9,000 repeaters with powers below 1kW. The present network covers just 64.7% of the 1 billion population. DBS is the key to providing high-quality radio and tv services for the whole population of China.

A single beam will cover the whole of China, and the proposed beam-shaping will permit densely populated areas to use 1.5m dishes for 'grade 4' community reception, or about 1.0m dishes for 'grade 3.5' individual reception. Under clear sky conditions, a 0.75m dish is expected to provide 'grade 3.5' performance in these areas. In the sparsely populated areas of northwestern China, 2m dishes will be used for community reception.

PAL will be used for transmission. Since studio equipment and rebroadcast transmitter equipment in China already use PAL, according to Hsu Chung-ming, there is no significent reason to go for a MAC transmission system through China's d.b.s. satellite.

Terrestial rebroadcast stations will take the signal from the satellite receiver and retransmit it over the local area. China's d.b.s. satellite will thus be used as a direct feed for a large number of re-broadcast transmitters. Tv coverage will be provided for remote mountainous regions which could not be economically serviced by a terrestial transmitter network alone.

Arabsat

In a supporting paper, Mr Shaweesh from Jordan outlined the speed with which developments have taken place in the field of satellite communications during the past 20 years, with particular emphasis on the emergence of regional satellite systems such as the European ECS and Arabsat.

The Arabsat project dates back to a meeting of Arab Ministers of Information in Tunisia in 1967, when it was decided to initiate a study for developing communications in the Arab world including the development and interchange of tv and radio braodcasting services.

Mr Shaweesh explained that Arabsat offered the only facility for real-time broadcast coverage of major events in the Arab world. Arabsat is seen as an important broadcast tool both for use within the Arabsat world as well as for the exchange of material with the non-Arab world.

Shaweesh touched on the problems of d.b.s. and how technological advances since 1977 had outdated the provisions of WARC-77. In particular, improvements in satellite receiver front end performance have meant that d.b.s. can be achieved with lower transmitted power from the satellite for a given antenna size or alternatively that smaller receive antenna dishes become practical for a given radiated power. Mr Shaweesh concluded that "we are in a period of extraordinary change in a field that was considered settled in 1977".

Terrestrial tv lives on

Even though there is much heated discussion around satellites and how they are going to revolutionise tv transmission, terrestrial tv transmitters are likely to remain the major carriers for much of the world well into the next century.

Rudi Gressmann, EBU, in a lecture on the history of the development of terrestrial tv transmission in Europe, told delegates that within the EBU area there are currently some 9,000 transmitters and repeaters in v.h.f. Bands I and III and over 20,000 in u.h.f. Bands IV/V.

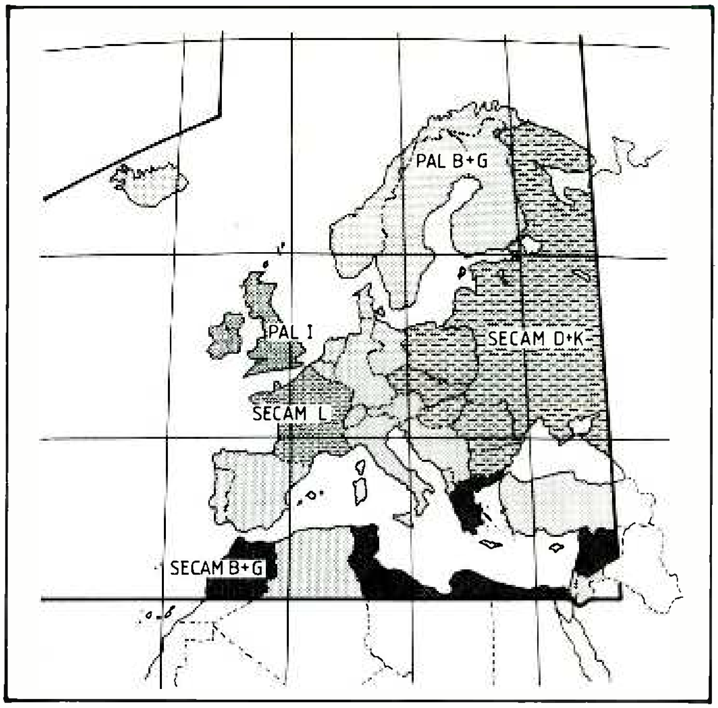
Gressmann questioned whether the present plan, as based on the Stockholm conferences of 1952 (v.h.f.) and 1961 (u.h.f.), provided the optimum use of the frequency spectrum.

The first problem that the European tv frequency plan comes up against is the one of multiple channel bandwidths. In 1961 there were no less than four separate channel bandwidths in operation in the v.h.f. tv bands. The UK's 405 line b/w services used 5MHz channels, whereas the French 819 line system used 14MHz channels. There were also the 7 and 8MHz channel bandwidths of the 625 line services. Since then the 5 and 14MHz channel services have been closed down, but even today there is still disparity between 7 and 8MHz channel bandwidths at v.h.f. Carrier frequencies (sound and vision) at v.h.f. are different all across Europe.

At u.h.f., even though there is a uniform channel spacing of 8MHz, there are differences in the sound-vision carrier spacing (5.5, 6.0 or 6.5MHz), which add to pan-European spectral discord.

There is little spectral harmony of tv transmitters within Europe. Gressmann reminded delegates that the OIRT countries of Eastern Europe still use much of Band II for tv transmissions rather than f.m. as is the case in Western Europe.

The average viewing choice provided by terrestrial tv broadcasting is approximately one programme per location on v.h.f. and about two or three on u.h.f. Although one major



exception to this is the UK, where there are now no longer programmes at v.h.f. but where there are (in most places) four programme channels at u.h.f.

The programme carrying capacity of the terrestrial tv transmitter network in Europe is not likely to increase above the present numbers. There are already pressures from powerful mobile radio lobbies to take over more frequencies from broadcasters. The shared usage of Band III between tv broadcasters and land mobile services in France as well as the wholescale closure of Band I and III in the UK are indicative of this trend. Gressmann commented however that pressure on tv frequencies from other non-broadcast services in Europe was possibly less now than it has been in previous years, but that nevertheless broadcaster's must make optimum use of the spectrum available.

If terrestrial tv transmission is not to become the "poor relation" of other media including d.b.s., cable, videocassettes and videodiscs, then studies should be intensified now. Gressmann warned that the mere fact that such a large investment had been made in the terrestial tv transmitter network is in itself no guarantee of the network's survival against the onslaught of new transmission media. Terrestrial tv transmission can only survive, argued Gressmann, if it keeps pace with modern technology. "This is only possible through standardization and harmonization".

John Curley, RET, told delegates that agreements that had recently been reached in some countries between broadcasters and land mobile radio users (e.g. the UK and France) for the sharing of a common frequency band by different services (l.m.r. and tv) precludes any hopt of standardised terrestrial tv transmission system across Europe on v.h.f.

High definition

The "Extended/j.d.tv" session promised to be a lively affair. It certainly was! George Watson of RTE, session chairman, described e.d./h.d.tv as being the most important subject at this year's Montreux.

Speakers differed by a factor of ten-to-one in their estimates of how many years it will take for h.d.tv to become reality. Tom Robson, IBA, positioned himself at the far end of the range with an estimate of 20 years. According to Robson, it is the realization of a practical h.d.tv home display unit that is crucial to the introduction of h.d.tv, and as he saw it, suitable flat screen products would not be available before the end of the century.

Robson advocated that the opportunity for a true worldwide standard would come with the next generation of systems and not the present. The next generation of tv standards would be digital and free from the present constraints of 50/60Hz compatibility. Such a standard could then be the standard for the next fifty years or so. Robson said that today's talkk of a standard was not a real world standard. Robson's opening remarks were later to be fiercely contested by several speakers.

Joe Flaherty, CBS, said that the weakness on Robson's argument was his belief that broadcasters have the power to control the living rooms of the future. "But, this is not true!" Cable, v.t.rs and video discs may have more effect than broadcasters in doing this!

In direct reply to Robson's argument that a home display unit suitable for h.d.tv would not be available for 20 years, Mr Sugimoto, NHK, said that a large flat screen display suitable for h.d.tv with a target price of $2,000 would be on show at the next Montreux in two years time.

Prof Messerschmid of the German radio and tv research institute (IRT) strongly disagreed with Robson's opening remarks: "Broadcasters cannot just sit back for 20 years".

Henry Yushkiavitshus, USSR, threw into the discussion the comment that the USSR was looking at a possible system using 50Hz in the studio and 75Hz field rates for transmission.

There is no disagreement that the world does need an h.d.tv studio production standard, but the question is when. The problem with choosing an h.d.tv production standard too early is that even though individual parameters (numbers of lines, field rates, interlacing and aspect ratios) have been discussed, only one fully operational standard has been proposed. The NHK proposed standard being based on 60Hz presents a conversion problem for the large number of countries using 50Hz.

The Montreux h.d.tv debate highlighted the amount of basic disagreement that still exists in this area.

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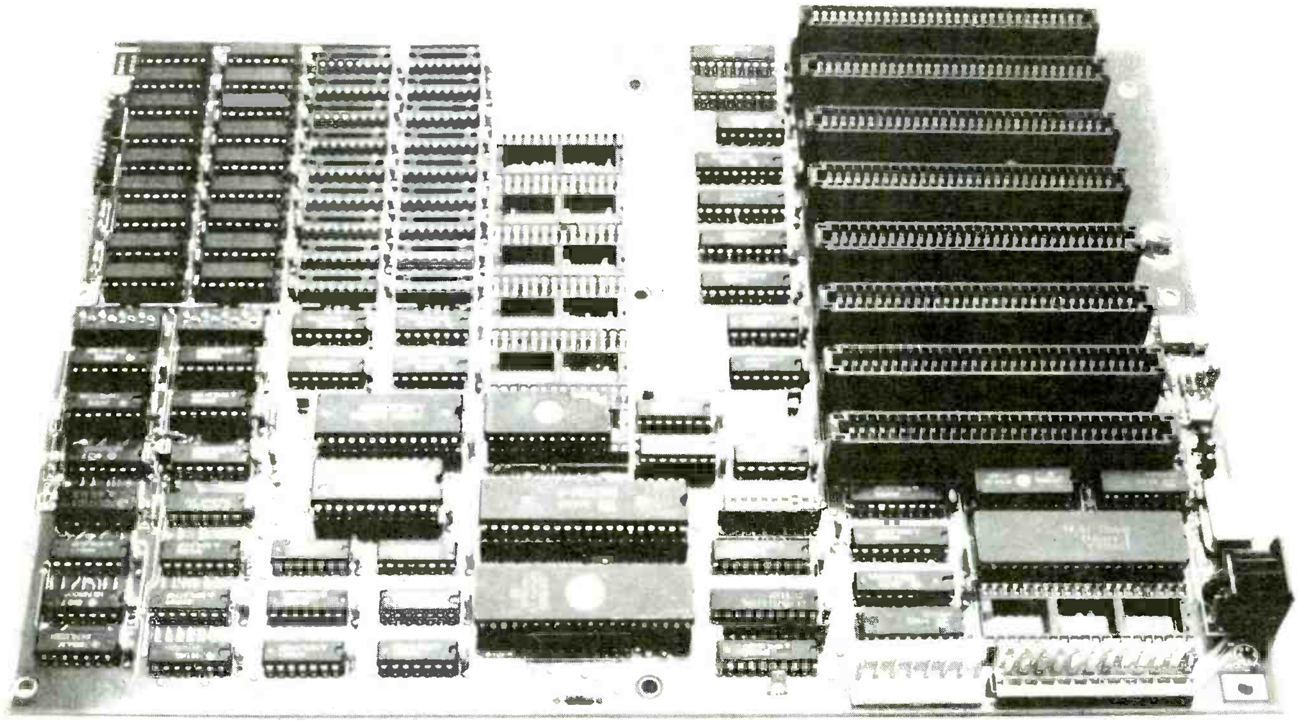

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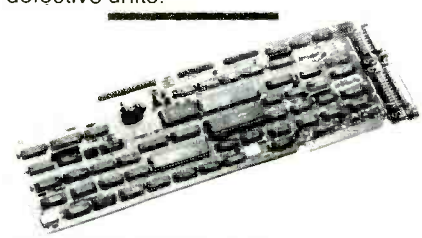

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CIRCLE 29 FOR FURTHER DETAILS.

ELECTROMAGNETIC PARADOX

Whereas relativity provides a wealth of paradoxical issues that have from time to time engaged your readers' interest, there is a seldom-discussed paradox of more direct significance to anyone concerned about the electromagnetic field.

Maxwell's equations demand that, when waves propagate through the vacuum, magnetic fields are set up which imply that there is an oscillatory electric displacement in free space. Yet, it is well established that electric displacement produced by the motion of an isolated electron in no way moderates the primary magnetic action of the electron in the immediate locality of the electron. Rosser, for example, writing at p.285 of his 1968 book 'Classical Electromagnetism via Relativity' published by Butterworths, has endorsed Fitzgerald's opinion that displacement currents in the field between the plates of an excited capacitor do not produce a magnetic field. This is consistent with the experimental finding by Graham and Lahoz (*Nature, 285,* 154 (1980)) that, when an externally applied magnetic field acts on the displacement current and a return conductor current set in parallel, the net force acting on the apparatus is that applicable to the conductor current. Since displacement current does not produce a magnetic field it cannot respond in setting up a force when subject to a magnetic field.

Surely, it is paradoxical that waves only propagate because displacement current in the field sets up magnetic fields but yet we know that in our bench experiments the displacement currents do not set up magnetic fields. I wonder if your readers can provide the answer to this problem.

Pending a better proposal, my suggestion is that the paradox can be put in context by noting that for any local action there has to be a local reaction and this applies whether we look at apparatus on our laboratory bench or at a region of remote space. In the bench experiment the primary motion of electrons in the current circuit produces a magnetic field and the reaction is merely the manifestation of this field. Local displacement currents are an embodiment of this reaction and so can hardly set up their own magnetic fields as well. In the free space situation, with the propagating wave, there has to be something locally in space that has an active field-producing role and something that has a reactive and secondary role. Thus, just as we argue that there is a displacement current between the plates of an excited capacitor, we must argue that in free space there are two 'somethings', only one of which is the reactive displacement. Both must be capable of relative motion with respect to the applicable frame of reference, the inertial frame or electromagnetic reference frame. Hence, our understanding of wave propagation is incomplete unless it caters for the physical existence of two displacements.

This argument lends support to the views expressed in my article in *Wireless World* (October 1982, p.37) where I argued that the ability of the vacuum to propagate electomagnetic waves without dispersion was direct evidence of dual or reciprocal displacement characteristic. Since writing that article, a further advance has shown that the progressive attenuation of one displacement in relation to the other can cause a wave to lose frequency slowly in transit and Hubble's constant has been deduced theoretically *(Lett. Nuovo Cimento, 41,* 252 (1984)).

H. Aspden
Department of Electrical Engineering
The University
Southampton

RELATIVELY INTERESTING

In the July 1985 issue, H. Morgan suggests that *Wireless World* "stem the flow of letters and articles on [Einsteinian] relativity."

But who then would publish the fierce debate between Einsteinian relativity and Newtonian-Galilean relativity? Several years ago, *WW* published an important article by Louis Essen, the great English acientist who designed and built the first caesium clock. Essen showed that Einsteinian relativity cannot be squared with the facts of nature. Who else would have published his critique? I do not know of another journal in all the world that allows criticism of Einstein's paradoxical—indeed, anomalous — beliefs.

The late Herbert Dingle, professor in the University of London, wrote a whole book, Science at the Crossroads, on his own experience with suppression, and attempted suppression, of the debate.

For the editors of *WW*, a fervent "Bravo!"

Lee Coe
Berkeley
California
USA

I have followed the articles and letters on relativity and the rest of the "modern physics" circus since the article by L. Essen in October 1978, which so impressed me that I started buying *Wireless World* instead of reading it in the library.

I would like to see more of the subjects which bore H.Morgan (Letters, July). You ask who is competent to decide who is right. I ask where else we can read open debate on these matters if you go back to being just another electronics magazine, printing inoffensive S-level "physics for electronics engineers" — in New Scientist?

If I was a professional physicist, I think I would be ashamed to admit it to a lay person whose idea of what I did might well have been formed from television programmes full of starry-eyed academics quoting from T.S.Elliot, and a background of loud, jarring music. Why do all the worst BBC science programmes have this? Is it to drown out the words? I might have claimed to be a psychologist and hoped to be taken for a tough behaviourist. Of course, the truth always comes out eventually. Where are the reputations of Freud, Cyril Burt and Lysenko now? Remember, all founded powerful, seemingly unchallengeable orthodoxies. Humpty Dumpty and a great fall...

Roderick Saunders
Birmingham

ENERGY TRANSFER

I fear it is not I that have misunderstood Ivor Catt (July Letters), rather the reverse.

In my June letter I pointed out that superposition of forces could not be expected to succeed when the forces in question were quadratic functions of current or voltage. I then proceeded to illustrate this claim by reference to a simple situation in electrostatics, and concluded with a derivation of the magnetic force from Special Relativity.

I fear these last two points detracted from my argument, and confused Mr Catt.

Mr Catt is upset that I choose to overturn his arguments (concerning forces between conductors guiding t.em waves) by discussing static currents and voltages, while he allows himself the privilege of building his arguments by reference to these same static forces. However, I would assert that there is no difference between the static case (with suitably chosen values of current and voltage), and the momentarily quiescent state in the middle of a broad pulse. If Mr Catt thinks that there is a difference then he cannot use the static case to prove that the force between conductors carrying a pulse is zero.

N.C. Hawkes
Abingdon
Oxfordshire

I wonder if some of the conceptual difficulties with the transmission line stems from the assumption — and it is an assumption — that power density in an em wave is measured by Poynting's vector? (Do I hear cries of dissent? But who remembers what Poynting's theorem actually says?) In fact there are any number of vectors that would be equally valid.

One such is Slepian's vector.

$$\mathbf{S} = \mathbf{E} \times \mathbf{H} + \text{curl}\,(V\mathbf{H})$$

where V is the electric potential. Poynting's vector tells us that the power flows through the space surrounding the wires, i.e. is carried by the em wave. Slepian's vector, on the other hand, tells us that all the power flows through the wires! It seems that either view is "true, but not exhaustive" (Churchill's phrase).

As an engineer I welcome this. It means that I can adopt either point of view, whichever is more convenient for the problem in hand.

Interested readers should consult "The Electromagnetic Field in its Engineering Aspects" by G.W. Carter (Longmans, 1954) Professor Carter devotes the whole of Chapter 13 to the flow of energy in an electromagnetic field.

P.L. Taylor
Marple
Cheshire

OPICAL COMMUNICATIONS

Having read the most interesting article in the August 1985 issue of *Electronics and Wireless World* entitled "Optical Communications — 1935 style", your readers may be interested to know that there are a number of these optical systems on public display, still looking as good as the day that they were made.

Two locations with which I am familiar are the German Occupation section of the main museum within Castle Cornet on the island of Guernsey, and the excellent German Occupation Museum run by Richard Heaume, also on the island of Guernsey, at Forest near the airport.

If any readers are proposing to take their holidays on this most delightful of islands, a trip to these two museums, and in particular the latter, will be well worth while, and will afford the opportunity to study many other examples of contemporary German technology.

Alan G. Hobbs, G8GOJ
South Croydon
Surrey

RELATIVITY

P.H. Spratt uses the word 'pretext' in the first sentence of his August letter. This word is defined in my dictionary as 'a false explanation or motive to disguise the true one.' I assume Spratt has some experimental evidence to prove I am a liar and a cheat. As a letter unanswered might be thought to be unanswerable, Spratt leaves me with no alternative but to reply. Before I do reply in some detail to his letter, would he please explain his evidence in very ordinary words even I can understand as soon as possible. This letter is an ultimatum.

I merely quoted measurements quoted by Eastwood who acknowledged the work of other scientists. Does Spratt realise he has libelled Eastwood and other scientists? He ought to look before he leaps.

M.G. Wellard
Kenley
Surrey

VALVE DISC PREAMPLIFIER

Mr Brice's valve disc preamplifier (*EWW*, June 85) is an interesting approach to a familiar design exercise, and I am with him in sentiment in his liking for valves for sound reproduction. However, I would take issue with him on two points:

Firstly, the RC coupling between the cascode stage and the next (cathode-follower) stage: Mr Brice's footnote on the circuit diagram states that the 10n capacitor and the 1M grid resistor puts the response at 20Hz down by 3dB. This woul be a fair statement if the cathode-follower input impedance was in fact the same, or nearly the same, as the resistor value. However the conventional wisdom of valve electronics is that the input impedance of a cathode follower is about 10 times the value of the grid resistor. (References: Langford Smith, Radio Designer's Handbook; Terman, Radio Engineers' Handbook). The mechanism is akin to that which raises the input impedance of a boot-strapped emitter follower in the world of solid state.

Assuming, then, that the input impedance of the stage under discussion is 10M, the response at 20Hz will be about −0.03dB. To achieve a −3dB figure at 20Hz a capacitance of about 800p would seem to be required.

Secondly, the coupling capacitor (1µ between the volume-control slider and the grid of the output stage: this is a cathode-follower identical to the first one, with presumably the same input impedance. A 1µF capacitance coupled to 10M, or even to 1M, looks a little like overcooking the bottom end response. And surely, (a minor quibble, this) the polarity of the capacitor, as drawn, is incorrect.

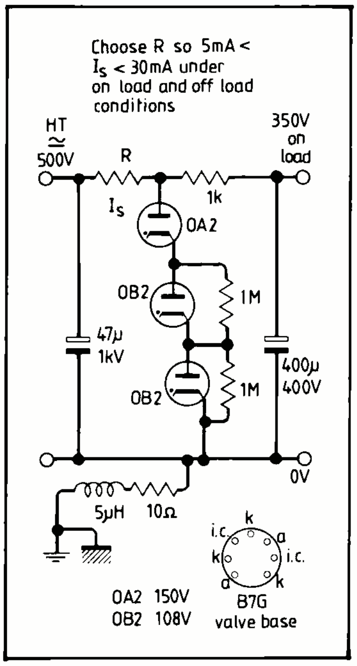
Finally, may I suggest a small but worthwhile refinement? If the preamplifier, in a warmed-up condition, is suddenly connected to the input of a solid-state main amplifier (as when the selector switch is turned from say, 'tuner' to 'disc') the output coupling-capacitor charging current must flow through the input circuit of the main amplifier. In other words the first transistor base would see a positive pulse of around 150 to 180 volts. It would not like this. The remedy is to include a high resistance, say 4M7 or higher, permanently across the preamplifier output, and to ensure that the preamplifier is fully warmed up and its voltages at equilibrium before it is connected to the main amplifier.

Despite the foregoing, which some may see as nit-picking, I say more power to Mr Brice's thermionic elbow!

D. Bolton
Victoria
Australia

I thank Mr. Jones for his constructive comments concerning my valve disc preamplifier circuit (Feedback, *EWW* July 1985). Your readers may be interested in two further suggestions regarding this design.

I mentioned in the original article that a smooth supply can be obtained with simple RC filtering, but it is better to use a regulated supply. Not only does this secure the best hum and noise performance but the regulator ensures that high off-load voltages are not applied to the anodes of the valves and the power supply decoupling capacitors during valve warm-up time. Several schemes were contemplated and tried. All the regulator circuits improved the sound quality: the final arrangement is shown in the Fig. 1. The OA2 and OB2 are two easily available voltage-stabilizer tubes. Over a certain



range of current flowing through a cold-cathode glow-discharge tube the voltage across it remains nearly constant. The circuit operates like a zener shunt-regulated supply. Its great advantage for h.t. regulation is that it is self-protecting, simple and cheap. Just as with zener diodes, the tubes may be used in series to provide voltages exceeding those of a single tube. The 1M resistors are added to facilitate striking of each individual tube. The power supplies were built on a separate chassis and this method of construction is recommended on sound-quality grounds.

The ECC83 would be suitable as the first-stage cascode valve, except that it is less robust than the ECC82 and, consequently, more microphonic, hence the decision to use the latter. I have found there is no alternative but to select low-noise valves individually for this first stage and that the more expensive types available are no better, in this application, than the cheap ECC82 s available at about 65 pence each.

Richard Brice
Teddinton
Middlesex

Letters
Letters for publication are always welcome, but the shorter and pithier, the better. I try not to edit original letters, but sometimes they are far too long, and therefore cut, and the writers upset. Please keep your letters short.

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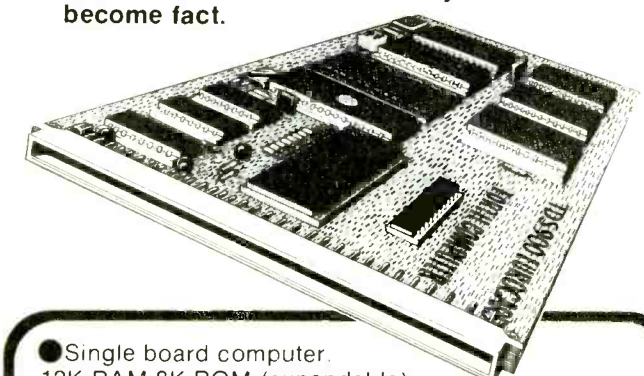

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Multistandard terminal unit

by J.D. Walker
B.Sc.(Hons)
G6FYU

Implementing a digital filter with a microprocessor leads to simple hardware for this programmable modem.

Recently I became interested in packet radio and soon realised that this mode of data communication would require a new tone standard, different to RTTY and simple ASCII, and that a new terminal unit (or modem) would be required. A consideration of the various tone standards soon showed that to obtain best performance for standard RTTY, Amtor and packet, both the tone standards and demodulator bandwidths must be changed to suit each case. The most common standards are summarised in Table 1. By using a minimum-configuration microcomputer and digital filtering implemented in software, the only alteration to cater for a new tone standard is program addition instead of a hardware change. Although the techniques described in this article are quite complicated it should be realised that because of its digital implementation this terminal unit is easily built and does not require any setting up.

Figure 1 shows the block diagram of a conventional analogue terminal unit which could be used to demodulate RTTY or Amtor signals. The tones from the receiver are split into two channels tuned to the two frequencies representing 0 and 1. The outputs of the two channel filters are rectified, low-pass filtered and then substracted. The sign of the subtraction indicates which channel contains the largest power at that instant and hence the most likely correct state of the output. The filtering operation can therefore be split into three operations, the two channel filters and the post detection filter. The power spectral density for the new tone system (1275, 1445Hz) used for RTTY is shown in Fig. 2).

The channel filter bandwidth is determined by the transmission rate, which in the case of 50 baud and F_e is equivalent to a 25Hz modulating frequency on an a.m. carrier of 1275Hz. The channel filter bandwidth for F_l is from 1250 to 1300Hz and for F_h, 1420 to 1470Hz, this being the minimum channel bandwidth for minimum signal-to-noise ratio. After detection the bandwidth can be usefully reduced to F_m (25Hz) with a post-detection filter. In practice, the filter bandwidths are normally made slightly wider so that the tuning is not too critical, and to compensate the bandwidth shrinkage between the channel and post-detection filters.

Implementation of filters using digital techniques

Digital filtering is based on sampling a signal at regular intervals and then summing previous inputs and filter outputs multiplied by appropriate constants. In analogue filter design, the appropriate transfer function is obtained by starting with a low-pass prototype and then applying a bandpass transform to get a bandpass transfer function. The exact details involved in realising Z transforms are outside the scope of this article (for a detailed exposition see ref. 1), except to say that by applying a similar process the transform given in equation 1 can be obtained.

$$H(Z) = A\left(\frac{1-Z^{-2}}{1-CZ^{-1}+BZ^{-2}}\right) = \frac{g}{f} \qquad (1)$$

where

$$A = \frac{1}{b+1},\ B = \frac{b-1}{b+1},\ C = \frac{2ab}{b+1} \qquad (2)$$

and $b = \cot \pi T(F_2 - F_1)$,

$$a = \cos 2\pi F_0 T \qquad (3)$$

T is the sampling period
F_0 filter centre frequency
F_1 lower 3dB point of filter
F_2 upper 3dB point of filter
A,B,C,a,b are constants based on F_0, F_1, F_2, T
g digital representation of sampled filter output
f digital representation of sampled filter input.

Equation 1 is the z transform for a digital bandpass filter and by rearranging this an expression in terms of previous inputs and outputs may be obtained as given by equation 4.

$$g = f_0A - f_2AZ^{-2} + Cg_1Z^{-1} - Bg_2Z^{-2} \qquad (4)$$

The operator z^{-1} indicates a delay of one sample period, so Bg_2z^{-2} means the filter output at the time before last multiplied by the con-

Following a period of amateur radio interest in digital communications John Walker joined the electronics industry in 1979 and developed a number of microcomputer systems using the Z80, 6502 and 6800/6809 microprocessors for both industrial and hobby applications. John, who is 23, graduated last year from the University College of North Wales in electronic engineering and has been subsequently employed in the designn and development of radar display equipment.

References
1. Digital filter design techniques, by J.T.R.S. Bradly. *Wireless World* May 1983. p.76-8.
2. *Radio Communication* August 1982.

A wide variety of f.s.k. tone standards have become established for modems in use on radio circuits. The accompanying software supports the established standards listed here.

Table 1. Commonly used tone standards for radio data transfer

RTTY (45, 50, 75 Baud)		
Old tones (Hz)	**Mark (Hz)**	**Space (Hz)**
170 shift	1445	1275
425 shift	1700	1275
850 shift	2125	1275
New tones (Hz)		
170 shift	2125	2295
425 shift	2125	2550
850 shift	2125	2975

Amtor
Tone standards as for RTTY except that the rate is 100 baud and the shift is always 170Hz.

Ascii (300, 600, 1200, 2400 baud)
Kansas computer standard, mark 2400 space 1200Hz.
Other modem tone standards also exist

Packet
AX25 mark 2200Hz space 1200Hz.
Data rate 300/1200 baud.
AX25 is the approved packet standard for amateur radio applications of packet data system.

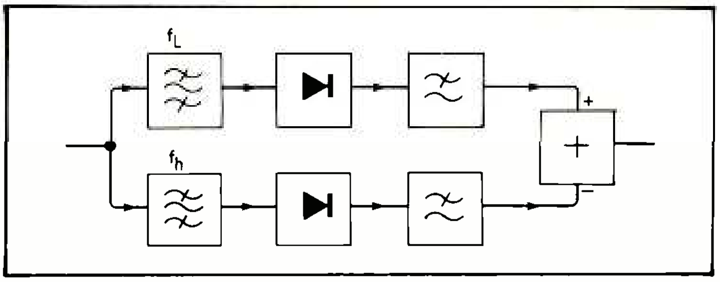


Fig. 1. **Conventional configuration of a two-tone terminal unit depicted here can be entirely realised by mathematical operations performed on digital samples of the input signal.**

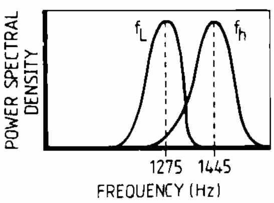


Fig. 2. **Power spectral density of the new tones standard for 170Hz shift at 50 bits per second sending speed is accurately matched by the digital filter realisations acheived by the use of an inexpensive 8 bit microprocessor using 16 bit arithmetic.**

stant B. An alternative method of expressing equation 3 is with a block diagram, shown in Fig. 4. From equation 3 it may be seen that by making the sampling frequency equal to four times the centre frequency that the constant 'a' becomes zero and this makes C zero, simplifying the filter arithmetic. Also in the case of a system with two channels, providing the bandwidths are the same, the input (or non-recursive) part is the same for both channels and this yields the configuration in Fig. 4, using a common input section for both filters. So that the sampling frequency is used for one channel and the general form for the other channel. This further reduces the arithmetic — essential if a simple microprocessor is to be used to implement the processing.

The ideal values of A,B,C for each tone standard may be calculated using equations 2 and 3, but in practice close exact fractional constants may be used instead. Although this tends to widen the filters by a small amount, this is of no consequence. The effect of the actual values can be compared with the ideal values either by back-calculation of graphically. By substitution of equation 5 into equation 1, the transfer function in z terms is transformed into the frequency variable f which upon taking the modulus of the expression reveals and amplitude response of the filter, plotted in Fig. 5.

$$Z = e^{j2\pi FT}$$

$$= \cos 2\pi FT + j\sin 2\pi FT \quad (5)$$

The other filtering operation is the post-detection low-pass filtering and this can be expressed as equation 6

$$D = \sum_{i=0}^{n-1} F_{li} Z^{-i} - \sum_{i=0}^{n-1} F_{hi} Z^{-i} \quad (6)$$

where F_l and F_h are the rectified outputs of the high and low tone filters respectively and n is the number of channel filter samples during a signal element. In the case of 50 baud and 1445Hz the element time is 20ms and the sampling period 172μs, so n=116.

Equation 6 may be expressed as a single sum:

$$D = \sum_{i=0}^{n-1} (F_{li} - F_{hi}) Z^{-i} \quad (7)$$

This is also a geometric series which can therefore by expressed as

$$D = DZ^{-1} + (F_{lo} - F_{ho}) -$$

$$-(F_{Ln} - F_{hn}) Z^{-n} \quad (8)$$

the final digital output being the sign of D. By applying equations 5 to 8 the response may be plotted in a similar way to the bandpass filters and this is shown in Fig. 6. It is interesting to note the rapid cut-off, as expected, and the sharp null at twice the 3dB frequency. This means that when working in the 50baud mode the unit will completely reject 100baud signals. The ripples in the stop-band are not important as these frequencies will have been previously attenuated by the channel filters.

Practical realisation of the terminal

The circuit consists of an analogue-to-digital converter and a small microcomputer based on the 68B09 microprocessor, Fig. 7. A 68B21 parallel interface is used to input the samples from the a-to-d converter and to output the demodulated data to the computer. Because the microprocessor can only execute one task at a time the three filtering operations must be executed in sequence as shown in Fig. 8. The need to complete all these operations before it is time to take the next sample means that careful programming must be used and to cater for some of the higher frequency tone standards the microprocessor must be clocked at 2.25MHz, about 12% faster than its rated maximum. However I found no problem at a clock rate of 2.25MHz (using a 9MHz crystal) using the standard 6809.

The filter operations are implemented using 16bit arithmetic because the filtering operations involve summing eight-bit numbers which inevitably results in greater than 8bit answers. This means that the terminal unit uses the full eightbits of the converter, enabling the unit to operate with input signals from a few millivolts to a couple of volts (peak). The need to use 16bit arithmetic makes the 68B09 an ideal microprocessor for this application because of its low cost compared to full 16bit microprocessors.

The modes of operation (different tone standards and rates) are determined by selecting the appropriate program in the eprom. This could have been done with a switch on the front of the unit, but it was considered that in most cases a computer would be used with the unit and by using an RS232 interface (68B50), the mode could be directly controlled from the keyboard via a set of escape sequences. This is particularly attractive now that most computer programs used for RTTY also control the PTT line on the transceiver, so resulting in a system completely controllable from a keyboard. The digital terminal unit therefore interfaces with the transceiver and computer as shown in Fig. 9.

Because the unit is completely controlled by a control part, the unit also contains a front panel status display, shown in Fig. 10, which indicates the tone standard, data rate and output status currently in use. Figure 11 shows a suitable power supply for the digital terminal unit. In the case of f.s.k. signals careful turning of the receiver is necessary to demodulate the input signal. This can

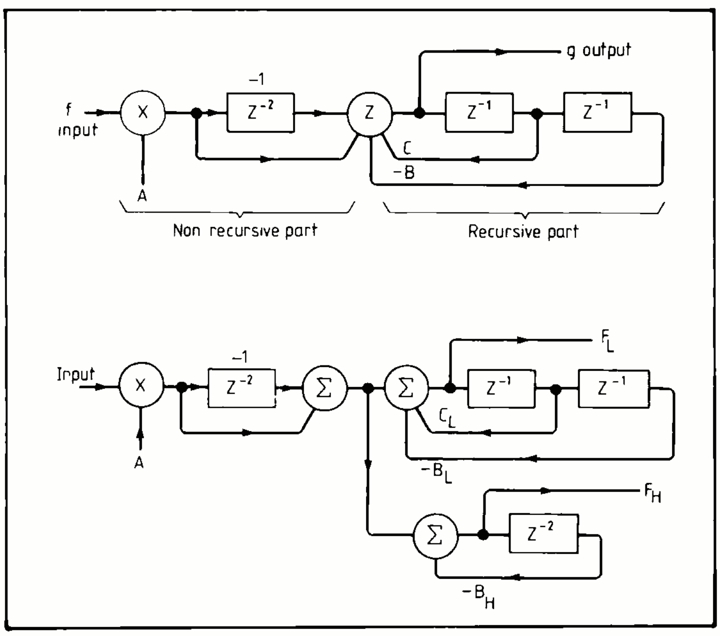


Fig. 3 & 4 **General form of the mark and space filters is given,together with its practical realisation. Note that the non-recursive part is common to both mark and space channels which contributes to the economy of mathematical operations leading to an elegant solution of the filtering task.**

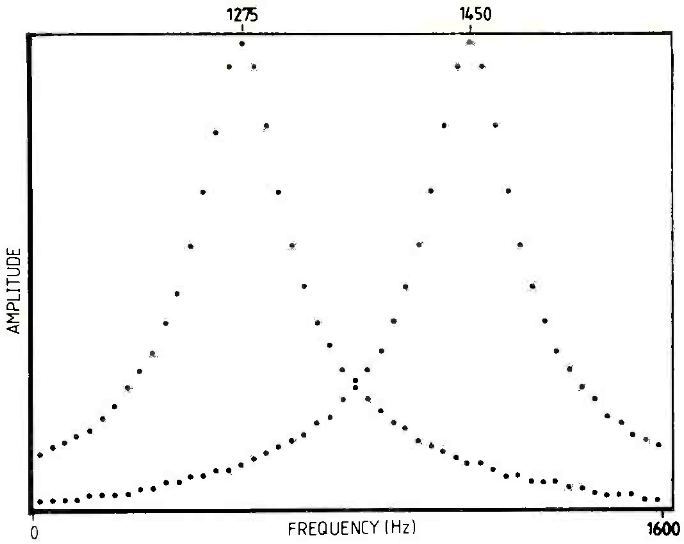


Fig. 5. **Actual response of bandpass filters for 170Hz shift (50 bits per second) using the new tone standard as predicted by computer modelling.**

be done either by ear, a Toni Tuna (tuning indicator described in reference 2) or via a tuning voltage available from the tones-out socket during receive. Clearly a vast number of tone combinations and data rates could be implemented, but in most cases only a few of the combinations will be of use. The escape sequences given in Table 2 have therefore been allocated in the prototype although other combinations may be easily implemented if required when the eprom is programmed.

Because ESC 4 will demodulate any data rate less than 100baud the unit powers up in this mode, but in the case of marginal RTTY signals a further improvement can be obtained by selecting mode 3 (ESC 3). The AX25/Kansas mode selected by mode 7 being a high data-rate mode does not lend itself to the two-channel digital filter approach described because of the small number of cycles available per bit time. Although the terminal unit can be programmed to operate as a missing pulse detector, better performance can be obtained at higher rates by using the microprocessor to measure the time between zero crossings. This is achieved by using the a-to-d converter as a limiter sampling the input at 10μs intervals. The time between transitions being used to decide if the output should be high or low. Because of the modular programming techniques used a section for 850Hz, 50baud using digital filtering could easily be added by simply adding an extra section to the program with the appropriate constants in the filter algorithm.

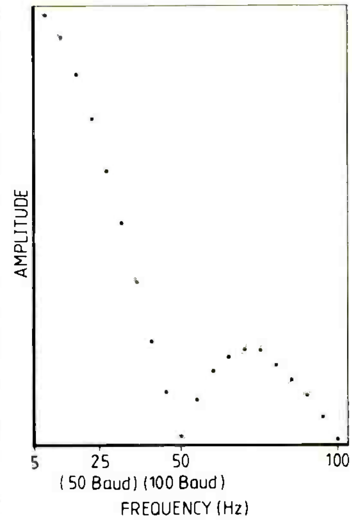
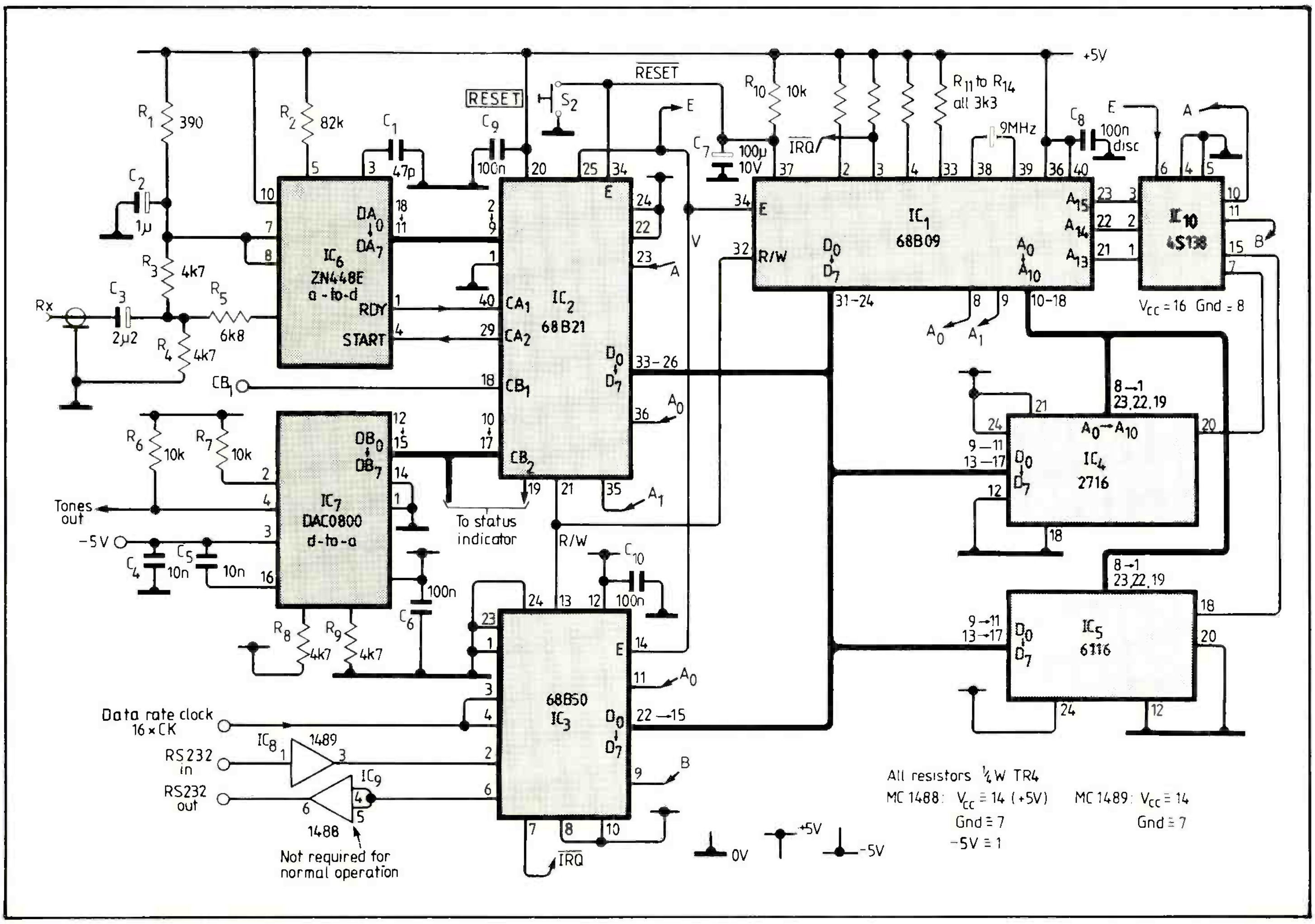


Fig. 6. **In addition to the digital realisation of the channel filters, further post-detector filtering tailored to the bit rate is also provided.**

Fig. 7. **Circuit of the minimum-configuration microcomputer used to perform the digital processing operations. The design uses readily available low-cost components throughout.**



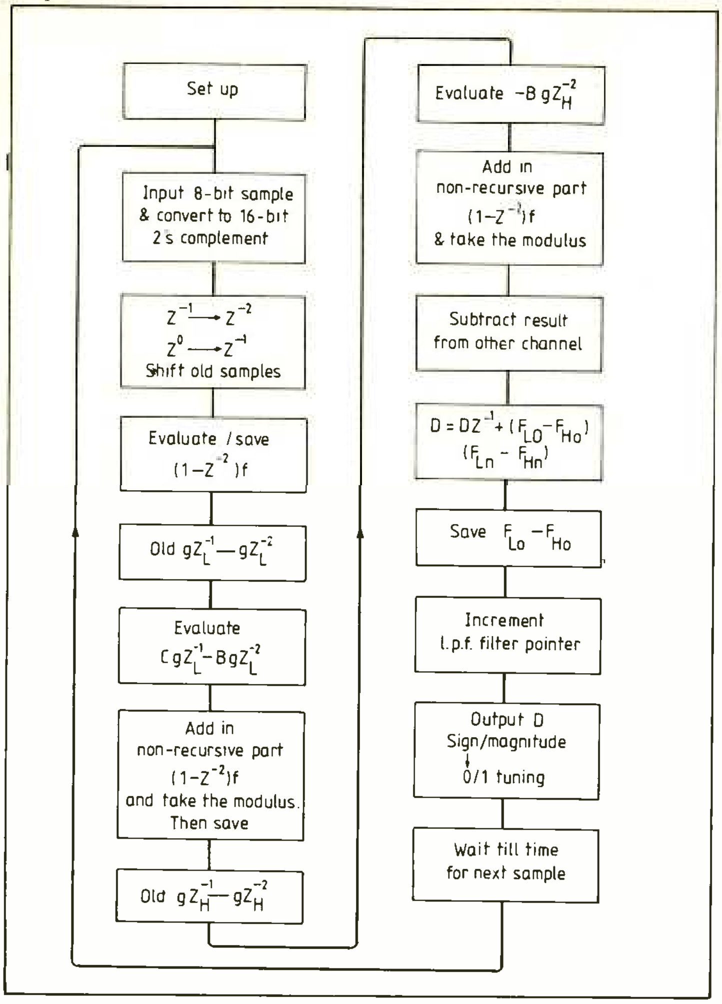


Fig. 8. **Flowchart of the program used in the digital terminal unit showing how both channel filter response are determined from the same input data samples. The mark and space component energies are compared and the resulting differences subjected to a final filtering operation.**

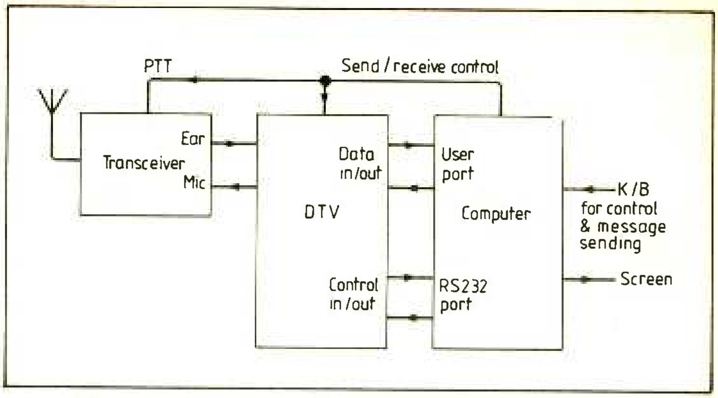


Fig. 9. **How the d.t.u. interfaces with two transceiver and computer.**

Table 2. Escape sequences used to control the d.t.u. via its RS232 port.

Sequence	Mode	Use
ESC1	170Hz shift new bones 50B	Amateur RTTY
ESC2	425Hz Shift new bones 50B	Commercial RTTY
ESC3	170Hz Shift old bones 50B	FSK position on new rigs
ESC4	170Hz Shift old bones 100	AMTOR & 75B RTTY
ESC5	Set normal	Resets normal mode to ESC6
ESC6	Set invert	Caters for invented signals
ESC7	AX25/Kansas up to 1200	Caters for new ASC11 modes.

DTU performance

After connecting the unit as in Fig. 9 and loading a suitable RTTY program into the computer, the digital terminal unit is used in a similar way to any other TU except that to change the mode of operation the appropriate escape sequences as shown in Fig. 9 must be sent to the DTU via the control port from the computer.

The performance has been found to be about 10 dB better than the ST-6 TU and the reasons are believed to be twofold: the channel bandwidths have been optimized together with the post-detection filter for the best s/n ratio, difficult to achieve with analogue components, and (2) the unit does not use a limiter. The DTU has also proved to be very effective in decoding both Kansas (2400/1200Hz) and Bell 202 (2200/1200Hz) tones at up to 1200baud and it therefore ideal for use with packet radio.

Although not described or implemented in the eprom the circuit given can also generate the tones required for transmission using a suitable sine table and digital-to-analogue converter. Finally, at a cost of £80-100 the unit clearly provides performance far beyond any other device for the price and is easily updated to cater for new tone standards which may become established in the future.

Eproms programmed for the escape sequences of Table 2 are available for £10 from the author, at 82A Grosvenor Road, Epsom Downs, Surrey.

In a subsequent article John Walker will discuss the basis of the Z transforms used for the bandpass and low-pass filters, together with the use of the digital terminal unit in other data applications.

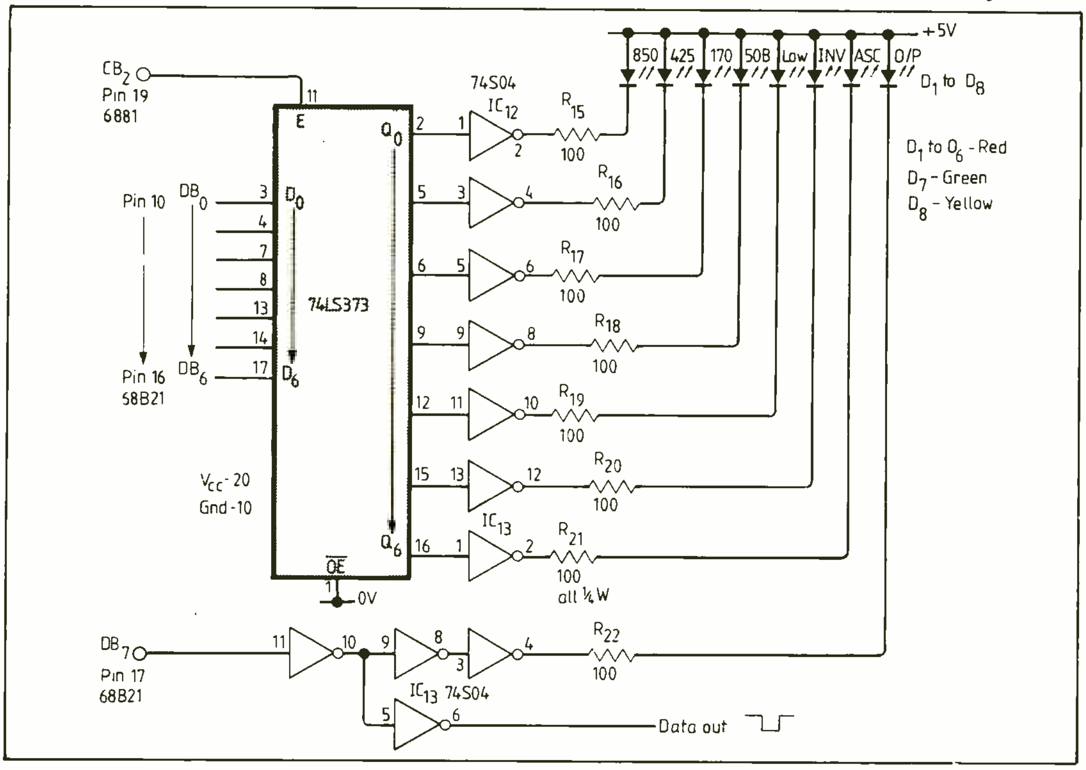


Fig. 10. **Circuit of the status indicator board used to display the tone standard currently in use.**

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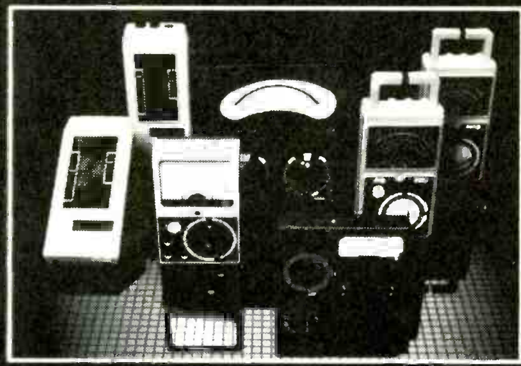

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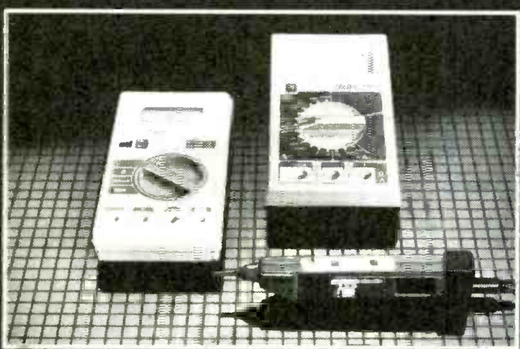

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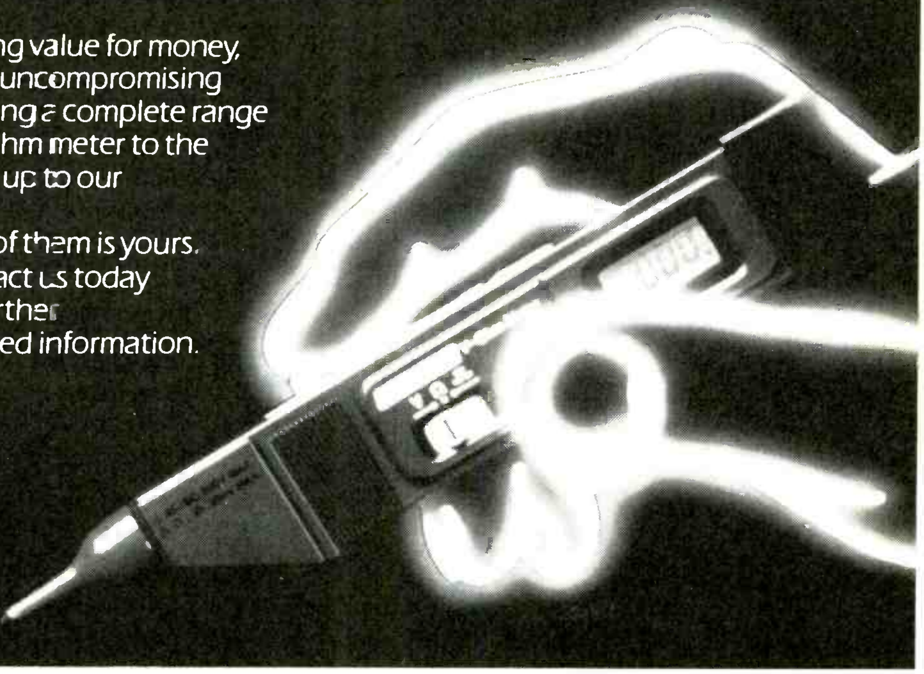

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The tale of the long-tail pair — part 2

by John Lidgey

Further applications ranging from analogue logarithm and exponential circuits, multipliers and dividers to fast logic gates.

High-precision, wide dynamic-range, analogue amplifiers rely on the use of linear resistive components to define accurately the negative feedback around a high-gain open-loop amplifier. With this classical feedback-amplifier configuration, the exact gain and linearity of the open-loop amplifier is of little importance, provided the open-loop gain is much higher than the closed-loop gain. The net gain of the closed-loop amplifier is just about equal to the inverse transfer function of the negative-feedback network. Clearly, precise, wide dynamic-range, closed-loop, linear gain is only achieved if the feedback network exhibits precise wide dynamic-range linearity. Fortunately, resistors are remarkably linear and a simple resistive attenuator, together with a high open-loop op-amp, are all that is required to achieve a very good linear amplifier.

Logarithmic and exponential circuits

To produce an exponential (anti-log) or a logarithmic analogue amplifier, the feedback circuit must be formed from a circuit element that exhibits the inverse relationship. As for the linear amplifier, the quality of the net performance is critically dependent upon the accuracy of the exponential or logarithmmic current-to-voltage characteristic used in the feedback path.

Logarithmic circuits. First let us consider developing an analogue logarithmic converter. Clearly, since the log of zero is minus infinity we can only be talking about positive (unipolar) inputs. The circuit shown in Fig. 1 is a simple log-convertor which uses a bipolar transistor (b.j.t.) in the feedback path. Collector current is equal to V_{IN}/R_1 and the output of OA_1 will be negative. Using the well known exponential relation between base-emitter voltage and collector current we can obtain an expredsion for the output voltage V_o,

$$V_o = V_{EB} = - V_T \log_e (I_c/I_s)$$

$$V_o = - V_T \log_e (V_{IN}Z/I_sR)$$

The b.j.t. yields a better exponential voltage-to-current relationship than a simple diode, due mainly to that fact that a b.j.t. behaves as a very short diode, there being essentially no minority carriers at the edge of the collector-base junction. It is an advantage that the collector-to-base potential is held to zero by the action of negative feedback, in that no base-width modulation effects occur. However, recalling the problems identified in the last article about the strong temperature dependence of the b.j.t. parameter I_s, the circuit is not particularly good in practice.

A modified version based on the long-tail pair structure is shown in Fig. 2. The output is essentially proportional to the difference in the two transistor base to emitter potentials, which is not dependent upon I_s, provided that the two b.j.ts are very well matched and at the same temperature (i.e. $T_1 \equiv T_2$).

Though the circuit is rather unusual in its topology, both OA_1 and OA_2 are provided with negative feedback, so that both inverting inputs are effectively held at zero potential and hence,

$$I_1 = V_{IN}/R_1 \qquad 1$$

$$I_2 = V_{REF}/R_2$$

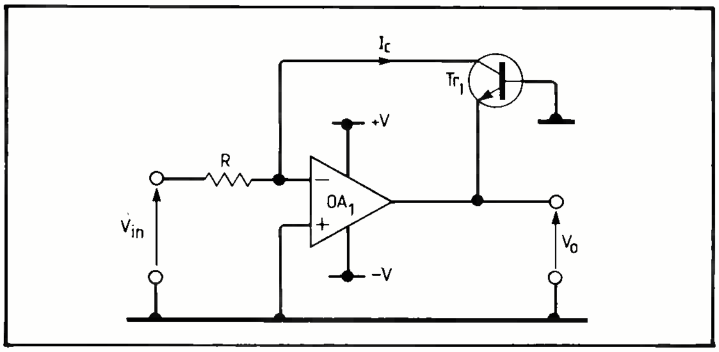


Fig. 1. **Simple logarithmic circuit.**

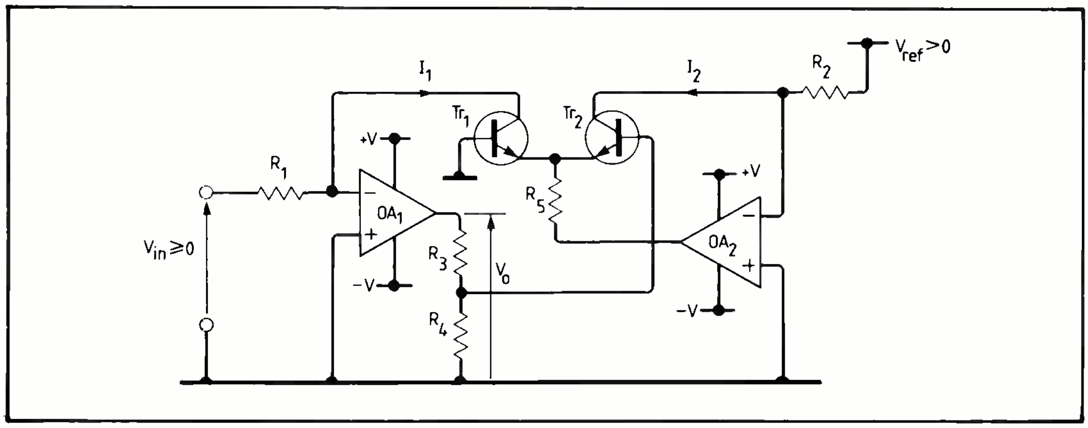
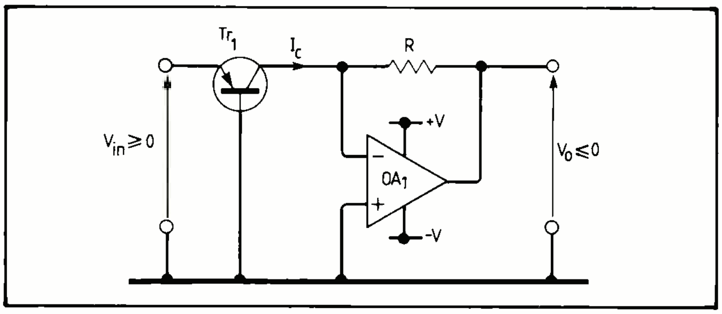


Fig. 2. **High-quality logarithmic circuit.**

Fig. 3. **Simple antilog. circuit.**



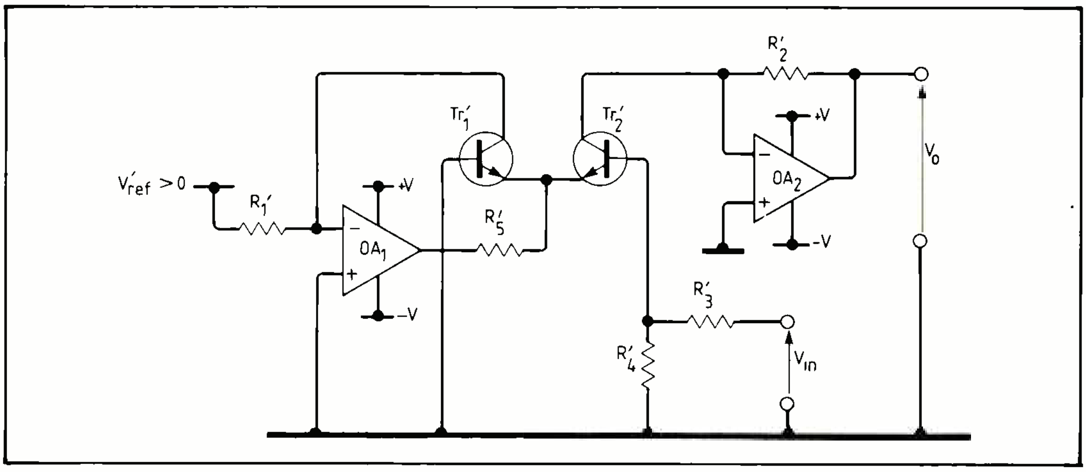


Fig. 4. **High-quality exponential circuit.**

Resistors R_3 and R_4 are chosen so that the base current into Tr_2 does not load the potential dividing action of these resistors on the output of OA_1 and hence the base to ground potential of Tr_2, V_{B2}, is

$$= \frac{R_4}{(R_3 + R_4)} \cdot V_o = V_{BE2} - V_{BE1}$$

As shown in the first article, since $T_1 \equiv T_2$, then

$$V_{BE2} - V_{BE1} = V_T \log_e (I_2/I_1) \qquad 2$$

and so combining equations 1 and 2 we get the expression

$$V_o = K_1 \log_e (V_{IN}/K_2) \qquad 3$$

where $K_1 = -V_T (R_3 + R_4)/R_4$ and $K_2 = V_{REF} \cdot R_1/R_2$.

In comparison with the circuit of Fig. 1 there is no I_s dependence in the output voltage expression, since this has been cancelled due to the output being directly proportional to the difference in base-to-emitter potentials of the two transistors. This represents a vast improvement of performance in terms of temperature stability and non-dependence upon the particular characteristic of the b.j.ts used.

However, K_1 is temperature dependent, as V_T is directly proportional to absolute temperature. This dependence can be removed if R_3 is much larger than R_4 and R_4 is chosen to have the same temperature coefficient as V_T. Since the natural logarithm is related to the base-10 logarithm simply by the multiplier 2.3026, this can easily be catered for in the design choice of K_1 to produce an output sensibly related to the base-10 log of the input signal. Suppose, for example, the circuit is operated at room temperature, giving V_T = 25 mV, and we choose R_1 = 100 kΩ = R_2 and V_{REF} = 1 volt; then with $(R_3 + R_4)/R_4 = 17.372$, the expression for output voltage reduces to

$$V_o = \log_{10} V_{IN}$$

where V_o and V_{IN} are both expressed in volts. The choice of K_1 and K_2 is determined by the scaling required on the signal and the value against which the input is being normalised.

Referring back to equation 3 the circuit can be used to obtain $\log_{10}$ of the ratio of two positive voltages if V_{REF} is replaced by a second positive input. This is a particularly useful in several applications, such as an analogue automatic transfer function plotter.

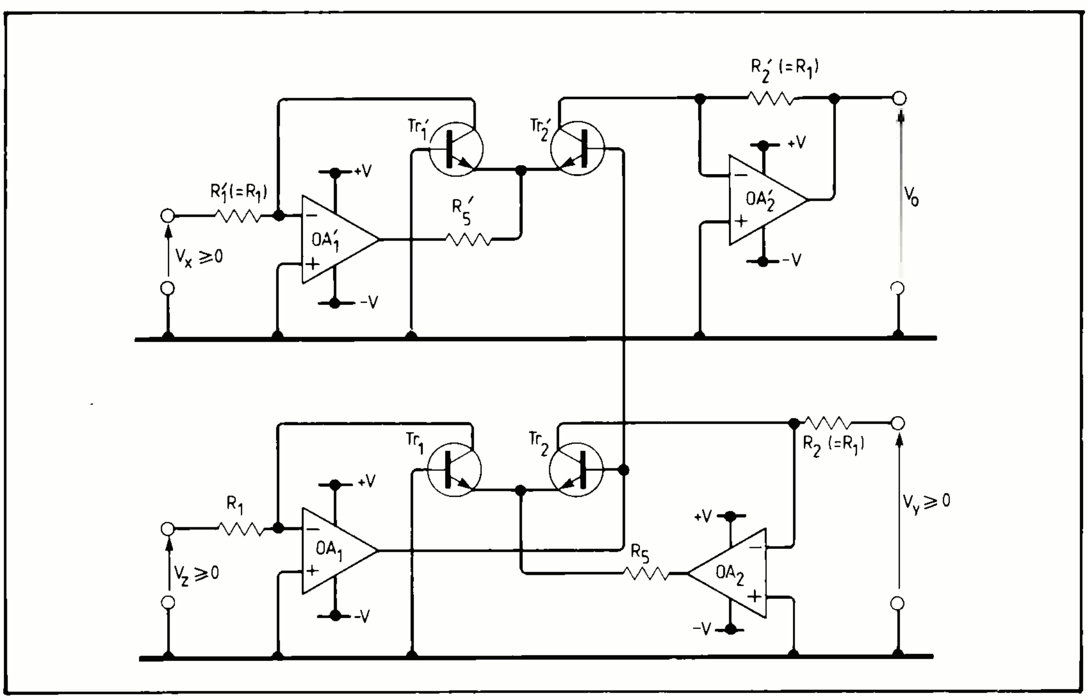
So far, R_5 has not featured in the analysis. The purpose of R_5 is merely to provide some current limit in case excessive current is drawn through Tr_1, Tr_2 and OA_2. If OA_2 is current-limited internally and the transistors can separately handle this peak current, then R_5 may be replaced with a direct link.

Exponential circuits. To achieve the opposite transfeer function to the circuit of Fig. 1, namely an exponential circuit, the resistor and b.j.t. are swapped over as shown in Fig. 3. A p-n-p transistor is required for positive inputs, the output being given by the equation

$$V_o = -I_c \,.\, R = -I_s \,.\, Re^{V_{in}/V_T}$$

Again, as was the case for Fig. 1, the circuit has practical limitations due to the temperature dependence of I_s. Adopting a similar approach, a long-tail pair is employed as shown in Fig. 4 to achieve a superior exponential circuit.

Fig. 5. **High-quality single-quadrant multiplier/divider.**



Following a similar analysis to that for a log-circuit of Fig. 2, the output expression obtained is

$$V_o = K_4.e^{K_3.V_{IN}} \qquad 4$$

where $K_3 = R'_4 / V_T (R'_3 + R'_4)$ and $K_4 = V'_{REF} . R'_2/R'_1$

Having employed the well matched long-tail pair configuration, the I_s parameter is absent in the final expression. As for the circuit of Fig. 2, the R''_4 potential divider is chosen so that the input is simply divided down, the base current demand from Tr_2 being a negligible load. Resistor R'_5 acts in the same current limiting role as R_5 in the previous circuit. The only remaining temperature-dependent parameter V_T in K_3 may be effectively removed by compensation with a potential divider R'_3, R'_4 which exhibits the same temperature coefficient.

Multipliers and dividers using log and antilog circuits

Multipliers and dividers are classified in terms of the number of quadrants over which they operate. For example, if the circuit will only operate with inputs of the same sign, both positive or both negative, the circuit is referred to as single-quadrant. A multiplier/divider circuit capable of operating with bipolar inputs is referred to as a four-quadrant multiplier/divider.

Single-quadrant multiplier divider. Having established relatively simple and accurate log. and anti-log. circuits described earlier, it is quite plausible to assemble a multiplier simply using two log. circuits of the type shown in Fig. 2, together with a conventional summing amplifier, the output of which is then fed to an exponential circuit such as that shown in Fig. 3. Mathematically, we are adopting the following strategy for obtaining the product of two input voltages: input 1 is V_1; input 2 is V_2 then $V_o = V_1.V_2 = \exp(\log_e V_1 + \log_e V_2)$.

Clearly, a divider is created if we subtract $\log_e V_1$ from $\log_e (V_2)$ using a differencing circuit. Although quite feasible, such a multiplier is complex, using in total seven op-amps and three well matched transistor pairs. A very elegant solution can be achieved more directly using the circuit of Fig. 5.

A careful inspection of the circuit reveals that it is the combination of the high-quality log. and exponential circuits described earlier with the potential dividers R_3, R_4 and R'_3, R'_4 removed. Using the analysis developed for the output of the log. circuit, namely equation 3, the expression for V_{B2} is

$$V_{B2} = V'_{B2}$$

$$= - V_T \log_e (V_Z/V_Y)$$

$$= V_T \log_e (V_Y/V_Z)$$

Since V'_{B2} is the effective input to an exponential circuit with V_x replacing the potential, V'_{REF}, then the output of the entire circuit is obtained by modifying equation 4 slightly, that is

$$V_o = V_x\, e^{V_{B2}/V_T}$$

Substituting for V_{B2} we obtain the final expression

$$V_o = V_x.V_y/V_z$$

It is important to note that the temperature of both pairs of b.j.ts should be identical and, as before, the transistor pairs should be very well matched. These requirements are relatively easily met if the four transistors are all on the same chip. Also, it should be stressed that the circuit is only single-quadrant. In practice should the product of two inputs be required, then V_z should be chosen appropriately as a fixed d.c. reference, providing a useful scaling factor. Alternatively, if the ratio of two inputs are required, then either V_x or V_y should be a fixed d.c. reference, this reference providing a scaling factor to the ratio of the two inputs.

Converting to a four-quadrant multiplier. It is possible to use a single-quadrant multiplier together with some additional circuitry to create a full four-quadrant multiplier. Two precision full-wave rectifiers are needed to process the two inputs, so that the circuit of Fig. 5 only "sees" positive voltages and then the output is effectively

$$V_o = [\,V_1\,] . [\,V_2\,] / V_{REF}$$

where the inputs are V_1, V_2 and V_z has been replaced by a d.c. reference, V_{REF}. In addition, some logic is needed to provide the sign-bit information. This could be done simply by testing the input signs using the sort of circuit shown in Fig. 6.

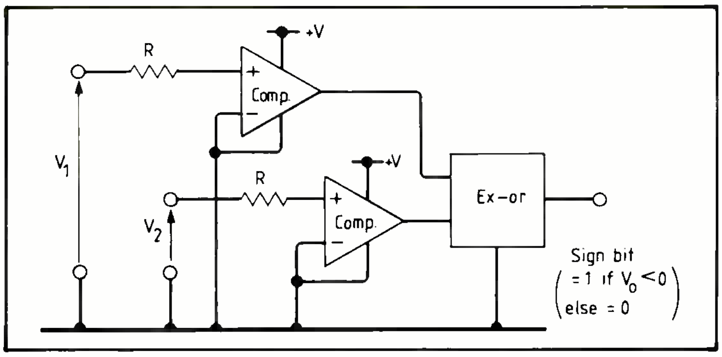


Fig. 6. **Sign-information circuit.**

Linear differential transconductance amplier

The transconductance (current output — voltage input) performance of the long-tail pair was investigated in my first article and it was shown that the circuit was linear over a range of about ± 25mV or so (see Fig. 2 of the September 1985 article). The simplest way of increasing the linear range and increasing the input impedance is to add emitter resistance as shown in Fig. 7. Two matched long-tail current sinks are used in preference to one since such a structure can be realised on a single chip with two pin-outs provided to allow the emitter coupling resistor, R, to be inserted by the designer.

Calling the differential input voltage V_{IN} and neglecting base currents compared with collector currents, then we can solve Kirchhoff's voltage law for V_{IN} as

$$V_{in} = V_1 - V_2 = V_{BE1} - V_{BE2} + (I_1 - I_o/2)\, R$$

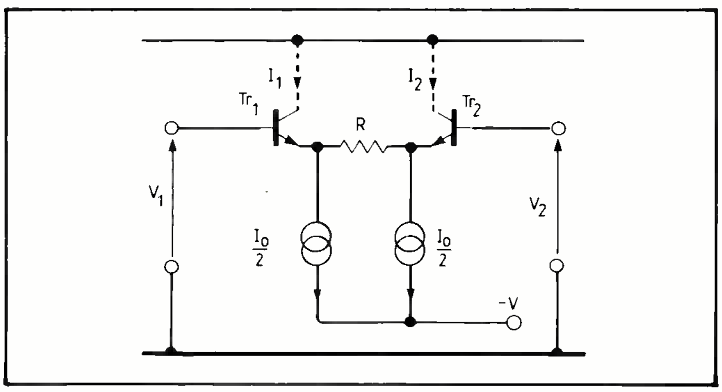
$$V_{in} = V_T \log_e (I_1/ (I_o - I_1)) + (I_1 - I_o/2)\, R$$

Normalizing this equation we obtain the following expressions relating V_{IN} to I_1 and I_2.

$$V_{IN}/V_T = \log_e ((I_1/I_o)/(1-(I_1/I_o)) + ((I_1/I_o) - 1/2)\, I_oR/V_T \qquad 5a$$

$$I_2/I_o = 1 - (I_1/I_o) \qquad 5b$$

Fig. 7. **Linearized long-tail pair.**



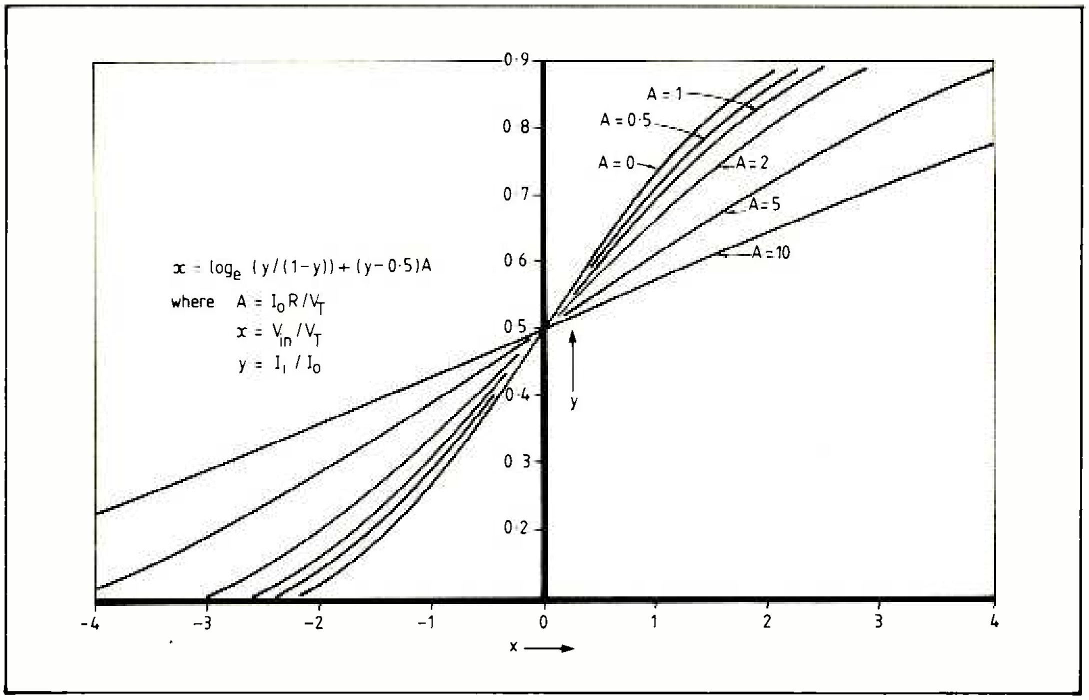


Fig. 8. **Linearized long-tail pair transfer characteristic.**

Equation 5a cannot be turned into a straightforward transfer function equation, so the best way of visualising the equation is to plot $y = I_1/I_0$ against $x = V_{IN}/V_T$. Figure 8 shows the plot for different values of $A = I_0R/V_T$. Notice $A = 0$ corresponds to $R = 0$ and the transfer current of Fig. 8 is identical to that of Fig. 2 in the first article of this series. As R is increased so the total transconductance becomes less but more linear. This is to be expected, since the effect of increasing R is to increase the negative feedback to the circuit with the usual result of stabilising and hence linearizing the transconductance at the expense of a loss of closed-loop gain. If we are operating the stage with a limited input and a high A value then equation 5a reduces to

$$V_{IN} = ((I_1/I_0) - 1/2).\ RI_0$$

$$\text{or } I_1/I_0 = 1/2 + V_{IN}/ (R.I_0)$$

$$\text{and } I_2/I_0 = 1/2 - V_{IN}/ (R.I_0)$$

The differential output conductance is now linearly related to the differential input voltage by

$$(I_1 - I_2)/I_0 = 2\ V_{IN}/ (R.I_0)$$

and the differential transconductance is therefore

$$g_{md} = 2/R$$

and the differential input impedance, R_{IN}, is approximately

$$R_{IN} \approx \beta.R$$

where ß is the small-signal current gain of Tr_1 and Tr_2.

The final expressions are really quite simple in form, but it is necessary to look at the detailed behaviour in order to assess the maximum differential input voltage that may be applied to keep the maximum non-linearity within specified bounds. It is left to the reader to look closely at equation 5a to establish the limits for a particular application.

Monolithic four-quadrant multipliers

An elegant wide dynamic range four-quadrant multiplier is shown in Fig. 9. The monolithic circuit uses four interconnected long-tail pairs, two of which operate in a non-linear mode. In practice, the two diodes would be transistors connected as diodes with the collector shorted to the base terminal in each.

The circuit is relatively easy to analyse, as each section has already been examined earlier. To simplify the analysis I shall assume that the ß of each transistor is high enough for the collector currents to be negligibly different from the emitter currents and also I shall assume that all the b.j.ts, including the diode-connected transistors D_1 and D_2, are well matched and at the same temperature.

The emitter resistors R_x and R_y provide linear converssion to the input voltages to the differential currents I_x and I_y shown on the circuit diagram.

$$I_x = V_x/R_x \qquad 6a$$

$$I_y = V_y/R_y \qquad 6b$$

Referring to the last section above, the condition needed here is

$$R_x \gg V_T/I_1 \text{ and } R_y \gg V_T/I_2$$

The resistor R_1 is in the circuit merely to ensure that the base bias potentials on the Tr_5/Tr_6 and Tr_7/Tr_8 are sufficient to keep these transistors in the forward active region.

Now potential V_1 shown in Fig. 9 is

$$V_1 = V_{D2} - V_{D1} = V_T \log_e (I_1 - I_x)/(I_1 + I_x) \qquad 7$$

This potential now drives the two non-linear (ordinary) long-tail pairs Tr_5/Tr_6 and Tr_7/Tr_8.

In the first article in this series the characteristic of the long-tail pair was established and, in terms of the present circuit, the collector currents I_5 to I_8 can be written simply as

$$I_5 = I_3/ (1 + e^{-V_1/V_T})$$

$$I_6 = I_3/(1 + e^{+V_1/V_T})$$

$$I_7 = I_4/ (1 + e^{+V_1/V_T})$$

$$I_8 = I_4/ (1 + e^{-V_1/V_T})$$

with the substitution from 7 for V_1 equations simplifies to

$$\left.\begin{aligned} I_5 &= I_3 (I_1 - I_x)/2I_1 \\ I_6 &= I_3 (I_1 + I_x)/2I_1 \\ I_7 &= I_4 (I_1 + I_x)/2I_1 \\ I_8 &= I_4 (I_1 - I_x)/2I_1 \end{aligned}\right\} \quad 8$$

The differential output voltage is

$$V_o = R_2 ((I_6 + I_8) - (I_5 + I_7))$$

and substituting from equations 7 and 8, then

$$V_o = R_2 (I_3.I_x - I_4.I_x)/I_1$$

Since $I_3 = I_2 + I_y$ and $I_4 = I_2 - I_y$ then $V_o = 2R_2 (I_xI_y)/I_1$ and using equations 6 we obtain the final expression that

$$V_o = K_m V_x.\ V_y$$

where K_m is the multiplier's scaling factor and is given by $K_m = 2R_2/ (R_x.R_y.I_1)$. Generally K_m is chosen to be 0.1 for convenience and compatibility with other

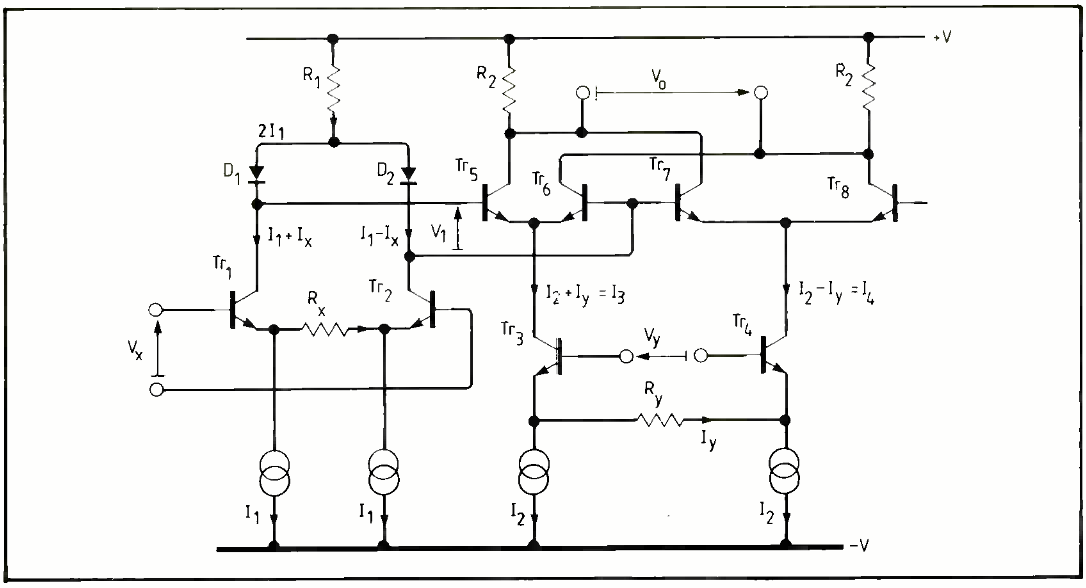


Fig. 9. **Monolithic four-quadrant multiplier.**

types of multiplier. Should a single-ended output voltage be required, then the circuit can be modified by adding a differential amplifier to the output terminals of Fig. 9.

The four-quadrant multiplier described here is an excellent example of the ingenious use of the accurate exponential relationship between emitter-base voltage and collector current of b.j.ts and the close matching and thermal tracking that can be achieved in a single chip circuit.

Emitter-coupled logic

So far, the long-tail pair applications discussed have been for analogue signal processing. Even in digital electronics the long-tail pair has some special features. The basic emitter-coupled logic gate is a simple long-tail pair used with a siingle-ended input, a typical circuit of which is shown in Fig. 10. The long-tail is resistive rather than an active current-sink to ensure high speed switching.

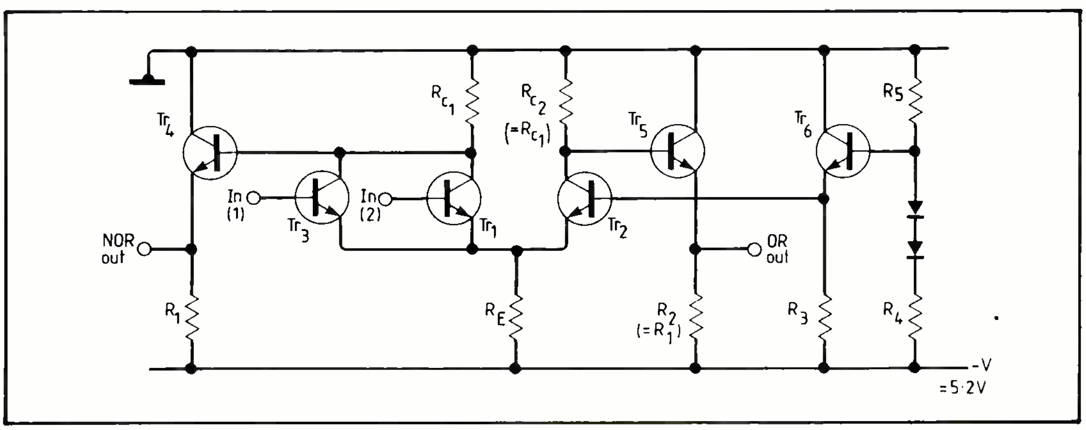
A single common-emitter can be used as a logic switch. Turning "on" the b.j.t. results in a forward bias on collector-base junction which results in a high minority carrier population inn the base region. To change state from "on" to "off" is relatively slow as the base region minority carriers must be removed before the collector current can be reduced to 'zero'. The e.c.l. gate is extremely fast primarily because the "on" state is associated with current saturation due to the long-tail current sink limit on the collector current; neither b.j.t. ever entering forward bias V_{CB} type saturation. A typical propagation delay is 2ns for one e.c.l. gate.

The penalty associated with this very rapid performance is a high power dissipation per gate which represents a fundamental limitation on the number of gates per unit chip area. A further disadvantage of e.c. logic is the poor noise margin, typically 50mV. This is offset somewhat by the fact that since the power supply current demand is almost constant, power supply spike due to LdI/dt effects on changing state are much less of a problem with e.c.l. than other b.j.t. based logic. E.c.l. does have a place in specialized, high-speed applications.

Tail-piece

The long-tail pair is a very powerful circuit element with a wide range of applications. Some of the applications are dependent upon the precise exponential I-V characteristic of the b.j.t. and some are dependent on the use of a matched differential-pair configuration with a current-sink bias. I have only discussed b.j.t. long-tail pair circuits in these two articles but clearly fets may also be used in the same configuration though the log/antilog and full four-quadrant multiplier circuits will only work with b.j.ts.

Fig. 10. **E.c.l. logic gate.**



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.

Fault Tolerant Hardware Design by Parag K. Lala: Prentice-Hall International, 263 pages, hard covers, £24.95, ISBN 0 13 308248 2. Chapters cover basic concepts of reliability, types of faults in digital circuits and how to model them, test generation, fault-tolerant design of l.s.i. and v.l.s.i. chips, self-checking and fail-safe logic and design for testability.

Half-megabyte memory for SC84

by J.H. Adams, M.Sc.

'Silicon disc' using 256K dynamic memory chips has novel refresh system.

I use a microcomputer primarily as a means of developing software and of writing long documents, such as this article. My SC84 computer gives better performance than many other computers but the discs don't go round any faster than anyone else's. When working back and forth between the ends of large files with Wordstar or when performing a major assembly, disc operations take a lot of time.

The reason for this is clear when one watches the process. In both cases the computer is operating with more than one file. In word processing, the computer memory acts as a 'window' into the file. As this window moves up and down a file larger than the free memory available in the computer, temporary files are created to store the data ahead of and behind the window.

In program development, assembly means getting data from the source file and sending data into object and listing files. Switching between the files takes time as the drive head has to traverse the disc surface many times. There's wear and tear on the drive and the computer operator, both of which can be eliminated by the use of what has become known as a 'silicon disc'.

Silicon disc is a large memory used either as a buffer into which the working disc's contents are loaded or, as in this case, treated as a pseudo disc. The system described consists of a 512Kbyte memory, accessed as one of 256 2Kbyte 'pages'.

Pages are selected by writing an 8bit value into a register on the silicon disc unit. This is rather like writing to the track-number register of a floppy disc controller. Once selected, the page may be accessed directly or by 'mapping'. In mapping, a block of memory can be made to substitute itself for an equivalent block of system memory. SC84, as with any other good computer design, has a mapping facility. The advantage of mapping is that areas of system memory are not permanently committed to transient facilities (the v.d.u. in SC84 is a good example of this). One must choose the mapping area carefully though as it is obviously not possible for code executing in the area of system memory to be mapped out to access the mapped area. For this reason, switches allow the unit to be permanently allocated or to be mapped to any 2Kbyte block within an 18bit address range. The silicon disc is seen as an adjunct to the disc operating system and so, for SC84, the mapping is over the section of memory even more fundamental than Scidos itself, the resident operating system Mcos.

The half-megabyte memory is in the form of 16 256Kbit dynamic memories, although the unit can be built with only half of this capacity. Thought has been given to making the silicon disc as versatile as possible. As such it relies on only two system signals; one indicates that a memory cycle is taking place and the other that a read operation is occuring. In a Z80 system these would be MREQ and RD; in an 8086 system they would be a combination of ALE and IO/M and the RD signal.

Note that no reference is made to external refreshing. The RFSH input shown on the circuit diagram is offered as a means of reducing unnecessary power consumption in Z80 systems. Refreshing of the memory is achieved by a combination of some rather clever facilities provided in the memories specified and the way in which the silicon disc is used.

An explanation of the design philosophy behind multiplexed-address dynamic memory was given in my recent series on the SC84 computer*. Suffice to say that in addressing dynamic memories, the address of the locations to be accessed is latched into the memory in two parts — a row address and a column address. This saves pins and thus cost on a 256Kbit device which otherwise would need 18 address pins. It also allows refreshing of the entire memory by regular access-

* SC84 is a 4/6MHz Z80-based computer running the Scidos operating system for CP/M software, described in the May, June, July, September and October 1984 issues. The three-Eurocard circuit board set for this project is still available.

Specification and performance

Memory capacity is 512Kbyte organised as 256 'tracks' of 2Kbyte each and power requirement is +5V at up to 0.5A, depending on the system cycle rate.

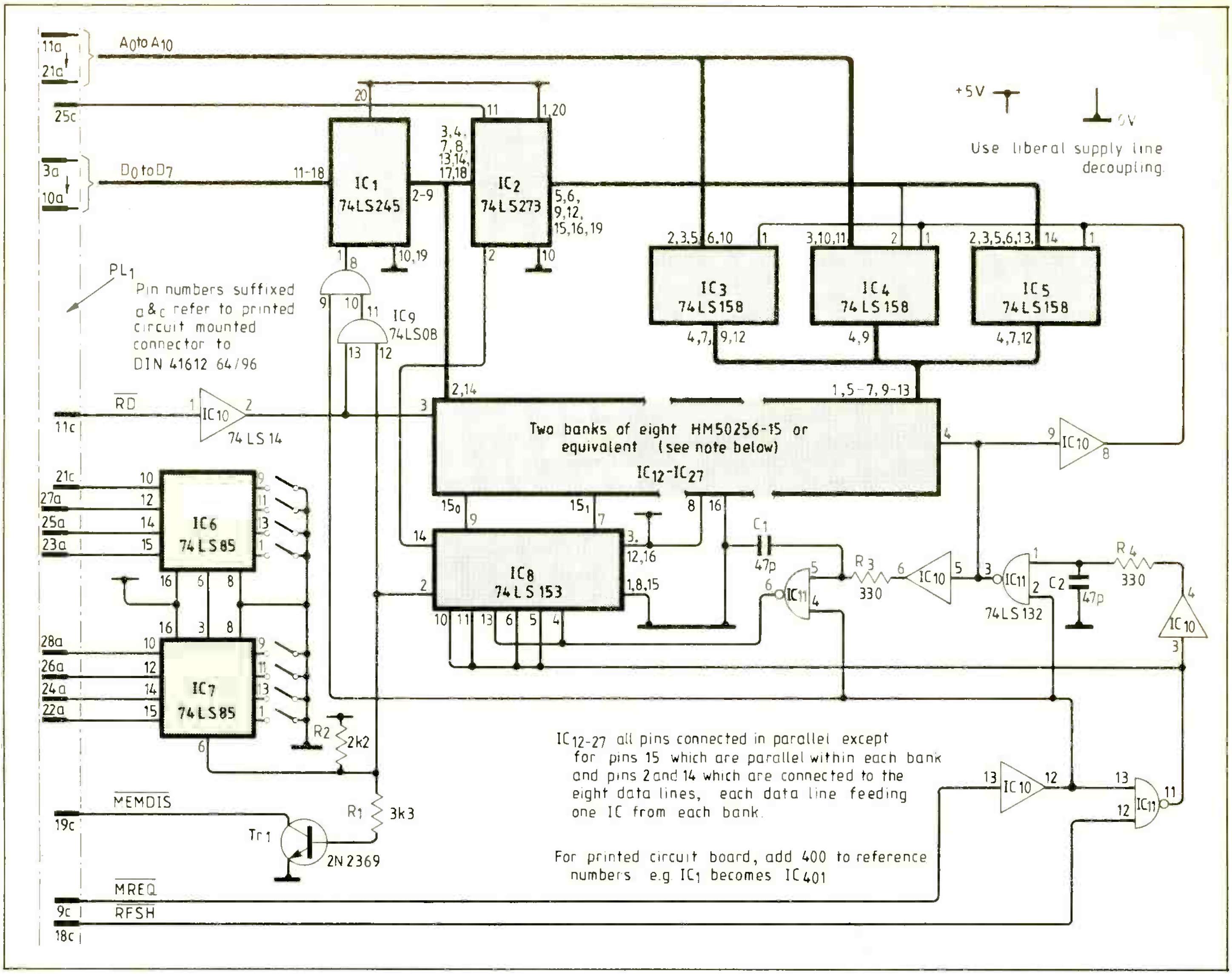
To test the performance of the 'silicon disc' compared with a conventional system, I used Wordstar to edit a 120Kbyte source file. The procedure was to perform a global alteration through the file, to save the file using ↑KS to move to the end of the file using ↑QC and then to move back to the start using ↑QR.

Timings for these operations on SC84 with and without the silicon disc and for a DEC Rainbow are shown in the table. As shown over extra time taken depends very much on the distance moved by the drive head during the magnetic disc tests, the SC84 and DEC tests were carried out under optimum conditions, i.e. with only the source file on the disc.

The fourth column in the table indicates how long a computer would take with a typically full disc. During the alteration, screen update was suppressed by pressing ESC as otherwise the test would have reflected the speed of screen update rather than of disc access — a factor which would have considerably increased the DEC timing.

The final test was to assemble a 20Kbyte Z80 source file to produce an intermediate file which would result in approximately 2Kbyte of object code, and a listing file. The assembler used was M80.

These tests are reasonably representative of typical uses of the silicon disc. Other advantages, particularly noticeable when using Wordstar, are that messages and overlays load and present themselves instantly and noiselessly.



Half-megabyte memory expansion circuit. Pins 15 of the three LS158 multiplexers are connected to ground.

Kits and p.c.bs

Memory board kits excluding p.c.b. are £92 inclusive from John Adams at 5 The Close, Radlett, Hertfordshire WD7 8HA. This price is £93 for readers in other parts of Europe and £94.50 for those outside.

Plated-through-hole p.c.bs for this project are £16 including UK or overseas postage from Combe Martin Electronics, Kings Street, Combe Martin, North Devon EX34 0AD.

ing of all rows.

The Z80 has an inbuilt refresh generator consisting of a control line and a seven-bit counter which is regularly incremented and output during a period when the Z80 doesn't need the external bus. While memories were addressed seven bits by seven bits (16Kbits) this was acceptable. When 64Kbit devices appeared, most were made to be actually seven bits by nine internally, although addressed as eight bits followed by another eight. This meant that a Z80 could still refresh these devices but it did make the i.cs more difficult to fabricate.

Some device manufacturers attempted to make their 64Kbit chips more versatile by building an equivalent of the Z80 refresh generator, but with 8 bits, into their dynamic memories and providing a pin to implement the refreshing process. This was a good idea as it allowed other refreshing techniques such as standby refreshing to be implemented but it took away a much needed pin. When 256Kbit i.cs were designed, this pin went to provide the ninth address line but in certain devices the internal refreshing mechanism has survived.

As mentioned, the address is latched into the memory in two parts by means of a negative transition on one of two control lines, row-address strobe RAS and column-address strobe CAS. The standard operating sequence for a dynamic memory of this type would be as follows. Begin with both RAS and CAS high, apply the row address, switch RAS low, apply the column address, switch CAS low. After this a read, write, or read-then-write operation may take place on the addressed bit, depending upon the WR control line. Strobe RAS may be taken high again a short period after CAS has gone low and, as a variation, CAS may then be repeatedly pulsed to latch in the addresses of, and therefore access, other bits within the same row.

What never happens in a conventional addressing situation, and what is exploited in the devices under review, is that RAS should go low while CAS is low. My words are carefully chosen as the data sheets for most 64Kbit devices do show a mode called 'hidden refresh', where after CAS has gone low and data is being accessed (RAS goes high), the address of a row to be refreshed is applied and RAS goes low, forcing a form of refresh. The differ-

Test	Silicon disc	SC84	DEC rainbow	SC84 typical
Alteration	43	170	179	182
KS	2	18	17	22
QR	12	47	62	160
Assembly	22	110	102	115

Continued on page 93

• INFORMATION •

A NEW SERVICE
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This information service is a quick and simple method of obtaining the very latest literature.

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INSTRUMENT RENTALS

Instrument Rentals have substantially increased their range of instruments for rental in their new 1985 catalogue. Test and measurement, communications, microprocessor development, data products and fibre optic test equipment is detailed in the catalogue which includes their extremely competitive rental rate for periods of up to four years.

CIRCLE 93
FOR FURTHER DETAILS.

ELECTROPLAN

You will almost certainly be aware of Electroplan's standing in the field of electronic measurement, for we are the UK's leading technical distributor of test and measuring instrumentation to users in technology-based industries.

Less well known, perhaps, are our accomplishments in microcomputer-based instrumentation — a relatively new, but now rapidly expanding, arm of our business.

Microcomputers from Hewlett-Packard and IBM are stocked, together with a wide range of compatible hardware and software, enabling customised measurement systems to be configured to the needs of specific user application.

This brochure attempts to describe our capability, and the items listed below provide some indication of our immense strength-in-depth of standard products that may be applied to measurement and control problems.

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If you require any further information, please circle the number on the Free Product Information cond.

CIRCLE 94
FOR FURTHER DETAILS.

P.S.P.

PSP Electronics have updated their free short form literature which includes photographs and information about their complete range of connectors.

The literature is in full colour, includes stock range additions such as the Souriau 851 series, and can be obtained by circling the number on the Free Product Information cond.

PSP is a franchised distributor for ITT Cannon, Thomas & Betts, Transradio, ITT Pomona Electronics, Pandult and Souriau and, as always, PSP are able to provide technical advice and services to meet clients' particular needs.

Manufacturers' catalogues with full product specifications can also be supplied on request.

CIRCLE 95
FOR FURTHER DETAILS.

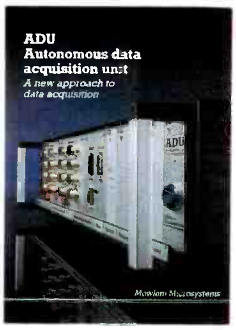
MOWLEM MICROSYSTEMS

The Mowlem Technology Group has recently launched a new company, Mowlem Microsystems Limited, to develop and market a range of data acquisition and control systems based on the ADU (Autonomous Data Acquisition Unit). As part of John Mowlem & Company PLC, Mowlem Technology is dedicated to supporting extensive development programmes within its specialist technology fields and has identified the potential of the ADU as worthy of substantial group investment. The basis of this belief lies in the design of the product: the ADU meets the requirements for an intelligent and highly flexible device for interfacing between transducers and microcomputers.

The design philosophy is such that the ADU is compatible with all readily available microcomputers and accepts signals from a wide range of transducers, as well as providing both analogue and digital outputs in its capacity as a process controller.

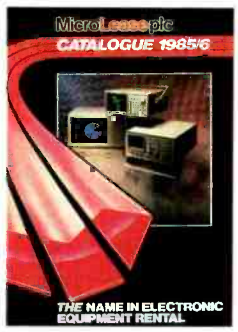
The unit embodies all the necessary hardware and software routines for data acquisition, test sequencing and adaptive control. The ADU's internal microcomputer eliminates the need for an in-depth knowledge of interfacing and software techniques and the user merely instructs the ADU of the nature of the tests, by inputting simple commands to the host microcomputer.

This flexibility and simplicity of operation allows the user to rapidly set up a testing system tailored exactly to his own requirements in a substantially shortened development time.



CIRCLE 96
FOR FURTHER DETAILS.

MICROLEASE PLC.



The MicroLease catalogue has been completely restyled, revised and updated for 1985/86. More pages, more equipment, more facts. From THE name in electronic equipment rental. Also, 1985 sees the introduction of our handy pocket equipment guide — so you can carry all the MicroLease rental information around with you.

The reason for all this activity is simple — we've concentrated on expanding our equipment range to become the most comprehensive offered by any U.K. rental company, as well as improving the professional support services that have given MicroLease their unrivalled reputation for speed, efficiency, quality and reliability.

Along with this increase in the range off equipment on offer, we've made our rates even more competitive for 1985/86 — with discount plans to satisfy the most cost-conscious customer. But despite these even more competitive prices, MicroLease still insist on providing greater levels of service — more reliable delivery, even tighter quality control and complete testing, servicing and calibration by expert technicians.

What's more, we're expanding our equipment range all the time — to keep pace with technological developments, to cover a wider range of industry applications and to meet the changing requirements of our customers. In fact, even if the particular unit or system you need is not shown in these pages, it's more than likely available now — simply phone us with your enquiry. So whatever your industry, wherever you are in the U.K. and whatever your requirement, MicroLease will deliver — That's why we're THE name in electronic equipment rental.

CIRCLE 97
FOR FURTHER DETAILS.

KEMO

This 8pp catalogue from Kemo (Filters) Ltd. gives full technical details of the company's range of variable filters for signal-processign annd allied applications. Filters covered in the catalogue include continuously variable, digitally set, multi-channel, computer-controlled, anti-aliasing and noise-measuring types. Devices are available with cut-off frequencies between 0.001Hz and 1MHz and passband response down to d.c., and among the latest development features in the catalogue is the company's new System 998 GPIB/IEEE serial interface. Copies of the catalogue are available free of charge.

CIRCLE 98
FOR FURTHER DETAILS.

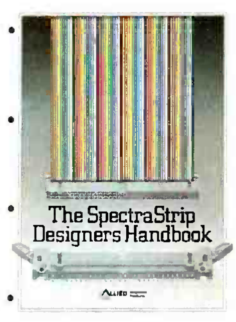
SPECTRA STRIP

A new 56-page Designer's Handbook is now available from Spectra-Strip Ltd. and provides complete engineering details of all the products in the company's wide range of ribbon cables and IDC connectors. Comprehensive electrical and physical specifications are supported by technical drawings, graphs and tables of dimensions, together with full ordering information.

Manufactured at the company's modern plant in Romsey, Hampshire, the ribbon cables include Twist 'N' Flat, Round 'N' Flat, Ground-plane, Colour-coded, Co-ax, Jacketed, Gey Zip, Flat-conductor, Twisted-pair and High-flexing varieties.

The compatible range of IDC connectors detailed in the Handbook include Sockets, Card-edge, Dual in-line plugs, and a variety of D-subminiature plugs, receptacles and associated accessories. Also detailed is the wide range of Headers available from Spectra-Strip, including Unprotected, 4-wall Protected, and Low-profile in all their various forms, such as Straight, Right-angle, etc.

The centre pages of the Handbook provide information on Spectra-Strip's very successful IDC Harnessing Service, which is receiving fast-growing support from manufacturers throughout the UK.



CIRCLE 99
FOR FURTHER DETAILS.

Humidity control

Normally, the extractor fan in this humidity control circuit is started when the bathroom light is turned on and the motor stops around 20 minutes after the light is turned off. If relative humidity exceeds about 80% however, the motor runs for about 20 minutes or until humidity falls below 80%.

Domestic induction-motor fans of up to 1.5A can be switched. For safety, check that the motor is impedance and overtemperature-protected; most modern fans include these features. Transients produced by switching are damped by a v.d.r. over the triac but as the circuit switches at or near zero voltage this is not a major problem.

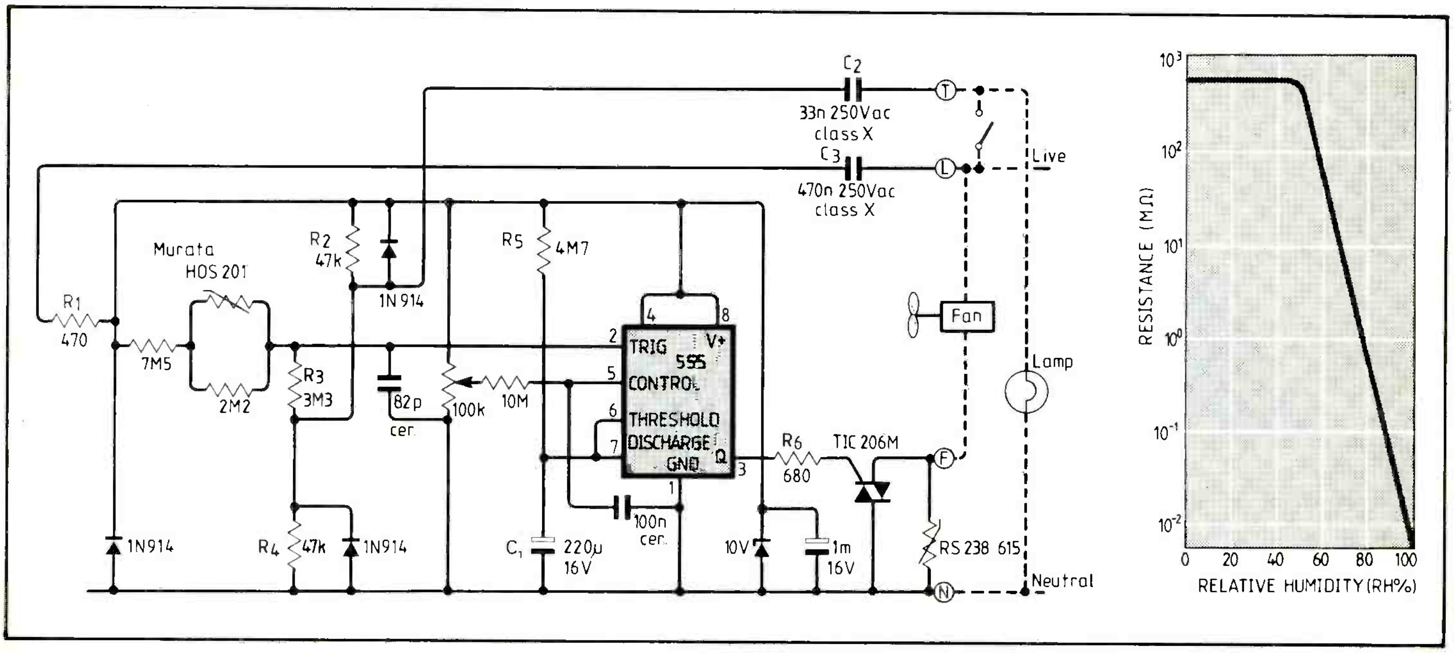
Network R_5C_1 sets the 20 minute delay. A 10V regulated supply is derived using C_3, R_1, D^{1-3} and a smoothing capacitor; full-wave rectification must be used to stop C_3 charging to peak mains voltage.

The sensor* requires an alternating signal of less than 1V. An 11V squarewave at the $D_{1,2}$ junction is used for this. Sensor resistance falls as air moisture increases and eventually the signal passing through the sensor triggers the timer. A potentiometer sets the timer trigger level. While the light switch is on, the timer i.c. is triggered through C_2.

Wiring around the high-impedance areas of the circuit, including the sensor, should be short and well screened by track areas at mains neutral potential. The sensor should be away from the triac and its wiring and it must, of course, have access to room air. Bear in mind that the whole circuit is connected directly to the mains.

M.R. Hadley
Lyndhurst
Hampshire

*Available from Norbain Electro-Optics Ltd, Norbain House, Baulton Road, Reading, Berkshire R62 0LT.



Add-on current dumping

Recently, several 'non-switching' class-B amplifier circuits have been published. Some of these are complex, some have thermal runaway problems and some require careful matching of devices. This circuit is so simple that it can be implemented in any class-B amplifier, yet it is effective enough to cure all of the problems that traditionally result in crossover distortion.

The idea is to make sure that the output device is always turned on, by configuring it as a constant-current source when it would normally be turned off. The principle is not new, but the realization is.

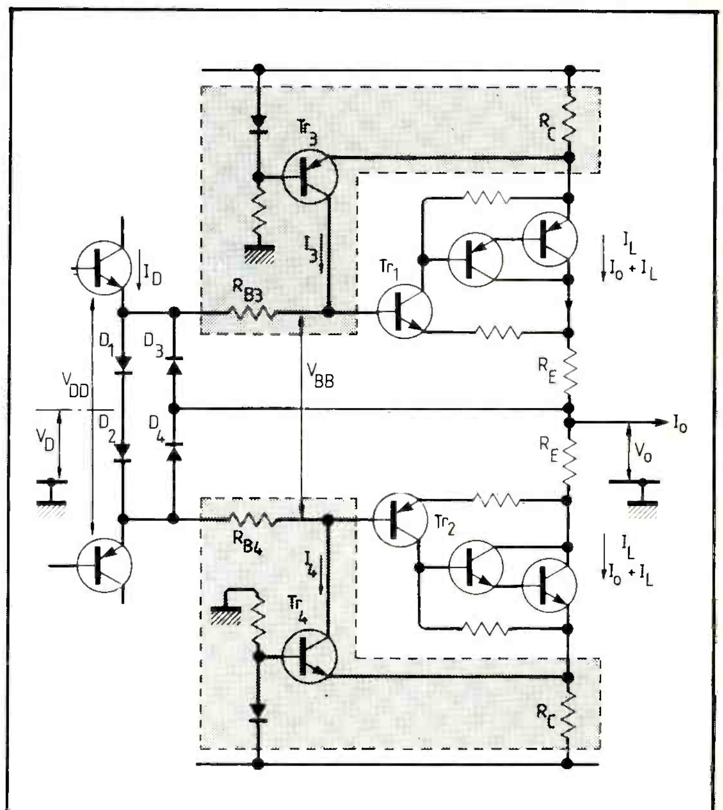
Transistor Tr_2 is forced into constant-current mode by collector current of Tr_4. This transistor senses the fall in Tr_2 collector current as I_2R_c falls, so I_4R_{B4} directly compensates i_oR_E, negative feedback through Tr_2 being the regulating current-derived negative feedback prevents thermal runaway without the need for special thermal feedback.

Take care selecting base resistor values $R_{B3,B4}$. Lower values of around 200Ω are preferred to prevent creation of an additional pole within the desired bandwidth.

Drive current I_D needs to be set at about twice the value of Tr_3/Tr_4 maximum collector current to allow the drivers to work in class-A throughout the full voltage swing. Quiescent current is set by I_3 and R_B/R_E. Making R_C equal to R_E simplifies calculations.

Generating bias voltage with diodes allows a simple output current limiter to be added in the form of $D_{3,4}$.

Erik Margan
Ljubljana
Yugoslavia

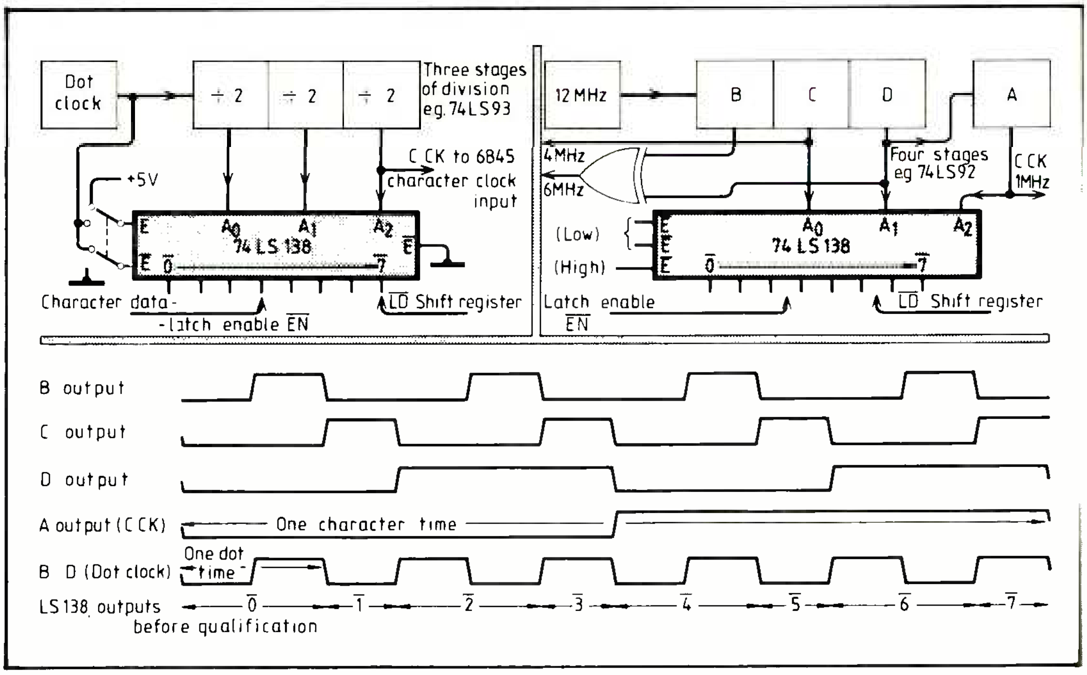


Easy character-generator timing adjustment

Display circuits using 6845 or similar c.r.t. controllers usually have a system of gates and inverters to extract strobe pulses from the dot-clock divider. These strobe pulses are for shift register loading and data latch enabling.

If this gating is replaced by a 3-to-8-line decoder, the outputs available cater for most timing requirements in systems with up to eight dots/character horizontally and beyond eight dots if strobes are not required in the additional space.

The advantage of this circuit is that timing changes are easily made after construction without the need to rewire or patch. This permits substitution of character generator roms and v.d.u. rams of various speeds and changes of parameters such as dot-clock frequency or number of dots per character.



In the general application, top left, each 138 decoder output goes active low once per character during the corresponding dot time. A switch selects output activity during either the high or low pulse of the dot clock. Alternative qualifying signals may be applied to the enable inputs.

Falling edge of the shift register LD pulse should coincide with the rising edge of the shift clock, which is the dot clock in this case. If the 138 is switched to give outputs during the clock low phase, this should be inverted before being used to drive the shift register.

The special application uses a 12MHz source to provide a 1MHz CCK signal, a 6MHz dot clock for six dots per character and a 4MHz output for a 6802 microprocessor. In the timing diagram for this application the 138 outputs are shown without qualification. I would suggest divider B output for 138 enabling, E, and a 6MHz dot clock to either E or $\bar{E}$.

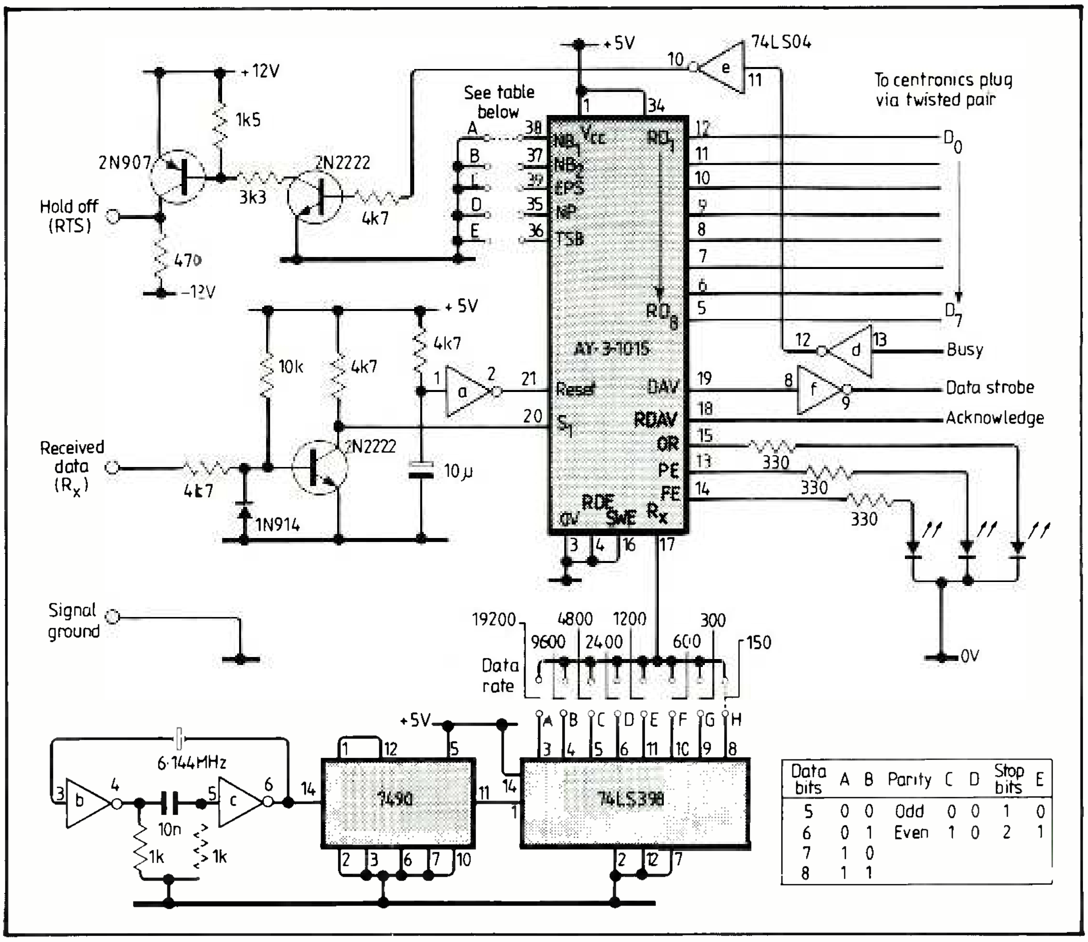
J.B. Bell
Grimsby
Humberside

RS232-to-Centronics interface

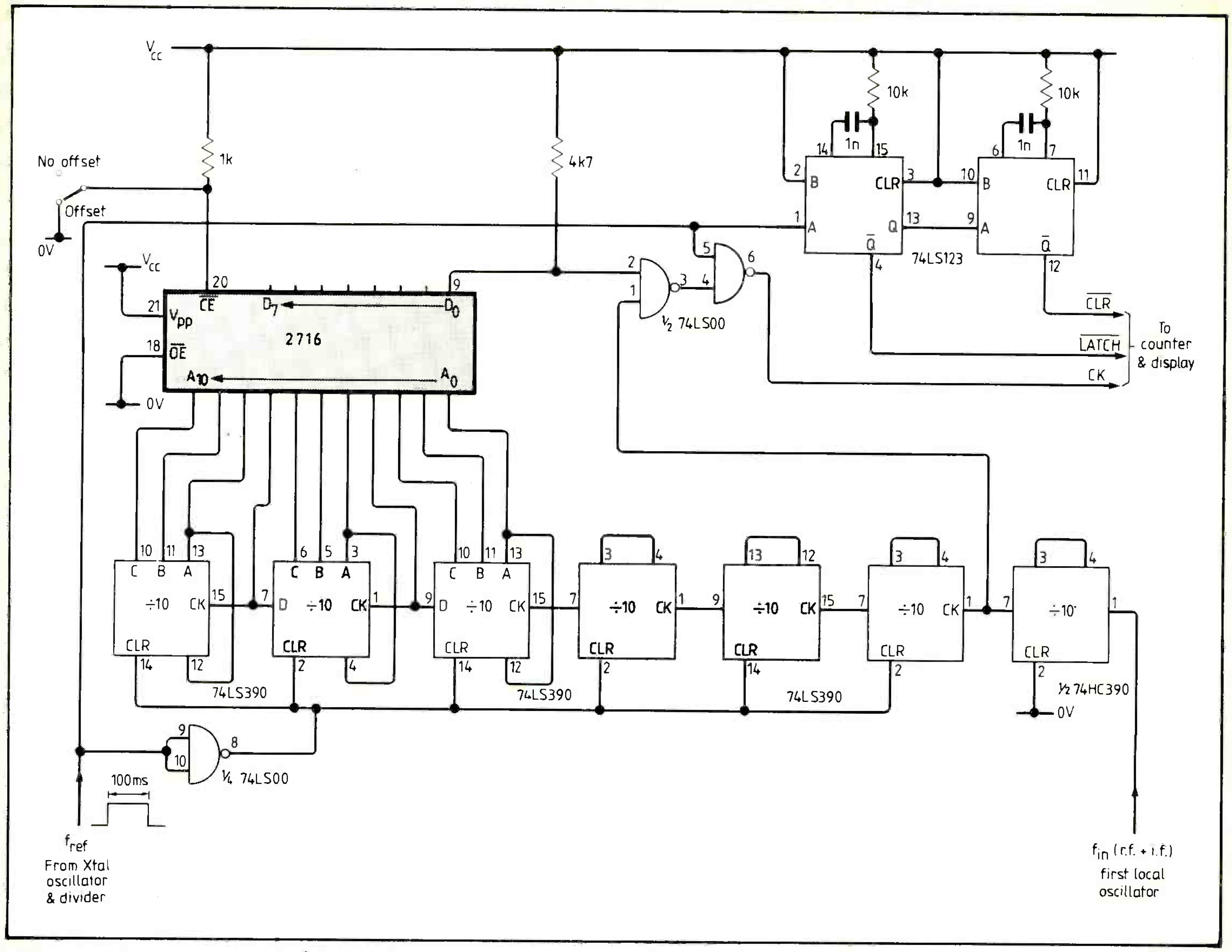
Serial RS232 data is converted to a form suitable for driving a printer with a Centronics parallel interface using this circuit. On the AY-3-1015 uart, for converting the asynchronous serial stream to strobed parallel output, the busy line is used to implement a CTS handshake.

Data rate and number of stop bits are link or switch selectable; clock frequency is 16 times the desired data rate. Whether one or two stop bits are used depends on the printer type. The three leds PE, FE and OR indicate parity, framing and overrun errors respectively.

D.J. Virden
Cheltenham
Gloucestershire



Data bits	A	B	Parity	C	D	Stop bits	E
5	0	0	Odd	0	0	1	0
6	0	1	Even	1	0	2	1
7	1	0					
8	1	1					



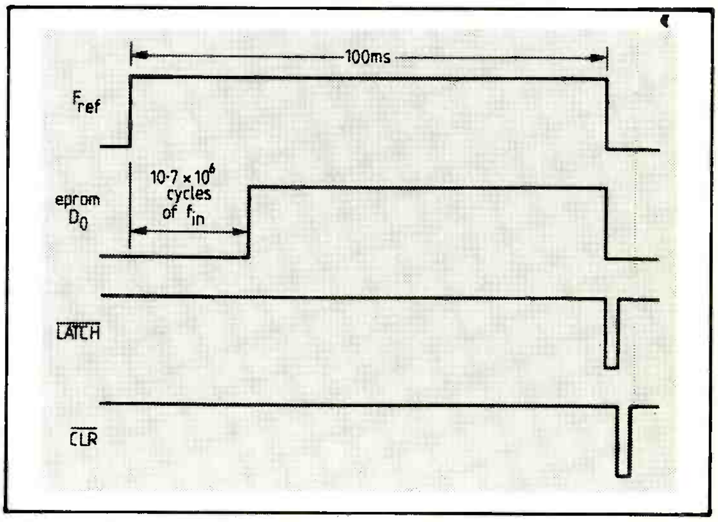
Digital-offset frequency meter

Conventionally, the method of displaying receiver input frequency is to take the first local oscillator frequency and mix it with a signal equal to the i.f. Mixer output contains both the sum and difference of the two signals, so filtering must be used to provide a signal suitable for a conventional counter.

My circuit uses an all digital method to subtract the two frequencies and is therefore more accurate than the conventional method. Output from the first local oscillator feeds a decade counter which should be a 74HC or HCT type as frequency here can be up to 40.7MHz for a receiver input of 30MHz and an i.f. of 10.7MHz.

Decade-counter output is further divided and used to address a 2716, 2Kbyte eprom. Data in the eprom determines the count to be recognized which in turn controls a gate between the incoming signal and the frequency counter. For example, if an offset of 10.7MHz is required then all locations from 0 to 106 are filled with zeros and remaining locations are left at FF.

Using an eight-bit eprom, it is possible to program eight different i.f. offsets simultaneously, and to provide a true frequency indication by disabling the eprom through its chip-select input.



George Cavarra
Bristol

8085/NSC800 microprocessor replacement

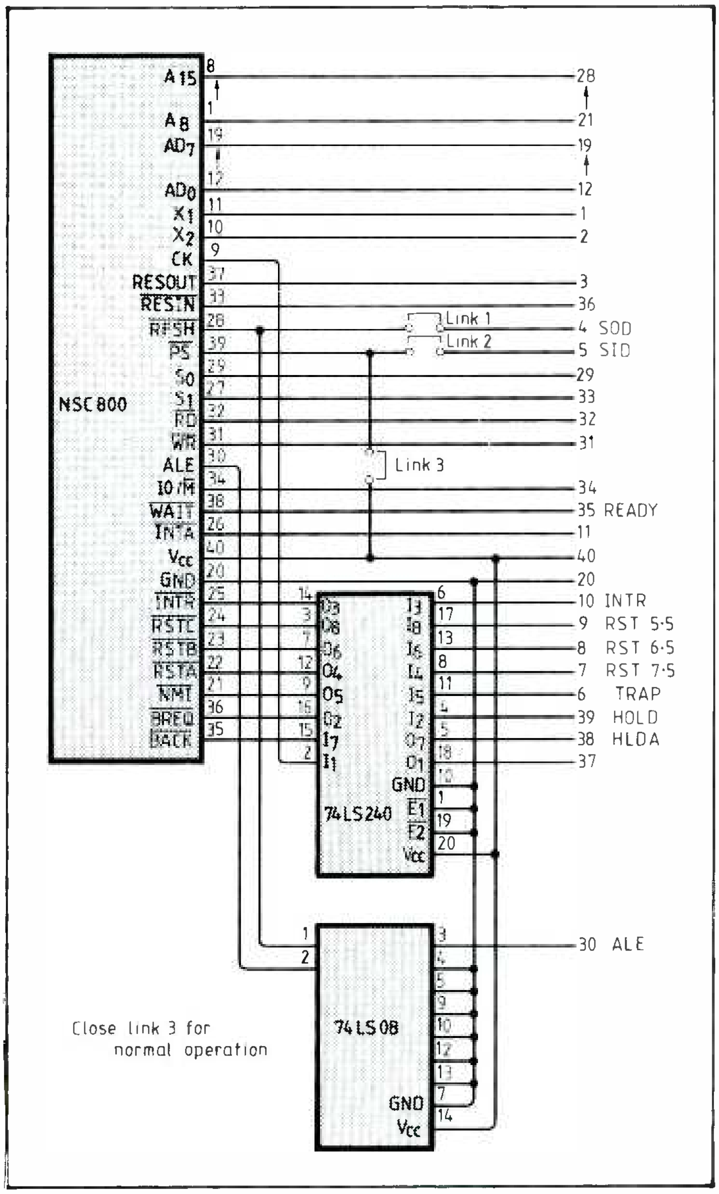
Prompted by the increasing amount of Z80-oriented CP/M software and Braunschmid's circuit idea on page 51 of the November 1984 issue, I substituted an NSC800N-4 processor for the original 8085 device in an Explorer microcomputer. In doing so I noticed some further differences between the two processors.

Comparing the timing cycles, the first obvious difference is the NSC800 refresh facility. Although this appears to be transparent on the 8085 system, generation of an ALE address-latching signal may have hardware implications on some computers. On the explorer it affected the system boot cycle. The remedy is to gate ALE with refresh signal RFSH using say a 74LS08 in the adaptor.

A more subtle difference is that the NSC800 clock output is 180° phase shifted with respect to ALE and read strobe RD. Again this may have hardware implications. On the Explorer, which supports an S100 bus, ALE and CK signals are gated together and so the phase shift has to be removed. Using the original adaptor, the clock signal can be passed through a spare inverter on the LS240 i.c.

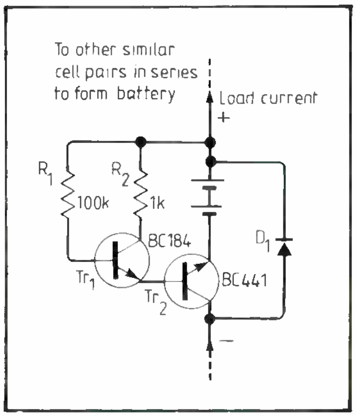
There is a yet more subtle difference in the length of write strobe WR. On the 8085 this lasts for three T states whereas on the NCS800 it only lasts for two. It was necessary to introduce a wait state on the Explorer to ensure sufficient time for memory write operations. This was simply a matter of closing a link, but it may not be so easy on other computers. Having overcome these problems, my computer is now satisfactorily running Z80 software.

T. Sumner
Orpington
Kent



NiCd battery charging

Rod Cooper's articles in the May and June issues showed the problems of reverse charging in sealed NiCd batteries. This circuit is designed to reduce these problems in a cheap and effective manner.



In a battery, the cells are grouped in pairs as shown. Normally the combined cell voltage keeps Tr_2 switched on. If voltage falls below 1.3V — which is equal to two diode voltage drops and one cell voltage — then Tr_2 turns off. The voltage across one cell cannot become negative. Optional diode D_1 allows other cells in the battery to function when this cell pair has cut out.

About 0.1 to 0.3V is lost in the circuit due to VCE_{sat} in Tr_2. In addition, current passes through R_1 even when the battery is not in use. Values shown give about 12A leakage current and 100mA load current.

Michael Robertson
Oxford

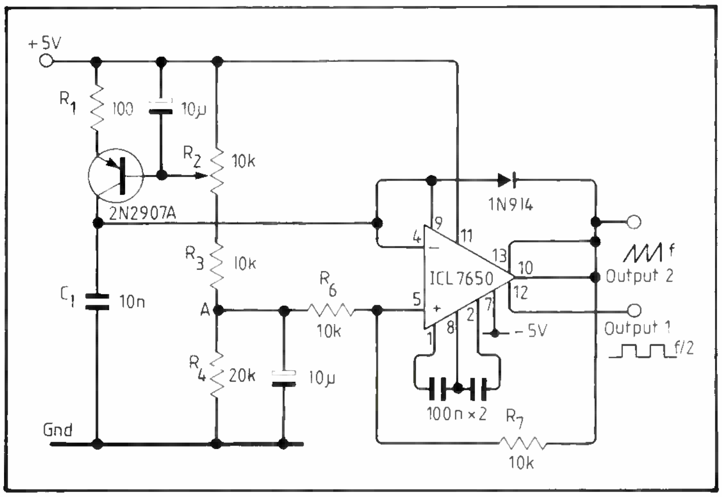
Five-decade oscillator uses one op-amp

A chopper-stabilized op-amp, the ICL7650, replaces two op-amps in a previously described circuit* to provide a simple five-decade oscillator, whose frequency is set using only one potentiometer. Output of the circuit is a squarewave.

The i.c's internal oscillator squares output of a variable frequency range ramp generator consisting of C_1, and a variable current source. Sawtooth output at pin 10 of the op-amp is directed to the internal oscillator input at pin 13 and a pulse-train output is taken from pin 12.

Kamil Kraus
Rokycany
Czechoslovakia

*Siegel, A.M., Single control adjusts variable oscillator over four decade range, *Electronic Design*, vol.32 no.24 Nov. 1984, p281.



Comparison of HOTOL with the US Space Shuttle is inevitable and major differences in basic technological philosophy can be seen as a result.

The first of these fundamental differences lies in the mode of take-off of the vehicle itself and the propulsion system associated with it. Taking the HOTOL case, with its horizontal take-off (and landing) it may be regarded as being a 'conventional' aircraft, which in many respects it is. Its configuration, not least of that of the wings which are used, owes much to Concorde; and it is stated that the runways from which it would operate are of standard Concorde length.

After the War Britain was 3rd largest steel producer. Now it is 10th. (Engineering Council, see panel)

For propulsion, a new departure is being made, with thrust being provided by a combination of air breathing and rocket engines to take the vehicle into Low Earth Orbit (LEO). This arrangement enables advantage to be taken of the free oxygen through which it is flying during its passage through the earth's atmosphere, and correspondingly to reduce the amount of liquid oxygen which would have to be carried for pure rocket (liquid hydrogen/liquid oxygen) propulsion. This forms one element in the design considerations which make vertical take-off unnecessary, an aspect which, know-how and background generally. This will be returned to later; but in addition to quoting Rolls-Royce on propulsion, British Aerospace gives three examples of major rocket projects for which the Group has had responsibility, together with two rocket engines — Spectre and Stantor. The vehicles ranged from Skylark, a small 'sounding' rocket, developed originally by RAE, Farnborough, through Black Knight, a 10 tonne-thrust liquid-fuelled rocket, to the Blue Streak heavy launcher. As the first stage in a multi-stage European satellite launcher, Blue Streak "performed faultlessly in eleven firings". This project was abandoned in the late 1960s.

In turn, this specific statement of experience, extending over some twenty years for launch vehicles, leads to the systems work being undertaken in the interlacking fields of remote control, communication and data handling as required for unmanned working. The capability of the British Aerospace organization, with the Rolls Royce contribution, is best illustrated by a straight quotation from the list given by the former in this connection: "Automatic and remote piloting control systems are already capable of handling ascent, in-orbit manoeuvring, payload deployment, re-entry and landing." It may be added that HOTOL is shown as being fitted with radar; and it does appear that the nose cone configuration would be basically the same as for Concorde.

It will be realised that any comparison of HOTOL with the Space Shuttle is bound to finish up with the question, "What advantage has the unmanned vehicle over the manned Space Shuttle, with its inherent capacity to stay in orbit for a period of some days and to act as a miniature space station?" The main substance of this question can be put in another way — "What is the justification for preceeding with a project which has reached the end of its design development studies when no immediate application for it can be seen?."

Clearly, there are two mutually dependent main issues, technical and economic, which have to be examined in the light of the unknowns that lie ahead. Even from the outline descriptions it becomes evident that by virtue of this background of experience and know-how, combined with the innovative ability shown in the project studies, these problems will be found to have been anticipated in great measure as an integral part of the essentially forward-looking project work. Consequently there are good reasons for assuming that, with this anticipation, the long and damaging delays which can take place in the early stages of engineering development would be greatly reduced, if not virtually eliminated in many areas of the work. Thus in view of the extent of the effort (both in human and material terms) which has to be

In 1900 Britain made 60% of the world's shipping. Today it makes 3%. (Engineering Council, see panel)

deployed at this stage in such a programme, it can be assumed that a more than significant saving in cost would be achieved.

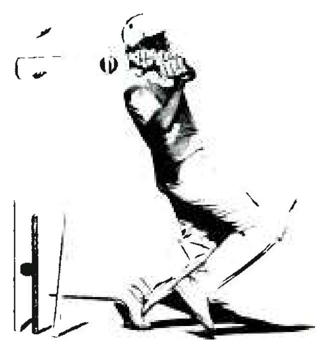
HOTOL has been called a low-cost spacecraft launcher by British Aerospace; and this can be seen as a key phrase extending over the entire project. Thus going on from the R & D end of the studies just quoted, one looks at the engineering economics of the whole project, beginning with the advantages exhibited by unmanned, as opposed to manned, operation.

First of all, the space occupied by the human crew, and particularly by their 'life support' equipment, can be devoted to payload, and their individual weight penalties removed. This gain in payload capacity will be offset to a certain extent by the corresponding demands of the replacement remote-control equipment; but it would appear that these demands would be much less for the unmanned condition.

Although not strictly comparable, similar considerations apply to the economies effected by the use of combined air breathing and rocket propulsion in conjunction with a winged vehicle configuration to permit horizontal take-off and — of equal significance — to make single-stage-to-orbit possible. These techniques, as discussed earlier, take full advantage of existing practice; and, as in the case of Concorde[1], this applies with particular force to the electronically based systems engineering required.

Thus, with this background it is possible to give a two-part answer to the first question related to the Space Shuttle:

a) On the economic side, the development costs of HOTOL, eventually fed into the operating costs, should be much less than for the Shuttle: while with the comparative lack of complexity in HOTOL both its initial (capital) and operating costs should be



Britain once exported motor bikes to over 100 countries. Now it imports almost every machine. (Engineering Council, see panel)

Britain's hidden

Most critics agree that the British are still a nation of inventors but that their record for bringing their new ideas to fruition is increasingly open to question. The range of the criticism is wide and is far from baseless; but this series set out to show that a very different picture emerges when unique technological strengths built up over the years are taken into account. If 'built up over the years' seems frightening in the context of invention and amid the clamour for University-based Science Parks, it is in the 'total engineering' power of the British that the unique capability to exploit the new ideas exists.

Opposition to this view is strongly expressed, in extreme cases amounting almost to a counsel of despair. This is seen, for example, in the recent Engineering Council advertisement where a group of pictures of a 'bowled-out' cricketer — reproduced in this article — and their captions carry a story of decline in varied UK industries.

These articles counter this with powerful examples, taken from the build-up of the aerospace industry, the full range of medical electronics, and — one of the most telling examples — in computer-based process and control applications (July article). With the example of the CEGB's National Grid control complex, that article highlights the thrust of the series — that the British have the power to develop their new ideas, and more significantly, to set up organisations which give complete flexibility to individual teams to work on their own projects.

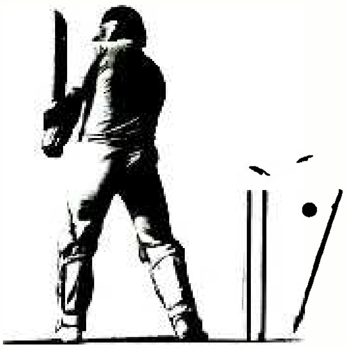
Another major aspect dealt with is that of continuity which brings with it a climate of confid-

much less.

b) Bearing in mind the low-cost aspect, HOTOL offers a means of staying in space in a controlled orbit at an operating height of some 300 km and for a (typical) duration of 50 hours. While in orbit, satellites with a total mass up to 7 tonnes can be launched; and it is inferred that observational data can be acquired for real-time onward transmission or brought back to earth in recorded form. All this is done without highly trained specialists having to be exposed to the rigorous conditions encountered in space; and without massive ground (rocket-range type) preparation and operational facilities being required.

Thus, the final conclusion can be reached that, because of all these low cost features, "Several HOTOLS could be provided for the price of one Shuttle"; and that this means that the number of vehicles available for a given programme expenditure would be greatly increased so that, for example, quick follow-up action could be taken to gain immediate checks on suspect data. This is in contrast to the more widely separated 'appearances' of the Shuttle, with the factors contributing to this including a much more lengthy turnround time in addition to the comparatively large cost of setting up a single mission.

Comparative figures for the two types of operation are a reduction in cost by a factor of five for sending HOTOL into low earth orbit; while even for geo-



Before the War almost every car on Britain's roads, was British. Now well over half are foreign. (Engineering Council, see panel)

synchronous launches a reduction of 50% is claimed for the unmanned operation. In this connection it is also claimed that HOTOL would be able to compete realistically for some three quarters of commercial market demands as predicted for the year 2000 onwards.

This reference to the year 2000 serves to introduce the concept of HOTOL becoming a manned aero-
space plane for the 21st century; information on these studies having been issued at the end of May 1985. (The comparative figures quoted above are taken from this source, and are obviously based on up-to-date — confirmed — surveys.)

The salient features of this striking project for a 'Transatmospheric Skyliner' are:

- The installation of a capsule-type passenger compartment in the payload bay with conventional airline seating for about 30.
- Retention of all elements of the basic HOTOL design as described for unmanned operation. Provision was made for both manned and unmanned operation right from the outset as part of the original concept.
- Forward looking plans for ultra-high-speed passenger service with the main section of the flight consisting of a ballistic trajectory outside the earth's atmosphere, with a powered climb to this path reaching a maximum of Mach 5, and with a corresponding descent path to landing after re-entry. The possibilities offered for the future by this flight pattern are spectacularly illustrated by the proposal for a one-hour service from London to Sydney (overhead to overhead in 45 minutes).

With this background, and reverting to the original composite question, it can be said that, as compared with the Shuttle, HOTOL would appear to offer a more flexible and a lower cost service for launching satellites and for similar tasks. On the other hand, at the present time the Shuttle stands alone in providing its re-usable Space Station faclity; and the importance of this and the pioneering work that went into it cannot be over-emphasized.

These innovative studies are of special interest to all R & D engineerss with management of a project where more than one branch of technology and several separate interests are involved. The HOTOL studies, with their comprehensive documentation, and with their interlinking with Concorde in particular, give an inside picture of the way in which advances are made, and consolidated, in a large, multi-team, high-technology project. A similar picture has been built up for other comparable UK projects,

Britain pioneered the world machine tool industry. Its share is now 3.1%. (Engineering Council, see panel)

notably for the CEGB in Big-system automation and telemetry (Article 5); and the work of that authority enters into the next section — on continuity.

However, there are two aspects of the aerospace total study which have made it uniquely suitable for this article, both strongly related to the future.

The first is that, although conducted as a pure research exercise, its content has been predominantly practical, outstandingly with regard to 'spin-off'. Spin-off, in its widest sense, and contributing to a number of *major* technologies within the aerospace context, represents what is perhaps the greatest strength of this multi-team project. It certainly justifies the approach which has been adopted and which has resulted in the informed and coordinated built-up of background of mutual benefit to, for example, the aerospace and electronics/control

Britain discovered the wireless. It now imports 96% of its portable radios. (Engineering Council, see panel)

engineers concerned. This does, of course, correspond with the interchange and spin-off shown with radar and television (Article 2) which developed in Great Britain even before World War II.

For this comparison, it should be pointed out that the spread of technologies is much greater for the aerospace concept — both radar and television are essentially electronic in character. Consequently, spin-off and mutual support extend over a much larger number of fields in the aerospace case. In turn, this means that shutting-down an individual project of this nature will affect any others which are being supplied with information or with results from it on which they may well be utterly dependent. There is no need to stress the seriousness of such knock-on consequences, quite apart from the loss in national terms which comes from the break-up of an

strengths

ence but, for real success, it depends on rapid adaptation by teams to new phases in the work and to the changes in approach which are necessary whare original activity is involved. This ability to adapt and to transfer technological know-how is fundamental to the claims of Britain's unique capability in invention and innovative development.

August's high technology example links automotive engineering and electronics, where innovative development work undertaken effectively as a private venture has brought together small groups operating in the field, and has shown that inventive ability combined with adaptable know-how are not far below the surface; they simply need 'bringing out'.

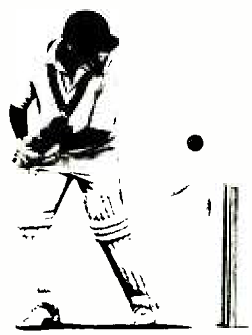
In the new discipline of human communications, three areas of closely interlocked work have developed, recognised by academics as original and far-reaching: human behaviour under crisis-control stress, immediate presentation of information for unimpeded operational use, and hyper-autism, which together with the concept of 'data marshalling' have all recently featured in these pages. Of these, hyper-autism is particularly significant in that individuals have been brought together to form an R & D organisation similar to that described for the private venture of the August article but working entirely on a voluntary basis. September's article describes their advances.

This present article, the last in the series, brings together these ideas to show where Britain's hidden strengths exist, where they are being suppressed, and how they could be brought to the surface again in the future.

established team.

These considerations are sufficient in themselves to justify the retention of a project which has reached the end of its design/development studies when its ramifications extend even over a fraction of those as quoted. In other words, on these grounds alone one can answer the original question, with the statement that the losses incurred by shutting down a project which has reached the early stages of engineering development (as distinct from studies), are so great that retention is justified on economic grounds alone.

It is, however, in terms of the future that complete justification may be found; and it is with this specific aerospace project under review that the full extent of the arguments in favour can be seen. Quite simply, such projects should be carried on because of the crucial base they provide in whole areas of technology.



Britain made the first practical computer. It now has only 5% of the Information Technology market. (Engineering Council, see panel)

Continuity

The whole question of continuity has been brought in at relevant points throughout this series; especially in relation to the climate of confidence which can be associated with it. Two kinds of climate of confidence, closely interlinked, exist here. The first, technical, has already been given considerable emphasis, particularly with regard to the transfer of know-how from one branch of technology to another.

The other kind of climate of confidence, assurance of the future, is more than the impossible ideal which it appears to represent, certainly if taken literally.

However, there are two elements which do involve the future and some degree of assurance. The first of these, which comes under the technical heading, is concerned with the dual issue of spin-off and sub-invention. This obviously cannot be taken into the long-term; but clearly it is vital for a reasonable time to be seen to be available for the 'side-issue' developments to be undertaken which produce spin-off. In this connection, it should be pointed out that, in terms of R & D management, one cannot justify expenditure of effort and resources on 'off-stream' work unless adequate time is available for it: it must not be scamped.

On the other hand, success even with a minor, but nevertheless new, development, can have an effect far beyond the immediate use to which it is put, particularly with regard to the personal side. That some widening of the base of the programme has taken place, and that effort has been devoted to the (effectively) separate work, indicates that the project has been made larger with a potential for interlinking with other R & D areas; and this can offer a wider view of the future.

If successful, there are, of course, economicc advantages which accrue from such an approach. One of these illustrates the principle given in Article (1), that methods and techniques developed for a specific part of a project do not have to be rediscovered and can be applied in the future, *provided* continuity is maintained over the whole series of programmes.

Two main issues covered by continuity come in here. The first is the straightforward use of the word for describing the coordinating and other processes, and the policy behind then, which keep even the largest projects flowing smoothly and successfully. A number of examples of such successful UK operations have already been given one of the most outstanding in the present context being that of the CEGB's far-reaching development programme for the control complex for the National Grid[3]. Extending over a considerable number of years and, if anything, being accelerated at the present time, this 'total' project has continuity literally as its key feature.

The second of these issues may be linked with the continuity which lies behind the proven capability of the British to show complete flexibility in approach when dealing with the new and untried, or of responding quickly to new phases in the work. The statement of this capability is in most respects the statement of the personal qualities required to undertake wide-ranging project work and advanced engineering which is demanded for the technological ventures already described. The acquisition of these qualities is by no means automatic; although it has been submitted in this series that, in a sense, they are almost a national characteristic. However, in practical terms, the process of acquisition takes time, whatever the inherent capabilities of the individual may be; and expressed as a period of education (which in many ways it is) should be recognized as being inseparahble from R & D work. Therefore, there is an implied commitment for continuity to be maintained for the individual to work effectively and smoothly without worrying about interruptions to his specific programme.

Britain once made all the textile machinery in the world. It now makes 8%. (Engineering Council, see panel)

The macro-project

Throughout this series it has been possible to show that there is an enormous fund of technological knowledge and experience which can be found in Great Britain at the present time and at all engineering levels. Moreover it has been possible to show that the British retain the power to set up organizations capable of handling the largest projects right from initial development to full exploitation of the original idea or group of ideas on which the project has been based.

However, it is felt that, although these examples have given a representative picture of the way in which these projects are run and of the British expertise in such fields, this capability should be examined in relation to a project which is very much in the future.

The 'macro-project' which has been selected for this purpose is entirely hypothetical; but the circumstances which surround it are far from hypothetical. They are the conditions of drought and consequent famine which are affecting much of the continent of Africa, and have proved of more than passing concern to the rest of the world. Expressed in utterly basic terms, the proposal is that this problem should be tackled at source with the primary task to provide water on a huge scale, first for human consumption and then for irrigation. Assuming breeder-reactor power would be available, the water would be obtained by evaporating sea water using nuclear power, and distributed by pipeline, perhaps initially by tanker. Each section of this plan would represent a development programme of unprecendented magnitude; but, on the other hand, need not be regarded as insuperable.

Power generation would probably have safety precautions as its biggest project engineering committment; but there is no reason to believe that this and all the other steps into new design and development areas would be beyond the capacity of the UK, bearing in mind the record and achievements of the supply industry and that of the manufacturing side both at home and internationally. It is perhaps not out of place to refer to a visit to a geothermal station in the North Island of New Zealand where it was clear that a new technological world had not been found to present insoluble problems.

In the same way, pipeline 'transmission' of water over long distances can be seen in South Australia and in the west of the island continent where temperatures can reach values not dissimilar to those encountered in Africa.

Continued on page 64

Last year Britain even imported 65% of its sports equipment. How's that! (Engineering Council, see panel)

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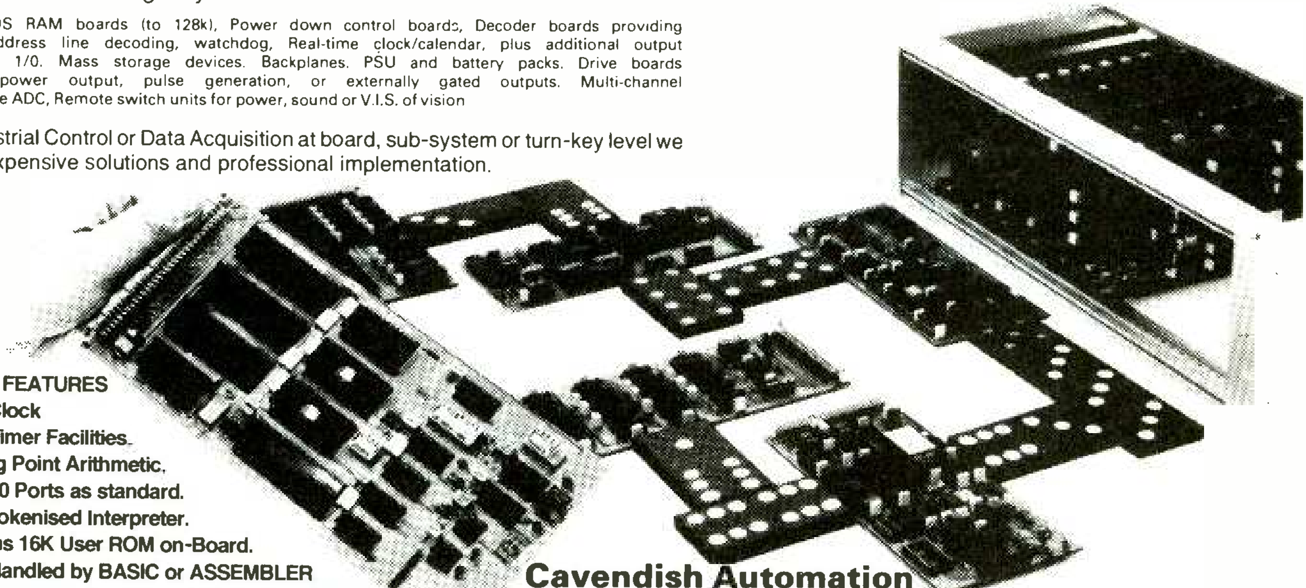

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68000 board

by R.F. Coates

The £100 Kaycomp — Bob Coates, 68000 computer board for engineers, students and enthusiasts — is developed using a terminal and takes a G64 bus interface.

Kaycomp is a low cost computer board using a Motorola 68000 microprocessor with 16-bit data bus. It is designed for use either as an evaluation/educational tool or as the processor board of a larger system, connecting to a wide range of readily available peripheral cards through its G64 interface bus.

Programs can be entered using a terminal to gain access to Kaycomp's 23 function monitor program Kaybug. There's also an optional line-by-line assembler available to speed up program development. Alternatively, the board also links to a host computer with assembler/compiler facilities. Communication software is included in the monitor program.

The 68000 microprocessor has a 32-bit internal structure. Eight data and seven address general-purpose registers are available to the programmer, all 32 bits wide. Its external address bus is 24 bits which gives a linear address range of 16 megabytes, Fig. 1.

Motorola evaluation kits for the original eight-bit 68000 i.c. were available for around £150. There is a similar kit for the 6809 microprocessor but it was not introduced in the UK. For the 68000 microprocessor, Motorola produce a design module costing £1500 — a tenfold increase over the price of a 68000 evaluation kit.

Of course the 68000 design module is a far more complicated product than its older equivalents and designed to allow evaluation on a wide scale. In many applications though this complexity is not necessary and there is certainly a need for a low cost evaluation system.

I designed Kaycomp so that it could be built in its basic form for under £100. In this form it has two RS232 serial interfaces and general-purpose i/o lines provided by a 68681 i.c., a monitor eprom, a small ram and a full 16-bit 68000 i.c. When expanded, the board has 128Kbyte ram, 64Kbyte eprom, two serial interfaces, a 68230 peripheral i/o device and a bus interface which allows connection to standard peripheral cards.

Large systems nowadays can have many processors and direct memory access controllers working together on the same bus to multiply processing speed. I considered that this feature was not essential to learning about and evaluating the processor and leaving it out saved a lot of peripheral logic. If you are interested in the type of work that requires multiprocessing, £1500 won't normally be a problem.

An external bus interface probably isn't essential for training and evaluation either, but I included one to increase the usefulness and versatility of the board. VME bus is the obvious choice for a 68000 processor board but the cost of implementing it is very high. To illustrate, one manufacturer produces a single Eurocard wire-wrap board for prototyping containing just VME interface chips for £600.

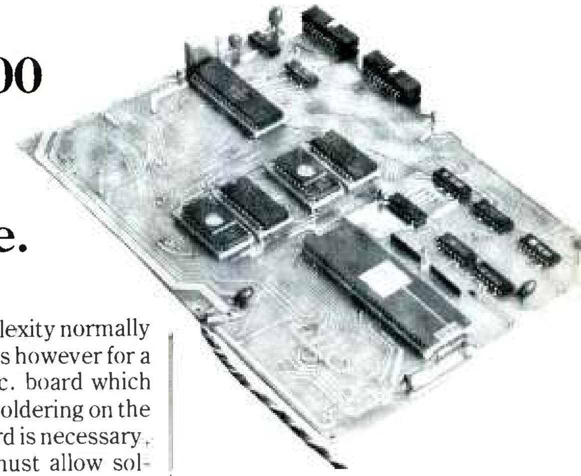
My choice was the European G64 bus designed for Motorola eight-bit processors. The interface circuit consists of just three t.t.l. devices. G64 is probably the best supported eight-bit Eurocard bus, with over 200 different cards available from many different manufacturers, but it is not well known in the UK yet. The main UK manufacturer is Syntel of Huddersfield which produces a wide range of processor and peripheral cards, back planes, racking systems, etc.

Kaycomp overview

Figure two illustrates the system. Kaycomp in kit form is double-Eurocard sized, measuring 234 by 160mm, and its p.c.b. is double-sided but to keep costs down, it is not plated through as a board of this complexity normally would be. Layout is however for a plated-through p.c. board which means that some soldering on the top side of the board is necessary. Sockets for i.cs must allow soldering on the component side too.

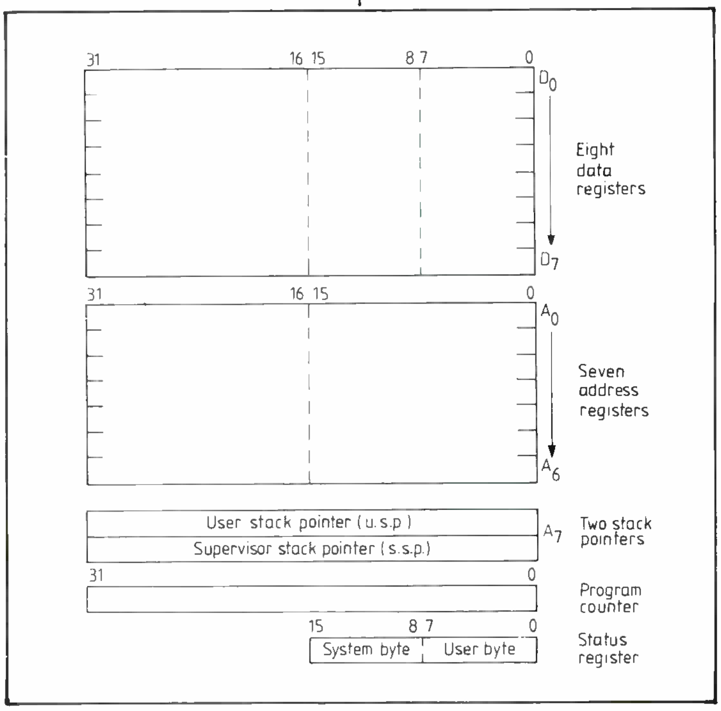
In order to keep costs down, some systems use a reduced-bus version of the 68000, the 68008, which although internally the same as the 68000 only has an eight-bit data bus and a 20-bit address bus. I decided against using this version. The board accepts either the 68000 or an enhanced version, the 68010, running at up to 10MHz. The 68010 is a virtual memory version of the 68000. This feature cannot be used with Kaycomp, but the 68010 also executes some instructions faster and has some extra ones too.

Memory consists of two eprom and two ram sockets. Two of each byte-wide memory are required to give a 16-bit data width. Links allow eproms with standard



Our front cover shows the 68000 board in its fullest form with G64-bus interface — this is the basic version.

Fig. 1. **The 68000 has a 24-bit external address bus giving an address range of 16Mbyte.**



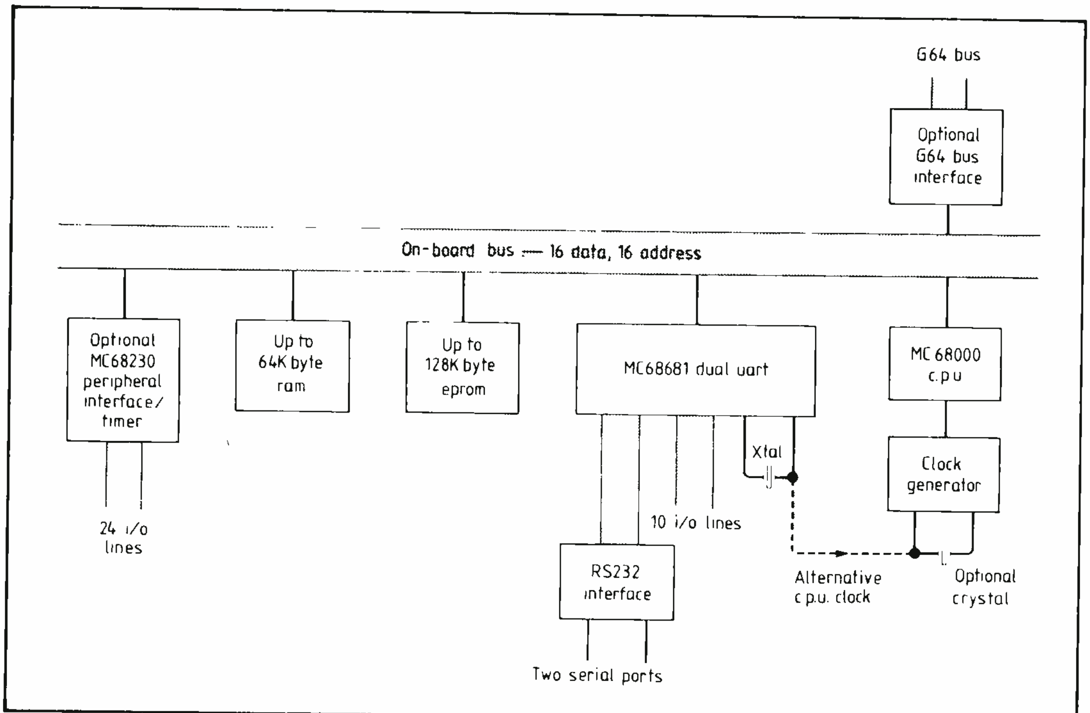


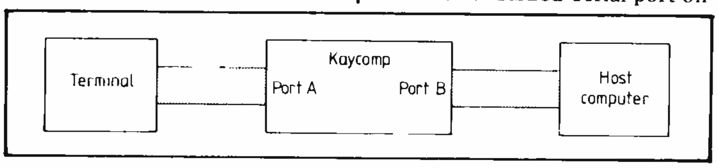
Fig. 2. **Kaycomp uses a full 68000 processor and two peripheral i.cs from the same family. Using these instead of more common 6800 peripherals means higher performance and increases the board's value as an evaluation tool.**

JEDEC pin configurations from 2732 to 27512 to be fitted, giving a range from 8 to 128Kbyte. Note that not all larger eproms conform to the standard pinout, notably those from Mostek.

Ram sockets currently accept either 2 or 8Kbyte static rams, i.e. either 6116 or 6264, to give either 4 or 16Kbytes. The board is laid out though to accept 16 and 32Kbyte devices for when monolithic i.cs become available, which will give up to 64Kbytes of ram. Hybrid 16 and 32K devices are available now but they tend to be expensive. Reasonably priced hybrid 32Kbyte rams consisting of four small-outline 6264 i.cs on a ceramic substrate are produced by Digital Memory Systems, the DMS8832-15PC, and by Hybrid Memory Products, the HMS 62832.

To allow programs to be developed and written on the board, there's a monitor program which fits into two 2732 eproms. This monitor, Kaybug, requires connection of a separate RS232 terminal. If a terminal is not available, many home computers such as the BBC microcomputer have an RS232 port and can be made to act as a dumb terminal. With this in mind, the monitor program can easily be set to produce either a 40 or 80-column display by a keyboard command.

Fig. 3. **Kaycomp can be used by simply connecting a dumb terminal but in this configuration, it is effectively connected in the terminal line from the host computer. In this way, software developed using 68000 assemblers and compilers on the host can be fed directly into the board.**



A second RS232 serial port on Kaycomp can be used to connect the board to a host development system or mini/microcomputer. Both RS232 ports come from a 68000 peripheral i.c., the 68681 dual asynchronous receiver/transmitter or duart. The 68681 internal oscillator requires only a 3.6864MHz crystal. A cheaper 3.579545MHz American colour tv crystal will suffice; data rates will be a little out but still within the required tolerance.

For full-speed operation, the processor requires a separate 8MHz crystal clock but if speed is not important, the duart 3.6MHz clock may be used. If you need to used the serial ports in an application, there's another version of the monitor program available which allows you to develop programs through an external G64 dual serial port card.

Parallel input/output is provided by another 68000-family i.c., the 68230 peripheral interface/timer. This optional i.c. is not used by the monitor and all of its facilities are available for user applications and evaluation.

Finally, there's the optional G64 bus interface which consists of three t.t.l. bus-interface i.cs. There are two sections in the G64 bus memory map, one for memory addresses and the other for peripheral addresses. The peripheral area consists of a 1Kbyte block somewhere in the memory map which is decoded on the processor board. Valid peripheral addresses are denoted by assertion of the VPA signal, which is not to be confused with the 68000 signal of the same name.

On Kaycomp, the G64 bus is provided solely for the addition of peripherals. The on-board memory is potentially quite large and capable of operating at much higher speeds than would be possible with memory operating through the interface bus.

Monitor software

Kaycomp's monitor program Kaybug allows you to enter and debug programs and exercise all the facilities on the board. Commands allow you to display/alter memory, set break points and run or single-step trace through programs. Registers can also be altered. Kaybug contains all of the usual monitor features.

At a basic level, Kaybug allows programs to be hand written and typed into memory from a simple terminal using the 'memory open' command. There is an optional line-by-line assembler to simplify this job. If a home computer is used source code can be written, edited and stored using the computer's facilities. When ready, the source code can be sent for processing by the Kaycomp line assembler. Object code is then produced and loaded into ram as each line is entered.

If you have a development system or development facilities on a micro or minicomputer, the second serial port allows program transfer. Kaycomp is then effectively connected in the terminal line from the host computer as shown in Fig.3.

One Kaycomp command allows the board to become 'transparent', i.e., the terminal communicates directly with the host computer as if the board did not exist. Programs can then be written and assembled or compiled in a high-level language according to the 68000 program development software available on the host computer. Another monitor command allows resulting object code to be loaded into Kaycomp's memory in Motorola S-format ready for running. The procedure may vary slightly depending on the host system used but this is a common way of developing programs.

Alternatively, a computer with 68000 'cross-software' can be made to act as both a terminal and development system, Fig.4. A monitor command allows object code to be loaded through the terminal port; the host port is not used.

Before you can understand the

circuit, you need to know a little about the 68000 processor, Fig.5. More detailed descriptions are given in the Motorola Data Manual and the MC68000 Microprocessor User's Manual.

About the circuit

Clock drive. The clock input is a t.t.l. compatible signal which is internally buffered for development of the processor internal clocks. There are 68000 processor versions with clock speeds from 4 to 16MHz faster versions are expected.

Address/data buses. These two buses are fairly straightforward. There are 16 data lines and 23 address lines but there is not an external A_0 address line. Addresses are considered as being byte sizes, i.e. eight bits, and although A_0 is used internally, the address bus is only capable of generating even-number addresses.

Asynchronous bus control. Bus control is a little different to that of previous eight-bit processors in that bus transfers between the processor and memory/peripherals are asynchronous.

On the 68000 for instance bus transfers are controlled by a synchronous timing signal E. This is an equal mark/space ratio signal upon which all bus timings are based. In the case of writing to memory the processor sets up the address bus and read/write signal in the first (low) half of the bus cycle and sets up data to be written in the second half. At the end of the cycle, the E signal returns low and data is latched into the memory.

When reading, the processor presents memory with the address and expects it to have data ready on the bus by the time that the E signal falls to latch the data bus into the processor. This means that the system designer must make sure that memory or peripherals used are capable of operating at the speed required by the processor or, more likely, that the processor clock speed is slow enough to suit the slowest device in the system.

In the 68000, this problem is overcome by using asynchronous bus transfers. The processor sets up the bus in the same way, but it then asserts an address signal called AS and holds the bus until it receives a data transfer acknowledge signal, DTACK, back from the memory or peripheral. DTACK signals from the various system elements are wire-or'd together before entering the processor. This ensures that each part operates at is highest speed.

Peripheral i.cs in the 68000 family produce the DTACK signal but extra circuits are required for this if peripheral devices from other families are used.

Accessing bytes. No A_0 address line is available so some means of implementing byte read/write operations is required. Two signals handle this, upper data strobe UDS for even byte locations and lower data strobe LDS for odd locations. For a normal 16bit word transfer, both signals are asserted.

Figures six and seven summarize the various bus transfers. Figure six shows a read and then a write cycle with no wait states inserted. After setting up the address bus the processor asserts AS, UDS and LDS and then waits for DTACK which it responds to by releasing the three signals. At that point, the addressed device must also release DTACK. If a slow device is addressed, it can be seen that wait states are inserted by the processor after S4 until DTACK is received. Figure 7 shows the action of UDS and LDS when addressing bytes.

68000 peripheral i.c. accesses. Asynchronous bus accesses work fine with 68000 peripheral i.cs but not with the wide range of 68000 peripherals which do not generate DTACK. There are three control pins on the 68000 especially for 68000 peripherals.

If the address decoding circuit asserts valid peripheral address signal VPA instead of DTACK, it indicates to the processor that the device or region addressed is a 68000 family device. The processor then executes the rest of the bus cycle synchronized to a 6800 type E signal as described earlier. It acknowledges this fact by asserting low the valid memory address output, VMA, which is gated with the device's chip-select signal.

The 68000 E signal, with a 40:60 mark/space ratio rather than 50:50, is at one tenth of the clock signal so a processor operating at 10MHz can access 1MHz 6800 peripherals. A synchronous bus access results in a somewhat slower cycle than is possible with asynchronous transfer.

Interrupt control Seven levels of interrupt can be provided for, which ideally would mean seven interrupt pins. To save on pins though, the seven interrupt levels are turned into three-bit binary, the eighth value, all pins high, indicating no interrupt. Normally, these three pins are fed directly from the three possible interrupt sources. Hence only three interrupt levels can be used, one, two and four.

When servicing an interrupt, the 68000 fetches an address from a vector and continues processing from that address. There are two types of interrupt vectoring though, 'auto-vectored' which is similar to that of the 6800, and vectored, where the interrupting device provides a vector number on the data bus in response to the processor executing an interrupt acknowledge

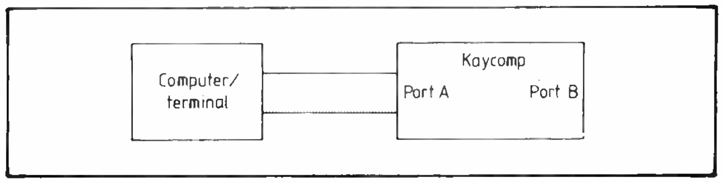
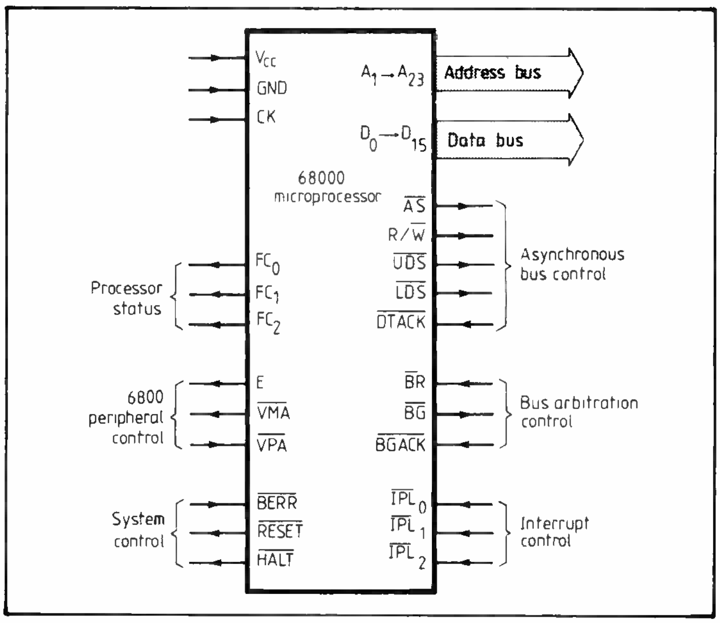
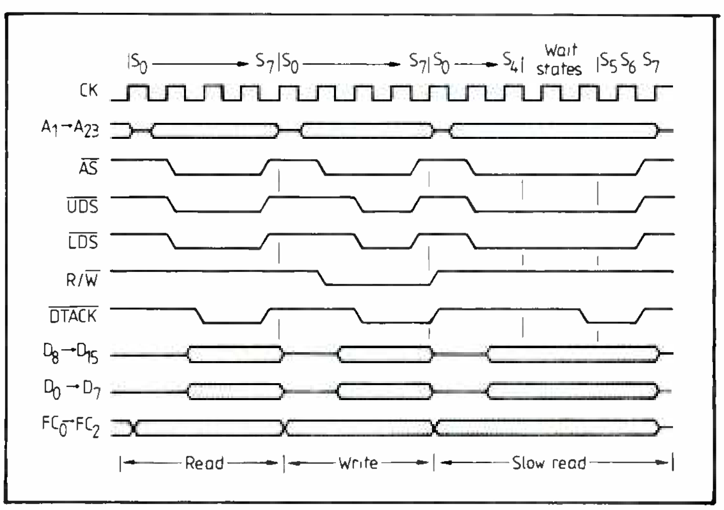


Fig.4. **A computer can be used as both a terminal and host for developing Kaycomp.**

Fig. 5. **Input/output signals on the 68000 processor, top, and** Fig. 6, **read-then-write bus transfer with no wait states.**





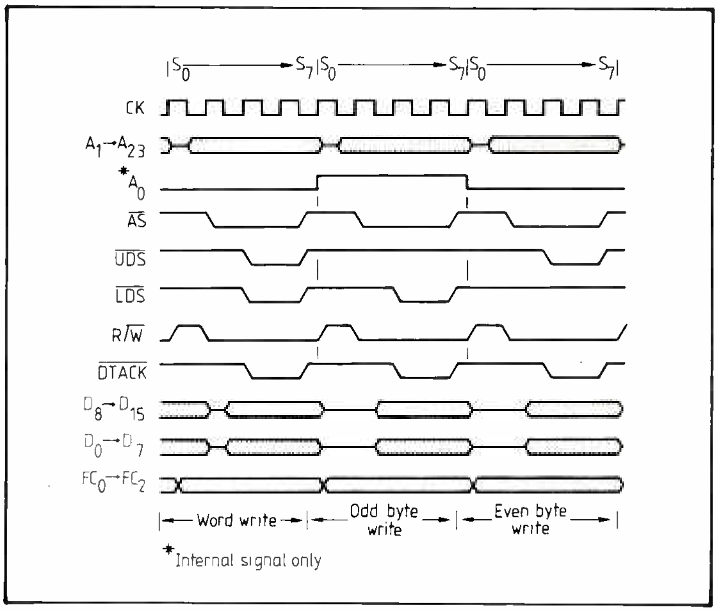


Fig. 7. **Action of upper and lower data strobes UDS and LDS used when addressing bytes. These strobes are needed because the 68000 has no address-line zero.**

Components and Support

Individual components complete kits including double-sided p.c.b. and data packs are available from Magenta Electronics, 135 Hunter Street, Burton-on-Trent, Staffordshire DE14 2ST. A kit for the minimum system described is available for £99.

G64 card suppliers include Syntel Microsystems, Queens Mill Road, Huddersfield, HD1 3PG and Thomson Semiconducteur whose UK distributors include Pronto Electronic Systems, 466 Cranbrook Road, Gants Hill, Ilford, IG2 6LE. G64 bus back-planes are available from these and also from BICC-Vero.

Cross-software for various host computers is available from a number of sources, for instance, Microtec Research, Frances Road, Basingstoke, supply 68000 cross-assemblers, Pascal and 'C' crosscompilers for DEC, Data General and IBM PC computers.

Bob Coates will program your pair of eproms (any type) with the Kaybug monitor software for £7 sent to 57 Dalebrook Road, Burton-on-Trent, DE15 0AB. Machine-code listings can be obtained by sending a large s.a.e. marked Kaycomp to our editorial offices.

cycle. This allows different interrupting devices on the same interrupt level to be serviced by different service routines without polling, which saves time.

Processor status. When processing an interrupt the processor places a unique code on status lines FCO/1/2 of all ones, which is used by Kaycomp to generate an interrupt acknowledge signal, IACK. This signal lets the rest of the board know what is happening. Other states are indicated by the status outputs, Fig.8, but only interrupt acknowledge is used on Kaycomp.

System control. Three signals constitute the system control section, bus error, reset and halt. Bus error, BERR, is not used on Kaycomp. It has two main functions. First, I mentioned earlier that bus cycles are terminated with DTACK. If the circuit does not send this signal, if for example access to non-existent memory location is attempted, the processor stops. A way around this is to have a hardware time-out circuit which generates a bus-error signal if DTACK is not asserted within a given period. A bus-error signal causes exception processing to allow an orderly recovery — hopefully.

The second use of BERR is in conjunction with HALT. If both are asserted together the processor will attempt to rerun a previous, failed, bus cycle in the hope that it will work the second time. This can be significant in terms of reliability if the processor is controlling say a large plant, but omission of this feature on Kaycomp will probably go unnoticed. If you attempt to access a non-existent location, you'll have to press the reset button.

The HALT pin is bidirectional and the processor can drive it low to indicate a double bus error. Bidirectionality also applies to the reset pin. A reset instruction executed in software causes the reset pin to be driven low for 124 clock periods. All peripheral devices connected to the RESET line are reset.

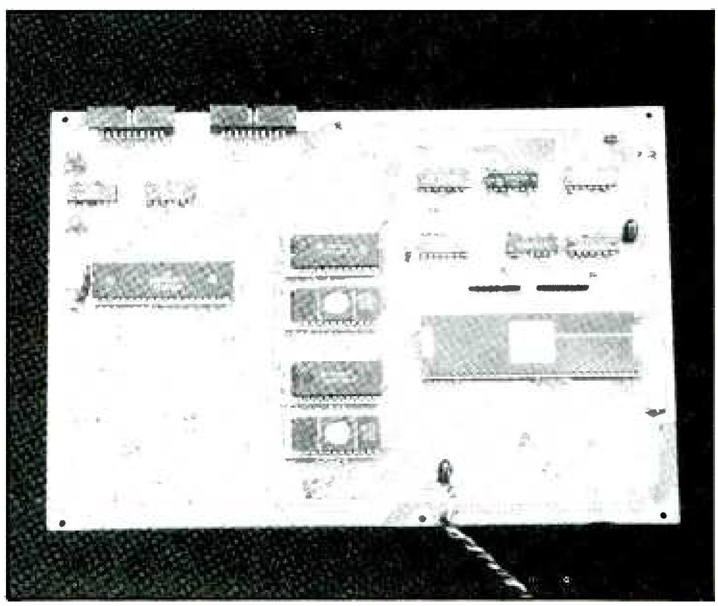
Taking RESET low externally will have the same effect on peripherals but it will not affect the processor. To reset the processor fully, at power-up for instance, both RESET and HALT must be taken low together externally. If the HALT line is taken low on its own, the processor is held in its current state until the line is released.

Bus arbitration conrol. Three pins, bus request, bus grant and bus grant acknowledge (BR, BG and BGACK) make up this section. These deal with multi-processor/d.m.a. functions which are not available on Kaycomp.

Bob Coates gives a more detailed description of the circuits in his next article.

Fig. 8. **Function codes indicating the state and cycle type currently executing. These outputs are valid whenever the address strobe is active (low).**

Function code output			Cycle type
FC_2	FC_1	FC_0	
Low	Low	Low	(Undefined, reserved)
Low	Low	High	User data
Low	High	Low	User program
Low	High	High	(Undefined, reserved)
High	Low	Low	(Undefined, reserved)
High	Low	High	Supervisor data
High	High	Low	Supervisor program
High	High	High	Interrupt acknowledge



The kit p.c.b. is not a plated-through type; this saves money but requires use of turned-pin i.c. sockets.

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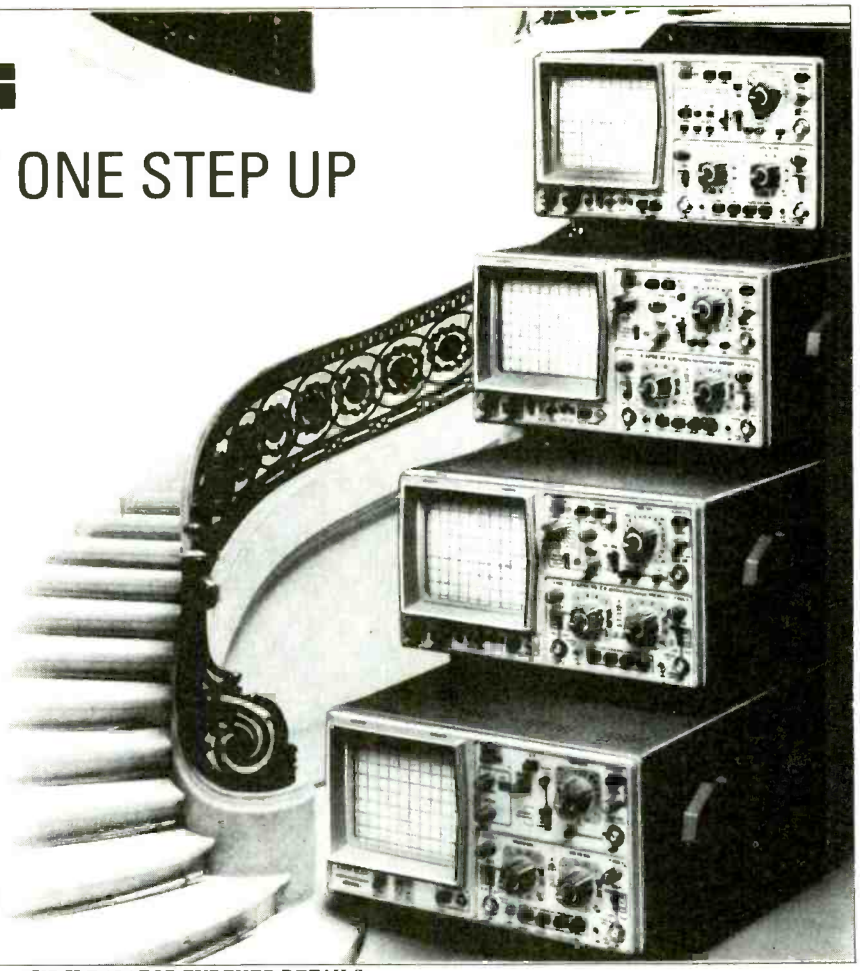

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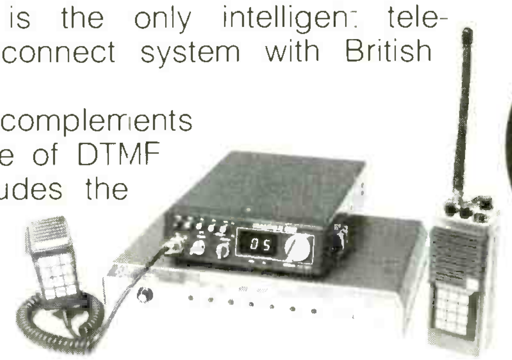

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M31-184GH	65.00
M31-184P31	65.00
M31-186W	69.00
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M31-271P31	65.00
M31-271GW	65.00
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M38-121LA	65.00
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V5004LD	59.00
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V7031GH	59.00
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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
ACY17	1.15
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
AF115	2.95
AF116	2.95
AF117	2.95
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
AFZ12	3.75
ASY27	0.85
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
BD183	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
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MJE340	0.40
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MPSA13	0.29
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OC45	0.55
OC70	0.45
OC71	0.55
OC72	0.85
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TIP33C	0.95
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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
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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	0.20
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	1.40
2SC1307	1.75
2SC1364	0.50
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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
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BY176	1.20
BY179	0.63
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ECL84	0.74
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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	3.95
EF85	0.50
EF86	2.25
EF86 Special Quality	3.15
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.85
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	0.95
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	1.75
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	1.50
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	6.95
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
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
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	4.95
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	7.95
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	3.50
MZI-100	125.00
N37	12.50
N78	9.85
OA2	0.85
OA2WA	2.50
OA3	2.50
OB2	0.85
OB2WA	2.50
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
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	1.26
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	0.80
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
QB3-1750	139.50
QB5-3500	495.00
QE03-10	4.95
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE02-5	19.50
QQE03-12	7.95
QQE03-20	35.00
QQE06-40	45.00
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
QV2-250	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	395.00
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
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4.400	85.00
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
UCL83	2.50
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.50
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	4.50
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
1C1	2.50
1C5GT	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
1X2B	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
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	27.50
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

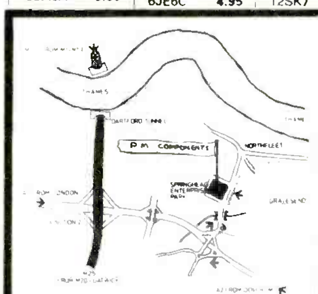
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4687A	9.50
4-125A	72.50
4-250A	79.50
4-400A	87.50
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B	49.00
4CX250B Eimac	59.50
4CX250BM	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4CX350F	79.50
4CX1500B	398.50
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
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
5J180E	1895.00
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
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
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
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.10
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CM5	1.60
6CM7	2.95
6CS6	0.75
6CW4	6.50
6CY5	1.00
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	1.15
6DQ5	5.95
6DQ6B	2.50
6DT6A	1.50
6DW4	2.15
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	1.50
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GS7	2.15
6GV7	2.50
6GW6	2.50
6H1	9.50
6H3N	1.10
6H6	1.95
6H6GT	1.95
6HF5	5.50
6HF8	2.50
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	2.00
6JB6A	3.95
6JE6C	4.95

6JU8	2.50
6JS6C	4.95
6J7G	4.15
6K7G	2.00
6K8G	3.00
6KD6	5.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	4.50
6L6GT	1.95
6LD20	1.15
6LF6	7.50
6LJ8	2.50
6LQ6	4.95
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00
6P28	2.00
6Q7	1.75
6Q7GT	1.20
6R7G	3.15
6S4A	1.50
6SA7GT	1.35
6SC7	1.50
6SG7	1.35
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
6SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U8	1.15
6U8A	1.50
6V6GT	1.50
6X2N	1.00
6X4	1.50
6X5GT	1.00
6X5GTY	1.00
6X8A	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7AU7	1.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD12	0.65
11E3	55.00
12A6	3.95
12AD6	1.50
12AG8	1.50
12AL5	1.00
12AT6	0.95
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12AU7	0.65
12AV6	1.95
12AV7	2.50
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	4.50
12BA6	1.50
12BE6	1.95
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12DW7	2.50
12E1	17.95
12E14	38.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J7GT	3.50
12K5	1.95
12K7GT	1.50
12K8	1.95
12SA7GT	1.95
12SG7	4.75
12SH7	1.95
12SK7	1.95

12SJ7	1.50
12SQ7GT	1.95
12SR7	2.50
12SQ7GT	1.50
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	145.00
13EM7	3.50
14S7	1.95
17DW4A	2.95
17EW8	0.95
17JZ8	4.50
18D3	6.00
19AQ5	3.50
19AU4GT	2.50
19G3	17.00
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21LU8	2.50
24B1	39.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
29KQ6	6.50
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6C	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
83	8.50
84	3.00
85A1	6.50
85A2	1.50
90AV	10.00
90C1	2.70
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	12.50
95A1	6.50
108C1	1.50
150B2	6.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
211	33.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	4.50
572B	65.00
705A	8.00
708A	8.00
715C	45.00
725A	275.00
803	14.95
805	39.00
807	1.95
810	85.00
811A	15.00
812A	35.00
813	23.50
829B	14.50

833A	95.00
866A	4.50
872A	27.50
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00
958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	4.50
2050	3.95
3545	4.00
404A	10.95
927	15.00
1927	25.00
4212E	250.00
4313C	4.00
4328D	9.00
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5687	4.50
5692	3.50
5696	3.50
5704	3.50
5718	6.15
5725	2.50
5726	1.50
5727	1.95
5749	2.50
5750	1.85
5751	2.95
5763	4.95
5814A	3.25
5829WA	6.50
5636	5.50
5678	7.50
5840	3.50
5842	11.00
5847	10.95
5879	8.50
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5965	2.25
6005	1.85
6012	16.00
6021	3.65
6057	2.50
6058	3.95
6059	3.75
6060	2.25
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	8.50
6080WA	9.50
6132	10.00
6136	2.50
6146B	9.50
6157	2.50
6158	3.20
6201	6.45
6205	6.95
6211	2.50
6267	4.50
6350	3.50
6360	4.50
6386	14.50
6545	8.50
6550A	10.95
6688	6.50
6870	11.50
6887	9.50
6883B	9.95
6973	5.95
7025	2.50
7027A	4.50
7032	2.00
7059	2.50
7167	3.95
7189	3.50
7193	7.50
7199	7.50
7247	2.95
7360	13.50
7462	15.00
7475	5.00
7486	125.00
7527	85.00
7551	6.95
7558	9.45
7586	15.00
7587	29.50
7591A	4.95
7609	47.00
7733	5.50
7788	25.00
7868	3.95
8012	15.00



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by Andrew Ray B.Sc., Intelligent Interfaces Ltd

Case study in interface design

Development of the Syscon 6 interface for using Commodore peripherals with a BBC computer illustrates the sometimes overlooked ratio between software and hardware design effort.

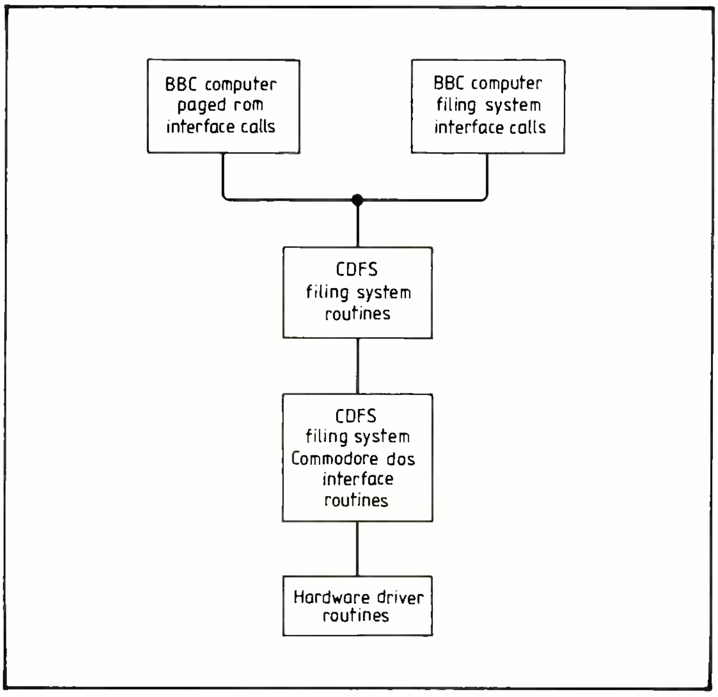
It is a popular misconception that microcomputer interfaces are a complex plug and socket and that their design time is equal to the time taken to make the necessary electrical connections.

The Oxford dictionary describes an interface as an area of interaction between two systems. This wider definition becomes more applicable as systems grow in complexity, particularly when distributed processing is involved. As the area of interaction grows, emphasis moves from interface hardware to interface software; this description of the design of Syscon 6 is an illustration of this trend.

Syscon 6 allows Commodore disc drives and printers, now often found collecting dust in educational establishments, to be used with the BBC microcomputer. Firmware makes sure that the user does not notice any difference between using the Commodore peripherals and the disc-drives and printers normally used with the BBC computer. The resulting interface software gives increased data storage capacity, data security and flexibility.

There are two separate interfaces in Syscon 6; both can function concurrently as data is transferred to and from the disc in blocks and to the printer a line at a time. Firmware for the printer interface allows Commodore printers to print a normal upper and lower case character set.

Fig. 1. **Software sections of the interface for controlling Commodore peripherals using a BBC computer.**



Commodore disc-unit design

To appreciate the design of the disc interface, CDISK, one needs to understand both the Commodore disc unit and the BBC computer disc filing system, the d.f.s.

Over the years, Commodore has produced a variety of disc units, all designed as intelligent subsystems with two microprocessors. One processor unit, described as the file-interface controller, handles communication with the host computer through the IEEE488 interface. The second processor acts as a disc controller. The processors communicate through 4Kbyte of shared memory used for data data buffering and operating-system work space.

The Commodore disc operating system, or dos, is in the disc unit. All versions support primitive direct-access commands such as those for reading or writing a block of data, and later versions support a relative-record filing system. However, random-access filing systems have always had to be supported by application programs running on the host computer.

Discs are formatted such that outer tracks have more sectors than those closer to the centre. Tracks are reserved for a directory of files and a block-allocation map, or bam. The dos includes error-checking, e.g., read-after-write verification.

Disc operating system commands are sent by the computer to the disc unit as strings of Ascii characters. When a dos command has been executed an error-status message, also a string of Ascii characters, can be read by the computer.

BBC computer d.f.s. design

The BBC-computer disc filing system is totally integrated into the main computer. An 8271 disc controller is used with software in a 'paged' rom. This simple but effective design results in rapid data storage and retrieval. Discs are formatted with ten sectors per track which gives 100Kbyte per side for a 40-track drive or twice that for an 80-track one.

There are two distinct areas of interaction between the BBC computer operating system and the d.f.s. The obvious one is the command-line interpreter. After the d.f.s. has been selected by *DISC, other commands such as *BACKUP, *COPY, etc., are passed by the operating system to the filing system for interpretation and execution.

The less obvious interface is used by languages and application programs written in assembly-language. These make use of seven specific operating-system calls for reading/writing data bytes, filing information etc., and 'OSWORD' calls.

Data in a disc file is always stored contiguously. To retrieve a file, the only information required is the file start sector and length. Disadvantages of this storage method are that disc surface faults cannot be tolerated and that frequent file writing and deletion can cause empty gaps between files. To fill the gaps, a *COMPACT command has to be used.

The first two sectors on the disc's first track hold d.f.s. catalogue information. Only having two sectors limits the number of files per disc side to 31 and file names to seven characters, which can be irritating. All files are treated by the d.f.s. as a sequence of bytes. Extremely fast random access filing is achieved by using a pointer.

CDISK interface design

After studying the Commodore dos and Acorn d.f.s. it was possible to draw up the Syscon 6 CDISK filing-system specification. CDISK would have to have all the facilities of the Acorn d.f.s. and, to be of use in educational establishments, it would have to be capable of transferring programs written on a BBC computer with the Acorn d.f.s. to a computer with CDFS without modification.

Commodore dos only fully supports sequential files, so most of the design effort went into a random-access capability for CDFS. Following aspects of the disc unit design were carefully considered.

Data transfer speed between the host computer and disc unit is limited for two reasons; the disc unit uses software for IEEE488 source and acceptor handshakes, and disc commands are sent as Ascii character strings rather than as a sequence of binary bytes. However, as the disc unit is an intelligent subsystem, the number of commands needed is reduced. Some operations, such as formatting a disc and searching for named files require only a single command.

We considered that the effects of limited data transfer rate on data storage/retrieval time could be reduced by efficient communication. This was achieved by buffering in the host computer and transferring data to the disc unit in blocks.

Efficient filing system operation depends on how data storage is organized on the disc. After considerable thought, we chose the following method. CDFS catalogue information, load address, execution address, etc., is stored in a dos sequential file.

These sequential catalogue files are referred to by an extended file name which CDFS pads to 14 characters using spaces. The file name is preceded by the CDFS directory character and followed by a space if the file is unlocked or an 'L' if the file is locked. Each catalogue file contains up to eight two-byte track/sector pointers to blocks which can, in turn, contain up to 128 two-byte track/sector pointers to the data blocks. Thus the maximum size of a CDFS file is 8×128 blocks or 256Kbytes, provided that the drive can hold that amount.

During operation, CDFS maintains a pointer for each open file which points to the next byte to be read from or written to. CDFS determines the data track/sector list block, the data block and the position of a byte in the data block from the pointer.

Commodore dos sequential filing system commands and facilities are used to locate and update the catalogue file while direct-access commands are used to read and write data track/sector list blocks and the data blocks themselves. The dos block-allocation map, bam, is automatically updated during sequential file operation. By using the dos block-allocate and block-free commands during read and write operations, CDFS ensures that the allocation map is kept up to date, avoiding conflict between sequential and direct-access operation.

General catalogue information is stored by CDFS in a sequential filing system.

The drive type is used to avoid dos directory tracks and determine data-block size. CDFS formats a disc using the dos NEW command and then writes the system files to it. Backup is carried out by formatting the disc in the destination drive and then copying each file in turn from source to destination.

DOS read-after-write verification identifies a bad block and CDFS then excludes it from further use, allocates the next free block and repeats the write operation. The interface system is flexible in operation as the sequential catalogue files, data track/sector list blocks and data blocks can be stored anywhere on the disc, allowing a file to be extended at any time. Optimal use of disc space is made as blocks are only allocated as required and freed when not.

The maximum number of files on the disc is limited only by the dos directory capacity and ranges from 151 to 224, depending on the disc-unit model.

CDFS operation

This is how a file is created and written to using CDFS

Opening the channel. This is done in response to an OSFIND call normally resulting from use of a Basic OPENOUT function. CDFS first checks availability of an open channel, checks file name validity and checks that there is no previously opened channel to a file of the same name. It then reads the system file if there are no channels already open to the same disc. During this operation, the disc is initialized if necessary and the write-protection state is determined. Next, CDFS determines whether the file exists, and if so, checks that it is unlocked and deletes it. Lastly, it writes the default catalogue file on disc to reserve space.

Reading and writing data. To increase speed, CDFS maintains two buffers for each open file in the computer memory. The first contains a section of the data track/sector pointer block and the second a data block. Whenever the pointer crosses a data-buffer boundary, the data block is written to disc. In the same way, whenever the pointer crosses the boundary of a data track/sector, the data track/sector pointer block is written to disc. The least-significant pointer bits specify the next position in the data buffer to be written to. After each write operation, the pointer is updated.

Closing the file channel. Here, the CDFS writes any valid data and data track/sector buffer to disc then erases the default catalogue file and writes the current catalogue file. Lastly, it erases then writes the current system file if no other disc write channels are open.

Having decided how data was to be organized on the disc and determined filing-system operation, the software design could be completed. The software sections are clearly defined. There are two interfaces to the BBC computer machine operating system (mos). First is the paged-rom interface which handles auto-start and auto-boot operations, OSWORD calls and commands not recognized by the mos, such as *CDISK and *CPRINTER.

The second interface handles the seven filing-system calls, OSFIND, OSBPUT, OSBGET, OSGBPG, OSFILE, OSARGS and OSFSC. Most of the commands used by CDISK are similar to those provided by the Acorn d.f.s., but some offer addtional features and there are some extra commands like *BLOCK.

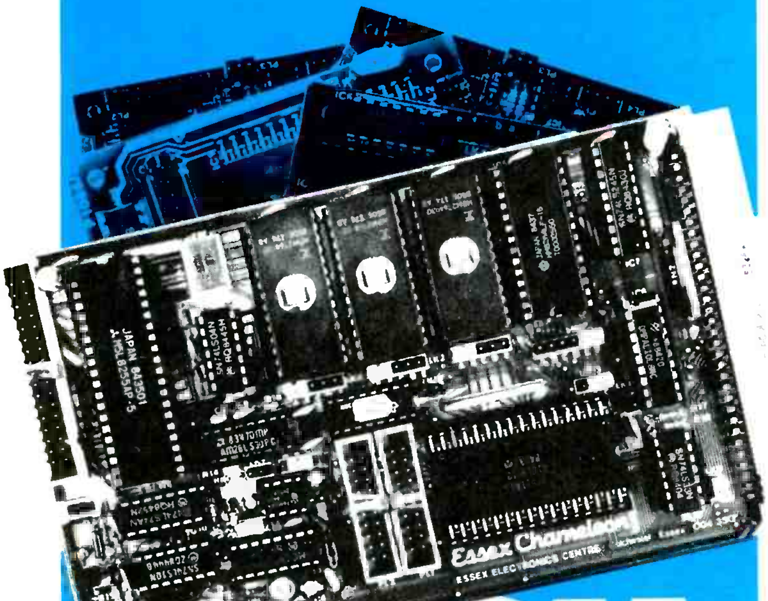
Conclusion

For the sake of brevity, I have not included a detailed description of the software. Nevertheless, I hope that you have gained some appreciation of the ratio of software to hardware design time, which in this case was around 100:1.

In any interface design, this ratio is a function of the mismatch between the interfacing systems. In this case, the mismatch was considerable. Although this is only an interface between a single-user microcomputer operating system and an intelligent disc-subsystem capable of undertaking one task at a time, the area of interaction between the two systems is large.

Table 1. CDFS catalogue file format. Catalogue information, load address, execution address, etc., is stored in a dos sequential file.

byte	contents
&00 - &03	load address, l.s. byte first
&04 - &07	execution address l.s. byte first
&08 - &0B	extent l.s. byte first
&0C - &0F	attributes
&10 - &1F	track/sector list block



Switched-mode power supply

by K.L. Smith Ph.D.

Last part of the instructional series on d.c. supplies is a practical description of a switcher to provide 13.8V at 13A.

In this, the last part of the Power Supplies series, I describe a flyback switcher — again to show how the theory is applied and to see if it works. There should be enough detail to enable anyone interested to gain some hands-on experience and perhaps embark on a design of their own.

I have deliberately chosen cheap, easily obtainable components. You can find the switch (a BU126) for less than a pound and the control chip (TDA2640) for a couple of pounds or so, in the advertising pages. The technology is therefore a straightforward application of the ideas to produce the following specification:

- power output 180 watts (13.8V at 13A)
- flyback mode, double-wound choke
- switching frequency, 16kHz.

I chose a flyback-mode circuit to introduce the slightly more complex detail necessary for its design: a forward converter should be simpler, should you with to experiment with one, although a storage choke is required, so there is probably not a lot of simplification in it.

Establishing parameters

The two important formulae required are quoted:

$$VA = \left(\frac{A_wF_wP_w}{\rho_c ml_wF_R}\right)\cdot\frac{\sqrt{2}}{\left(1+\frac{\eta^2}{3}\right)^{\frac{1}{2}}}\cdot\frac{\eta}{(1+\eta)}\cdot\hat{B}A_{core}f \quad \ldots (10A)$$

and

$$\frac{V}{Turn} = \frac{2\eta}{1+\eta}\cdot\frac{\Phi_{max}f}{\delta_{min}} \quad \ldots (9A)$$

Table 1 lists the quantities with the values relevant to the operation of this design.

The choke

A core large enough to store the energy (or in other words, handle the throughput) is required. Two Mullard Ferroxcube-E cores type FX3609 were chosen and should be ample for P_o = 180W. The dimensions of the cores used are given in Fig. 1(a) and (b). The ferrite material is type A16 (3C8) and the absolute maximum flux density allowed before saturation at 100°C is just over 300 milliteslas. The pair of cores can handle the required absolute peak flux of 126mWb.

Using the data collected, the calculation proceeds via the two equations. Throughput, VA =

$$\left(\frac{180\times10^{-6}\times0.5\times7.5}{1.7\times10^{-8}\times1.3\times125\times10^{-3}\times1.4}\right)\cdot\frac{\sqrt{2}}{\left(1+\frac{0.4^2}{3}\right)^{\frac{1}{2}}}\cdot\frac{0.4}{1.4}\cdot73\times10^{-6}\cdot16\times10^3$$

$$= 190\ VA$$

This result indicates that the required 180 watts should be comfortably obtained.

The second equation gives the required volts per turn to support the peak flux, at f = 16kHz. From this the number of turns on the primary is easily found. In practice, I used 4 volts per turn and with an input level of 360 volts, this rounded off to 90 turns for N_p.

In a flyback circuit, where the mark to space ratio is not unity (i.e. our "8" differs from 0.5), the output voltage at any secondary is not simply the turns ratio difference. Therefore to find the secondary turns we must use

$$\frac{V_i}{V_o}\cdot\frac{\delta}{1-\delta} = n \quad \ldots (1)$$

This gives a ratio of 15.1:1 at the nominal V_i of 340V and output of 13.8V, and requires 6 secondary turns. I wound half of these beneath the primary and the other half on top — with a *non-shorting* copper foil screen between each winding. The secondary has to handle 13 amps and a bunched winding is the best answer. I used 13 strands of 24 s.w.g. copper enamelled wire, all in parallel on each 3-turn half-secondary.

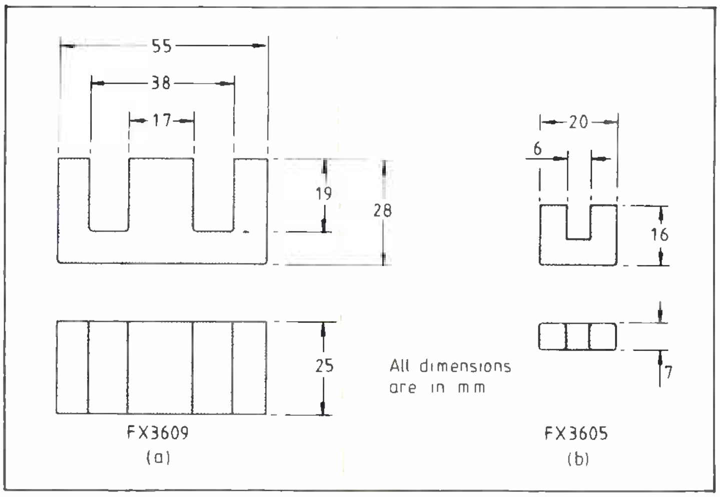
One or two points arise in the design. The first is the difference between the absolute maximum flux allowable in the core, and the working peak flux under normal circumstances. A safety factor is given by:

$$\frac{\hat{\Phi}_{max}}{\hat{\Phi}} = 1.72$$

$\hat{\Phi}_{max}$ was used in the volts per turn expression. The normal $\hat{\Phi}$ appears in the throughput formula.

There is a tertiary winding placed on the choke for sensing

Fig. 1. **Dimensions of Mullard Ferroxcube Cores. At (a), type FX3609 as used in the power choke. At (b), the small "U" cores type FX3605 employed in the driver transformer. Both are made from type A16 (3C8) material, $\hat{B}_{max}$ = 310 mT, μ_a = 1000.**



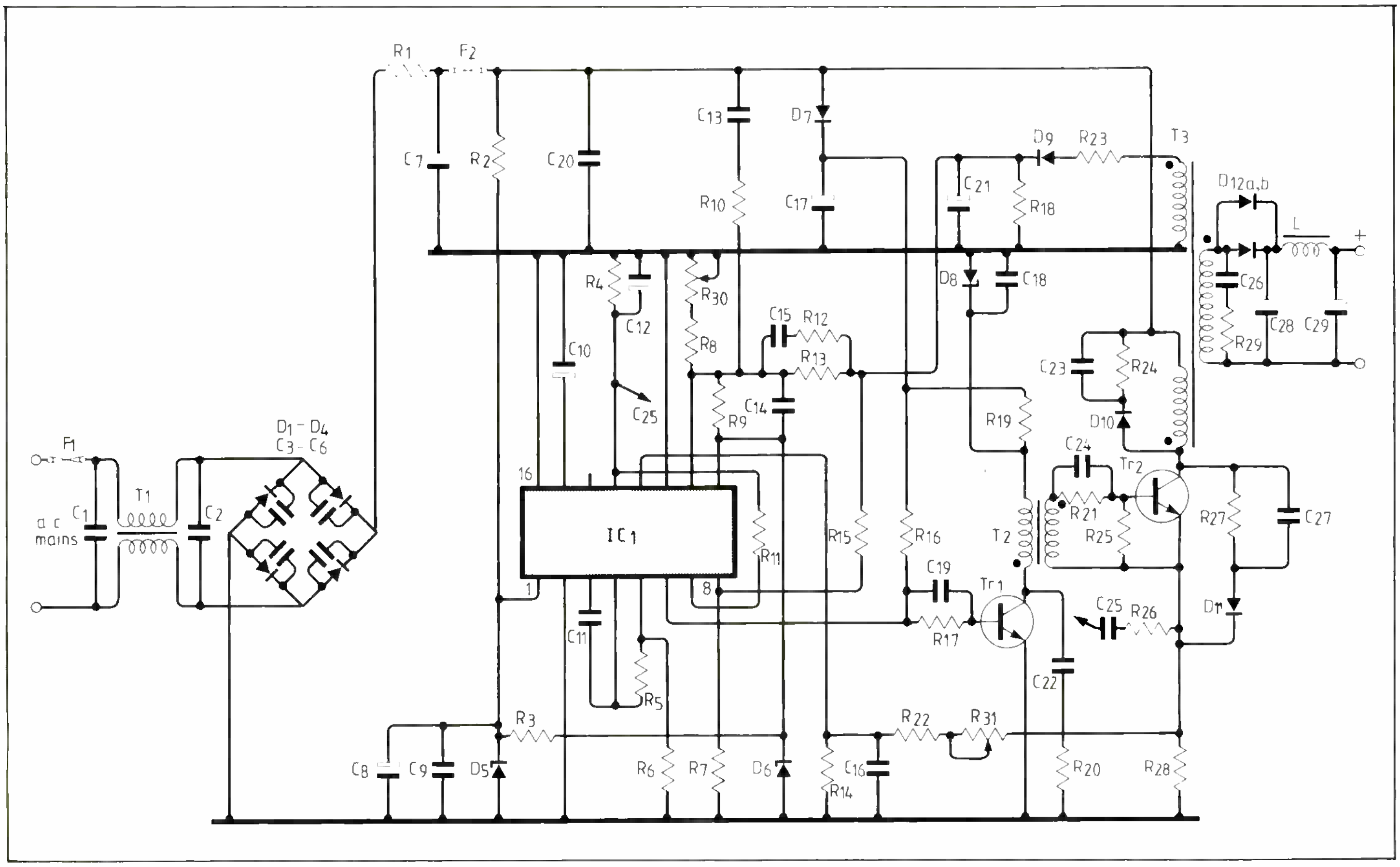


Fig. 2. **Circuit diagram of power supply.**

the voltage level to enable the feedback system to control the output stability. The flyback choke factor η was chosen to be 0.4: thus, full control is maintained down to a power output of a little less than half the 180 watts. At that point the current in the choke winding falls to the critical zero value and the control circuit detects this and drastically alters the factor to keep the output fairly level. But much stability is lost, and the output smoothing is liable to worsen. Also, the mode of control changes, and an audible whine may arise — from the magnetostriction in the ferrite core.

There is a large d.c. component in the windings of the power choke. The optimization of the a.c. performance (i.e. the inductance) therefore requires a gap in the magnetic circuit. As I mentioned in earlier articles, Hanna curves are usually employed to estimate this. My approach was "experience tempered with experiment", in other words, I slid the cores apart very carefully under power — and watched the slope on the current wave being monitoring with an oscilloscope until it showed the shallowest decline. (This was difficult, as there was considerable magnetic pull.) I then inserted paxolin shims of the required thickness.

Table 1. Design parameters and quantities for 180 watt flyback switcher

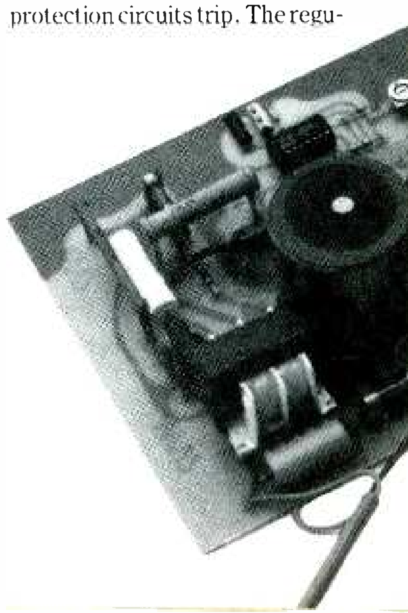
f	switching frequency	16 kHz
P_c	resitivity of copper at 20°C	$1.7\times10^{-8}\Omega m$
m	resistivity increase with temperature, (ref. 20°C)	1.3@20→100°C
F_R	A.c resistance: d.c. resistance of windings (extra factor in 10A)	1.4
A_w	cross-sectional winding area (not window area)	$180\times10^{-6}m^2$
F_w	winding copper factor	0.5
l_w	mean turn length	$125\times10^{-3}m$
$\hat{B}_{max}$	absolute maximum peak flux density	300 mT
A_{core}	magnetic core area	420 mm²
δ_{min}	duty factor (mains high)	0.36
δ_{max}	duty factor (mains low)	0.47
δ	duty factor (normal)	0.38
η	minimum to maximum P_o chosen to be. . .	0.4

Operation

The full practical circuit is shown in Fig. 2, with the printed circuit layout in Fig.3. The TDA2640 s.m.p.s. control chip I chose is being replaced by later types, such as the TDA1060, in up-to-date designs. Briefly the 2640 operates as follows (see Fig. 4),[1].

A voltage of +12V is required on pin 1. I derived this via a Zener diode (D_5) from the main d.c. line. If the voltage falls below +8V on pin 1 then the protection circuits inside will switch off the supply. Pins 3,4 and 5 are the oscillatorcontrol component connections. C_{11}, R_5 and R_6 produce a switch rate of 16kHz here. The pulse width modulated output appears at pin 6, feeding the base of the drive transistor, Tr_1. Pin 7 is a connection for "low feedback protection". Resistor R_{11} connected to pin 13 reduces the duty cycle to a small value if there is a loss of voltage on pin 10.

It is important to detect overvoltage. A sample is taken to pin 8 via a rectifier network from the sensing winding on the choke. The potential on pin 8 is compared with the reference voltage on pin 9 from the 6.2V Zener (D_6) and if the level is exceeded, the protection circuits trip. The regu-



lation control system operates via pin 10. Again, the reference is the voltage on pin 9 and the pulse-width modulator varies the drive waveform; i.e. the factor δ to maintain level output. If you look at the circuit in the feedback loop, a number of actions can be seen: R_{13}, R_8 and R_{30} supply the sample. The present RV_1 sets the level of output voltage. The combination C_{15} and R_{12} improves the transient performance: C_{13} and R_{10} is a feedforward network taking a sample of mains hum from the main d.c. feed to enable the modulator to compensate for it. Finally there is a shunt network, C_{11} R_9, which sets the gain of the loop and obviates possible instability.

Pins 11 and 12 sense any over-current through the switch — and turn off the circuit to protect it. The sample is taken across the 1 ohm resistor, R_{27}. The threshold is set by R_{31}.

The components C_{12} and R_4 from pin 13 to the common line form a slow-start circuit. When switching on, the drive to the switch is gradually increased, reaching full drive after a couple of seconds. Thus, inrush surges are avoided.

Finally, the chip incorporates a fault-condition counter. The number of restarts counted before the circuit is turned off permanently is set by C_{10} on pin 15: after the final trip, the whole supply must be turned off, then on again to restart. Pin 14 is a remote-control point, left floating here.

Components

C_1	0.1 µF 600V	R_1	2R7 8 W	D_1	
C_2	0.1 µF 600V	R_2	22k 5 W	D_2	2 A
C_3	1 nF	R_3	5k6	D_3	Mains Bridge
C_4	1 nF	R_4	390k	D_4	
C_5	1 nF	R_5	39k	D_5	12 V zener
C_6	1 nF	R_6	10k	D_6	6V2 zener
C_7	225 µF 380V	R_7	5k6 2%	D_7	1N4004
C_8	10 µF 10V	R_8	4k7	D_8	75 V zener
C_9	0.1 µF	R_9	1k	D_9	BY206
C_{10}	10 µF 25V	R_{10}	6M8	D_{10}	BY210
C_{11}	1.7 nF	R_{11}	82k	D_{11}	BY210
C_{12}	1 µF	R_{12}	10k	D_{12}	a,b BYV32
C_{13}	100 nF	R_{13}	27k		
C_{14}	1 nF	R_{14}	470R	Tr_1	BSX21
C_{15}	4.7 nF	R_{15}	27k 2%	Tr_2	BU126
C_{16}	4.7 nF	R_{16}	150k	IC_1	TDA2640
C_{17}	25 µF 380V	R_{17}	1k		
C_{18}	10 nF	R_{18}	3k3	T_1	mains filter
C_{19}	8.2 nF	R_{19}	22k 5 W	T_2	see text
C_{20}	0.47 µF	R_{20}	3k3	T_3	see text
C_{21}	4.7 µF	R_{21}	5R6		
C_{22}	100 pF	R_{22}	470R	L_1	10 µH
C_{23}	330 nF	R_{23}	33R		
C_{24}	1.5 µF	R_{24}	10k 9 W	F_1	2 A slow
C_{25}	1 µF	R_{25}	100R	F_2	1 A
C_{26}	1 nF	R_{26}	1k		
C_{27}	2.2 nF	R_{27}	2k2 9 W		
C_{28}	1000 µF 35V	R_{28}	1R 2 W		
C_{29}	1000 µF 35V	R_{29}	330R		
		R_{30}	4k7 preset		
		R_{31}	2k2 preset		

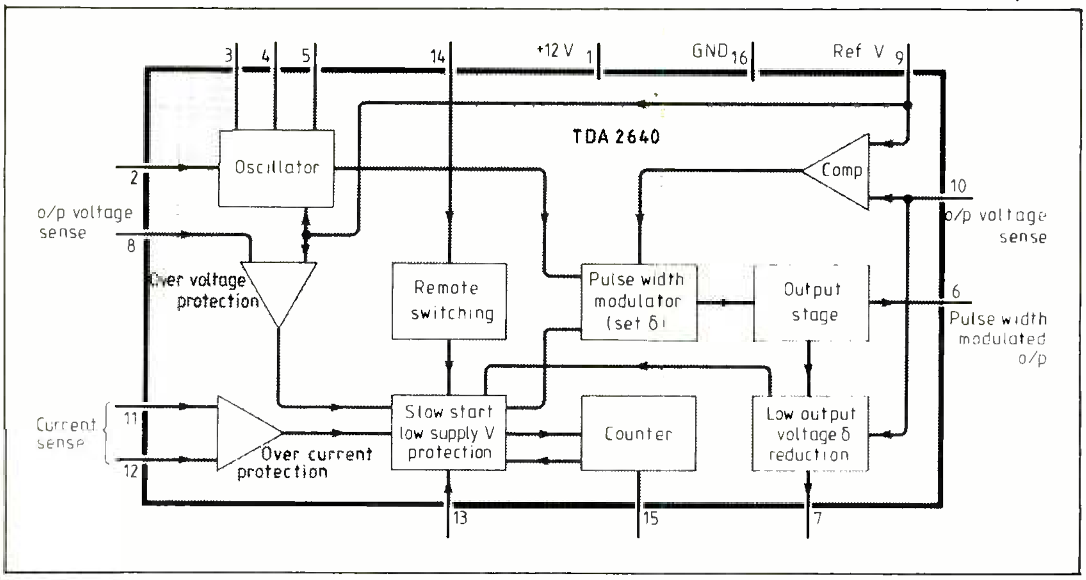
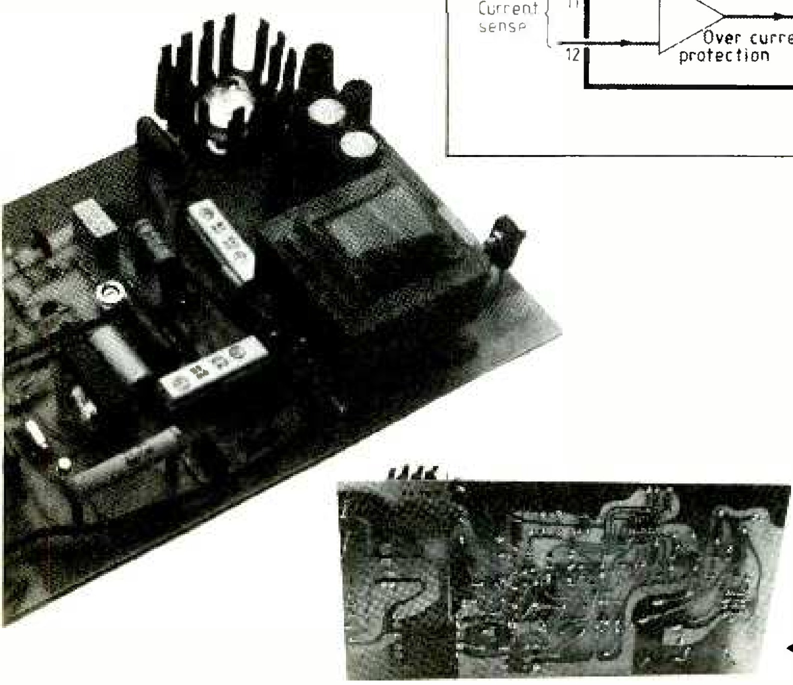


Fig. 4. **TDA2640 contains advanced control and monitoring circuitry, as outlined here.**



◀ Fig. 3. **Component side of the printed circuit board.**

Driving the switch

The variable-width voltage pulse from pin 6 of the control chip requires converting into the appropriate current-drive waveform to operate the BU126. I discussed the reasons, and how the fast turn-on and reverse base-current turn-off waveform was produced, in part 5.

The driver transistor Tr_1 is a BSX21 and stores energy in the

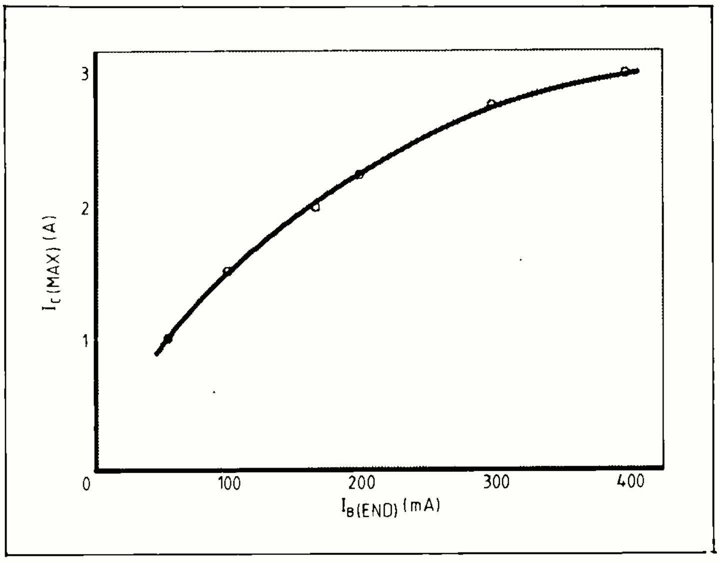


Fig. 5. **The maker's data regarding base current requirement, given graphically.**

References
1. TDA2640 Control IC for Switched-mode Power Supplies Mullard Technical Information No. 19.
2. Television Switched-mode Power Supply Using the TDA2640 White, L.M. Mullard Technical Communications, July 1975.

driver transformer (T_2) while the main switch is off. When the BSX21 goes off, the energy stored in T_2 turns on the BU126. The base drive current must therefore decline as the field collapses in T_2. The secondary inductance must be large enough to support the drive right to the end of the on time — the worst case is when the duty cycle is long and there is a minimum V_i. Output current of the BU126 *rises* over this time. Lowest forward base-current $I_{B(END)}$ must still keep the power switch into saturation up to the trailing edge. From the maker's data, the base-current requirement for the BU126 is shown in Fig. 5. If the quantities are known, the required inductance can be calculated from

$$L_s = \frac{(V_D - V_{BE} - I_B R_{21})\,\delta T}{\Delta I_B}$$

where V_D is the drive voltage, and ΔI_B is the current droop. Other symbols self-explanatory. At a very rough level, with V_D around 6 volts, ΔI_B 100mA, V_B one volt and δT, 22 μs, L_s works out at about 1mH. This agrees with maker's figures[2].

At turn off, the base current must decline, then reverse. The energy for the reverse base current is supplied by the leakage inductance of T_2.

Other components in the driver stage include C_{22} and R_{20} which underdamp T_2 as Tr_1 goes off. This speeds up the rise and produces a slight overshoot on the base drive waveform to the BU126. Components C_{18} and C_{21} increase the reverse base current at turn off and D_8 clamps the top of T_2 primary winding to prevents spurious turn-on pulses from reaching the output switch.

Driver transformer

The construction of T_2 is based upon a pair of FX3605 'U' cores (Fig. 1(b)). Its secondary was wound to have 0.8mH inductance, found from

$$L_s = \frac{\mu_0 \mu_a N_s^2}{C_1}, \quad \therefore N_s = 26 \text{ turns}$$

where μ_a is the amplitude permeability C_1 is the core factor for a pair of FX3605s. From maker's data, $\mu_a = 1000$ and $C_1 = 1.2\text{mm}^{-1}$. These 26 turns were wound outside the primary with 36 s.w.g. enamelled wire. The primary supported some 75 to 80 volts during the pulse, which was stepped down to a secondary level of 5 to 6 volts, giving a turns ratio of about 14:1. It was wound with 380 turns of 42 s.w.g. enamelled wire.

Snubber

The power transistor has to be protected from voltage pusles arising mainly from the leakage inductance of T_3. This is true especially for this circuit which has no energy-recovery winding on the choke. Components C_{23}, R_{24}, D_{10} and C_{26} with diode D_{11} perform this function — called in the USA "snubbing" circuits. Resistors R_{24} and R_{26} dissipate a large power and must be heavy duty types (9 W wire-wound).

Final output

The last operation is to rectify and smooth the available pulses of energy at the output winding of T_3: fast diode pair BYV32 is designed for this service. The total average current it can handle is 20A, which is plenty for this application. Output smoothing is achieved by C_{28} assisted by C_{29}, which are 1000 μF low-series-resistance types. The small (≈ 10 μH) choke L_1 reduces the high frequency "edges" likely in the output of a flyback s.m.p.s.: it was added empirically, not really designed into the circuit for optimum performance. Components C_{26} and R_{28} also help to damp transient edges at the output winding.

Finally, T_1, C_1, C_2 and the small capacitors around the diode bridge help to suppress interference flowing back into the mains. In a tightly controlled professional design, the level of mains-borne and directly radiated interference would have to meet the standards laid down, as I mentioned in part 1 of this series.

From page 48

However, as experience indicates, the difficulties do not end when the technological problems are solved and water becomes available for cultivation of food crops. It has to be anticipated that all soil will be completely infertile, without even a trace of humus being present; but again a possible solution can be seen in work done overseas on agricultural technology. At the beginning of the century, a British project was conducted in India on the production of compost, and in which, incidentally, bullock carts were used to crush tough, woody material before composting. In this instance the significance of composting lies in the fact that a variety of organic materials, particularly vegetable matter, into a form of fertile soil, with a high humus content, sometimes known as a compound manure, and strongly reminiscent of the Black Land (alluvial soil) of the English Fens.

Composting, described as low-cost biotechnology[1], depends for its action on bacterio-chemical conversion processes; and, as carried out in the UK on a domestic scale, using mainly kitchen waste, is virtually cost-free. It is therefore possible to envisage a large-scale operation being set up, initially in the UK, to produce compost for replacement of eroded soil in regions denuded of trees and vegetation generally.

Yet again, the problems are more than formidable, but the solutions are not beyond the bounds of possibility. Briefly, from the production engineer's point of view, composting is a long process (full conversion, even with accelerators, takes 6-9 months or more.) As seen by the farmer, however, this is a normal sort of time scale; and with the proposed scheme it might be possible to make use of the farmer's experience and yet evolve something more like continuous production by taking serially from groups of heaps graded according to age.

Also from the production engineer's point of view, handling poses a number of problems; but it would appear that advantage could be taken of existing agricultural practice and of the slow-moving nature of the process. Export to other countries by sea might well be done by means of converted oil tankers with the compost treated to make it more fluid, thus enabling existing pipeline delivery techniques to be used.

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1. Young, R.E.: 'Managing research and development', *Wireless World*, June 1985
2. Hooker, S.G.: 'Not much of an Engineer, Air Life Publishing Limited, Shrewsbury, England, 1984
3. Young, R.E.: 'Big-System automation and telemetry', *Wireless World*, July 1985

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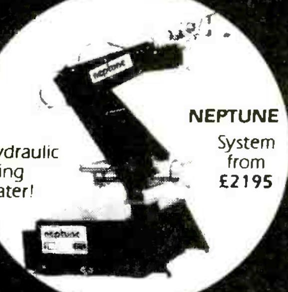

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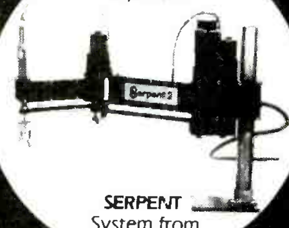

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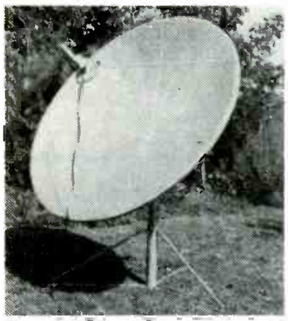

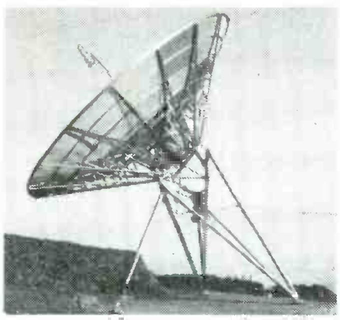

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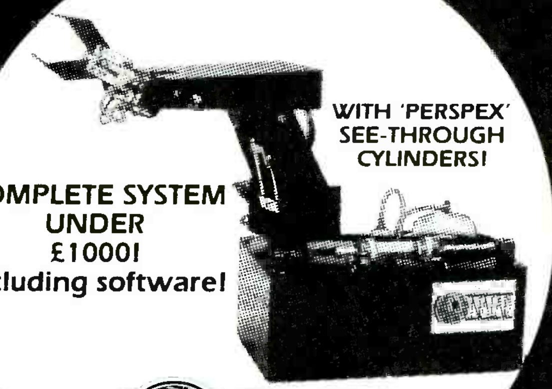

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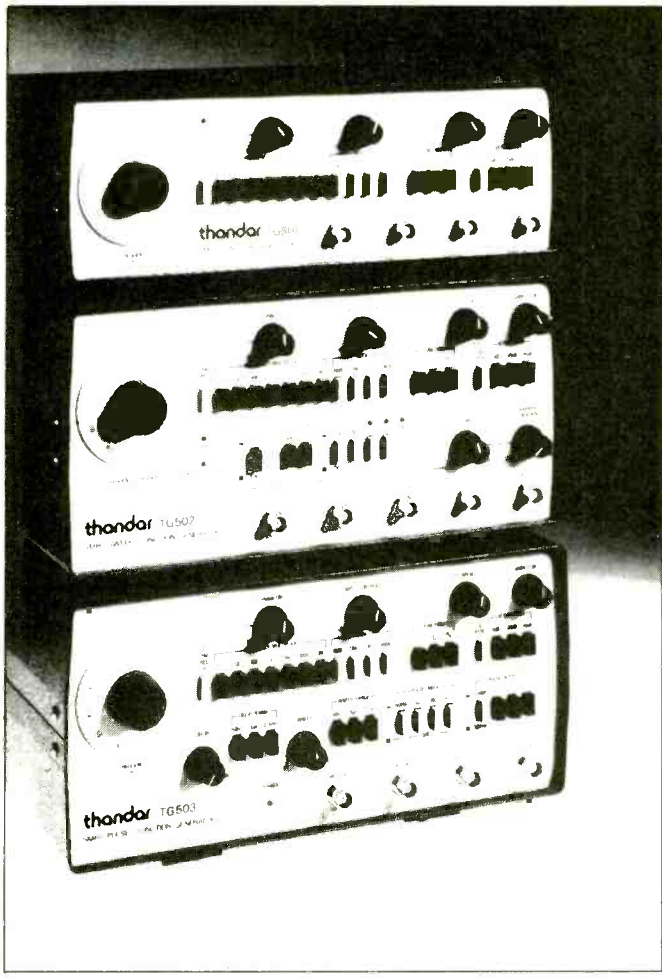

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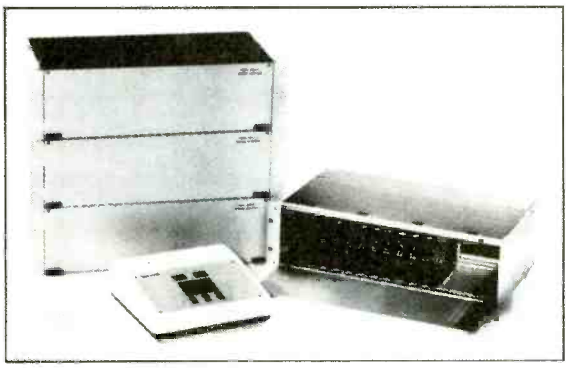

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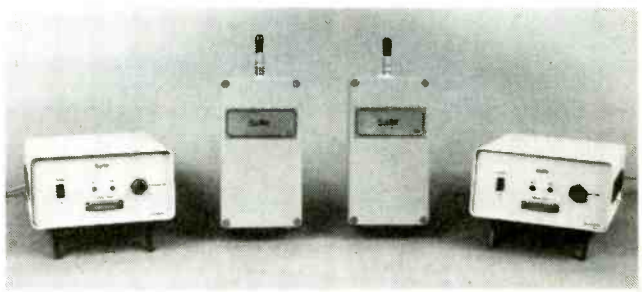

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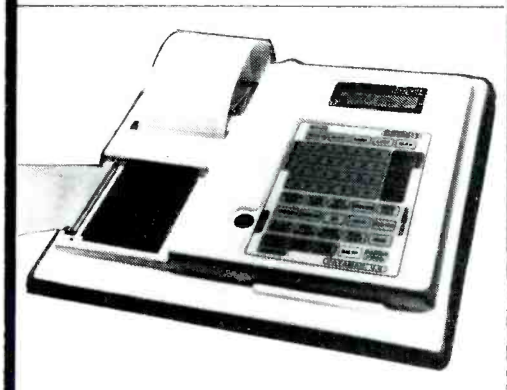

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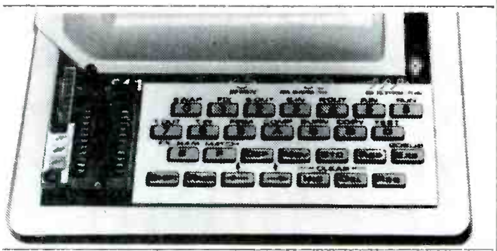

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Call cost calculator

by S.A. Cameron

To conclude this series, a description of the software and the reprogramming procedure.

The call costing procedure must take account of the many permutations of distance, connection charge and tariff.

For calls on the British Telecom system, inland and international, there are 13 distance zones, three charge rates and three modes. In all there are 117 combinations, but because of repetition they can be stored in only 80 data blocks. Each block consists of six bytes specifying cost and time; it may hold data for the initial call unit or for subsequent units.

If every call category had unique data for both initial and subsequent units, then 234 blocks would be needed. Fortunately, direct-dialled calls normally carry the same charge for initial and subsequent units and so the storage requirement is greatly reduced.

Consider now the calculator's 2Kbytes of ram. The combination look-up table occupies 0.5K and the data block area takes 1K, giving up to 256 two-byte combinations and 174 six-byte data blocks.

The look-up table reference consists of two bytes. One points to the address of the block specifying the initial charge unit, the other points to the block for subsequent units.

The system is sufficiently flexible to allow any combination of distance, rate and mode; for example there could be 16 Dists, four Rates and four Modes or 28 Dists, three Rates and three Modes and so on.

Now, how do we refer to the initial and subsequent units through the look-up table?

Each Dist, Rate and Mode has a binary number allocated to it (Fig. 1). Each of these factors has a limit — Lmdist, Lmrate and Lmmode — which is the number of possible distances, rates and modes: in our case, $0D_{16}$, 3_{16} and 3_{16} respectively.

The address of the initial data block reference in the look-up table is given by the formula

$$(\text{Start of look-up table}) + 2 \times ((\text{Dist} \times \text{Lmrate} \times \text{Lmmode}) + (\text{Rate} \times \text{Lmmode}) + \text{Mode})$$

Incrementing this address will give the block address reference for the subsequent unit.

The start address of the initial data block in the data block area can be expressed as

$$(\text{Start of data block area}) + 6 \times (\text{look-up block reference})$$

Consider an example. An operator-controlled call (normal charge) at peak rate over 35 miles costs 114p for the first three minutes and one-third of that for every succeeding minute. Accordingly, the bytes containing the initial unit information will be

Cost	Time
01 14 00	03 00 00

and those for subsequent units

Cost	Time
00 38 00	01 00 00

These groups can be stored anywhere in the call data block area. If we decide to make the initial unit block the first block in the area (that is, starting at $20F0_{16}$), then its reference will be 00_{16}. The subsequent unit block will be the second block, with a start address at $20F6_{16}$ and the reference 01_{16}.

Now we must place the references 00 and 01 in the look-up table. But where?

The value of Dist (for a call of over 35 miles) is 02_{16} and the Rate and Mode are also 02_{16}. We have the same Lmdist, Lmrate and Lmmode as before and so plugging into the formula gives

$$2000_{16} + 2 \times ((2{\times}3{\times}3) + (2{\times}3)+2) = 2058_{16}$$

as the address where the initial data block reference 00 is placed. The address reference for subsequent units, 01_{16}, is stored at location 2059_{16}.

Reprogramming

To reprogram for yourself, write down all the block information for initial and subsequent call units. Allocate a unique hexadecimal number to each unique block and put them in numerical order into the call data block area starting with block 00. Then using the formulas above, go through each combination and locate the look-up address for the unique data block references.

System parameters

System parameter bytes can be altered by the user to control the operation of the system. Parameters beginning with Sc (see Table 3) are the addresses to which the program will jump from the scrolling message procedure when the appropriate keys are pressed. This arrangement allows jumps to user-supplied routines within the ram space. It also allows expansion software to be accessed. The Adjump address is the jump location used on pressing Reset after a telephone call has been made. These locations are filled with default addresses on bootstrap loading.

Stsps and Cadast are the start address of the data areas. By default they are 2600_{16} and $20F0_{16}$ respectively. Initad is the start address used by the reprogramming routine: by default it

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He qualified as an instructor in Cadet Force signals while at the Duke of York's Royal Military School, Dover. Spare-time interests include music, tennis and writing poetry. He is publicity manager of the Brunel University Industrial Society.

Table 1: for the B.T. tariff structure. The unit can cost calls on any system in the world.

Rates:

0000	Cheap/economy
0001	Standard
0010	Peak

Modes:

0000	Direct-dialled
0001	Operator-controlled, lower charge
0010	Operator-controlled, normal charge

Special services:

0000	None selected
0001	Advice of duration and charge
0010	Credit-card call
0010	Fixed time call
0100	Personal call

Distances:

0000	Local
0001	Under 35 miles
0010	Over 35 miles
0011	Over 35 miles, low-cost routes
0100	Channel Islands
0101	Irish Republic, Isle of Man, calls to cellular radio subscribers
0110	International charge band A
0111	International charge band B
1000	International charge band C
1001	International charge band D
1010	International charge band E
1011	International charge band F
1100	International charge band G

26C0	Scjump1	Scroll message jump store for Dist key (binary)
26C2	Scjump2	– for Rate key (m.s.b./l.s.b.)
26C4	Scjump3	– for Mode key
26C6	Scjump4	– for Start/stop key
26C8	Adjump	On addition jump location
26CA	Stsps	Start of Sps data
26CA	Cadast	Call data start address
26CE	Initad	Initial address for reprogramming
26D0	Bootcnt	Bootstrap control (bit)
26D1	State	State control
26D2		spare
26D3	Flaprd	Flash period (binary)
26D4	Buzprd	Buzzer period for software monostable
26D5	Mklim1	Marker limit, seconds (b.c.d.)
26D6	Mklim2	– hundredths of seconds
26D7	Lmdist	Limit for distances etc. (binary)
26D8	Lmrate	e.g. Lmdist=10₁₆ if there are
26D9	Lmmode	16 distances to be considered
26DA	Lmsps	
26DB	Totcos1–4	Total cost store, m.s.b.–l.s.b. (b.c.d.)
26DF	Lstdist	Last distance store (binary)
26E0	Totuni1–2	Total units store, m.s.b.–l.s.b. (b.c.d.)
26E2	Scmask	Keyboard scan mask (bit)
26E3	Prthold	Port hold control
26E4	Cobuch	Cost base unit character, e.g. P for pence
26E5	Chxstr	Checksum store (binary)
26E6		spare
26EF		spare

Table 3: System parameters. Address are in hexadecimal form. Data format is shown in brackets.

points to the State control parameter at $26D1_{16}$.

Mklim bytes are used to change the end-of-unit indication limit. They are initially set to give 40 seconds.

The Lm— parameters are used for unravelling the packed characters in the call-type text area. They indicate the limit for call-type selection and are used for data area access calculations.

Totcos, Lstdist and Totuni are the storage bytesfor the running totals. On bootstrap they are all reset to zero.

Certain bits in the state control byte indicate to the system the position of the decimal point in the cost data, with respect to the least significant byte. All costs are expressed in the cost base unit (Cobu). An appropriate abbreviation — P for pence, for British users — is stored in Cobuch, $26E4_{16}$.

State byte bit1	State byte bit0	Cost format	Cobuch
0	0	999999	P
0	1	9999.99	P
1	0	99.9999	P
1	1	.999999	P

This decimal format applies also to the Totcos bytes. The floating-point format is used in the total cost and cost information display procedures. It features automatic suppression of leading zeroes and variable-justify for overflow.

The time and cost display has a fixed format and displays no decimals unless bit 1 and bit 0 are 10 or 11.

If a hundreds form of the base unit exists, as with the pound sterling, this will be indicated by bit 2 and the display will accordingly be subdivided into pounds and pence.

The special service (Sps) data is separate from the normal costing as it represents a distance-plus-service element which can be treated as a connection charge — a one-off additional cost to the call.

Each Sps cost occupies two bytes of memory at the base unit level. For British Telecom this gives a cost range of 0 to 9999p. Should the Sps costs be far more than this, State bit 7 can be set, multiplying costs by 100 to give a range of 0 to 999900p in 100p steps.

If no Sps service is required the facility can be disabled by setting State bit 5.

The data storage format follows the pattern used previously. A look-up table the length of Lmdist, accessed by the Dist parameter, has address references pointing to the start of Sps data blocks twice the length of the number of services available.

Each Sps binary number is the offset in this data block. It points to two bytes giving the cost of that service at that distance. The data blocks appear immediately after the look-up table.

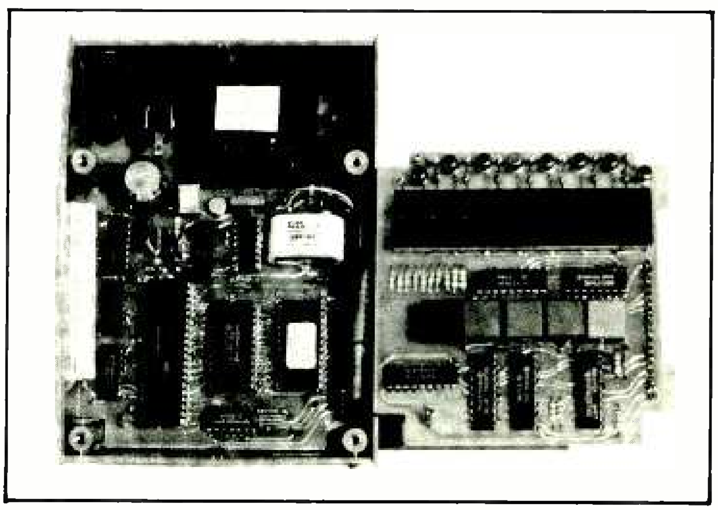
Programming procedure

Before switching on, remove the top panel of the instrument and link program pin D_7, to V+. Switch on. The display immediately shows the Initad address and data at that location in hexadecimal format. From here you can gain access to any point in the memory map. If the system crashes, this routine will always work so that corrections can be made.

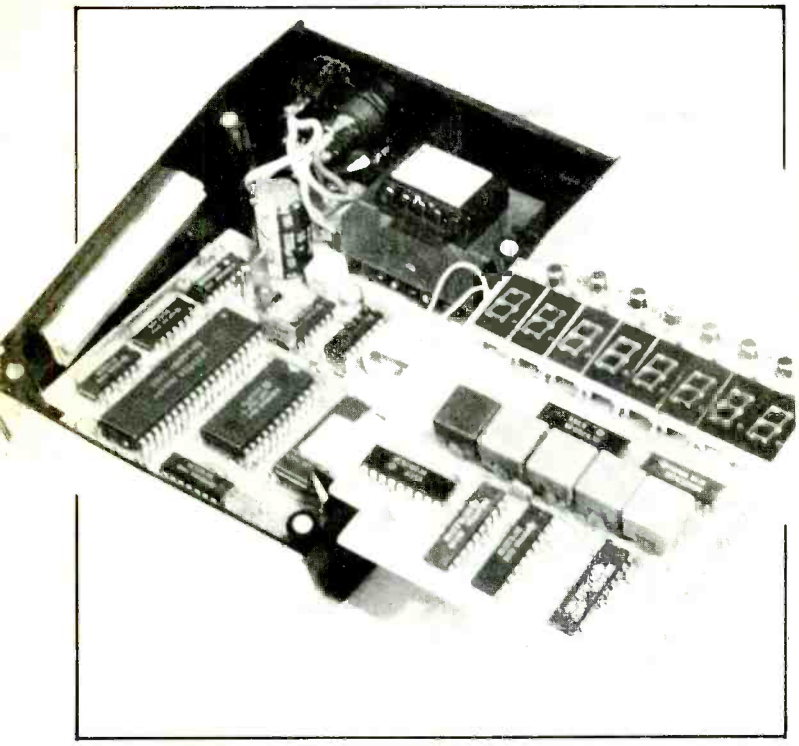
The flashing digit can be incremented by the Rate key or decremented by Dist. Carry is applied only in the case of changes to the least significant digit. The Mode key switches control from each

Table 2: ram map. Addresses are shown in hexadecimal form. System interrupt variables should be used with care as they contain important display counter values, divider and sequencer constructs as well as key-pad scanning information. Call type text is stored sequentially as Dist, Rate and then Mode texts in 3,2,2 character blocks respectively. Areas 2000-21D0, 2600-2630, 2680-277F are bootstrap-loaded from eprom if Bootcnt (26D0) does not contain AA_{16}.

2000–20F0	Look-up data bytes (up to 0.5K)
20F0–21CF	Call data blocks (up to 1.5K, relocatable)
21D0–25FF	Spare
2600–2630	Sps look-up table and data blocks (up to 0.5K, relocatable)
267F	Top of stack
2680–26BF	Introductory message text
26C0–26EF	System parameters
26F0–270F	Sps text (packed)
2710–274F	Call-type text (packed)
2750–27BF	Spare
27C0–27EB	System work-space
27EC–27F7	System interrupt variables (virtual interface start)
27F8–27FF	Display area



All the electronic components are mounted on two printed circuit boards which fit into a standard plastics box.



The instrument, based on a Z80 processor with 2K of ram, uses low-cost components thhroughout. The same hardware could be used to implement a general i/o controller, for example in a security installatioon or central heatiing system.

Table 4: System control. The status byte $27F3_{16}$ is used for inter-communication between the interrupt routine and the main program.

Bit	description	set (1)	clear (0)
0	Key pressed	new key	no key
1	Timer control	timer on	timer off
2	Auto-repeat	sustained	single key entered
3	New number indicator	intermediate number	same number
4	Correct addition sequence	add to total	do not add to total
5	Flashing (1Hz)	on	off
6	Buzzer with flashing	enable	disable
7	Buzzer trigger	trigger monostable	do not trigger

Table 5: Cost data and display formats are controlled by the State byte at address 26D1.

Bit	description	set (1)	clear (0)
0	Decimal point pos'n bit 0	see cost format table	
1	Decimal point pos'n bit 1	see cost format table	
2	Hundreds selection	No hundreds	hundreds
3	Decimal point	left-hand	right-hand
4	Total cost/total unit	enable	disable
5	Sps selection	disable	enable
6	Buzzer	disable	enable
7	Sps multiplier	1	100

digit to the next.

The Start/stop key toggles between address and data control. Changes made by the user are not transferred to the displayed address until Start/stop is pressed to switch to address control. Addresses are incremented and read automatically during data loading with the Start/stop key.

The Reset key returns the data at the current address to its old value. If Reset is held down then the address is reset to the Initad address.

When programming is complete the user should ensure that the control byte Bootcnt $26D0_{16}$ is set to AA_{16}. This will disable the bootstrap loader from overwriting the altered data on subsequent switch-ons.

The unit may now be switched off and the D_7 link removed.

The introductory message (which can be up to 64 characters long) may be changed by writing to ram locations 2680_{16} to $26BF_{16}$. The purpose of this message is to show the user whether the system still contains the updated cost and time data. It is therefore wise to include in it an issue date.

The byte Chxstr ($26E5_{16}$) contains a checksum of all the bytes from ram locations 2000_{16} to 2630_{16}. It is updated automatically on switch-on.

An indication of the total units used is displayed when the Start/stop button is pressed during total cost display. Reprogramming of these displays can be disabled by State bit 4.

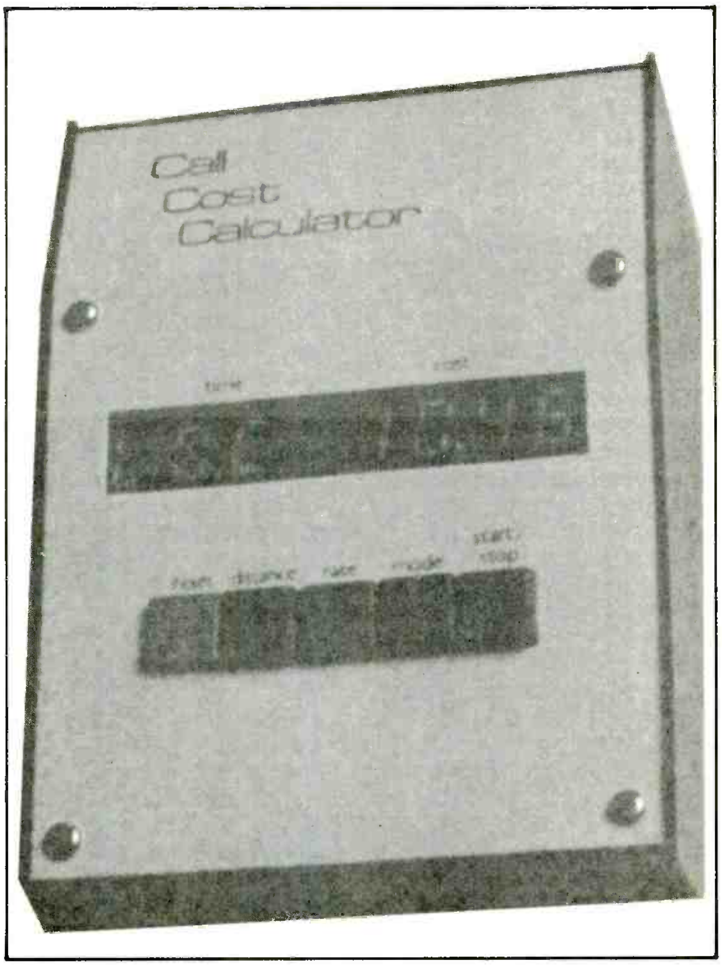
Display byte

The display character byte follows the standard bit-segment format. Bits D_0 to D_7 correspond to segments a to h (as shown in the display board circuit diagram in the August issue). Setting any bit causes it segment to light. State bit 3 indicates to the software whether the decimal points in use are right-hand or left-hand.

Assembler listing

An assembler list of the software is available for £3 from the author at 7 Donnington Court, Worthy Road, Winchester, Hampshire SO23 7BJ. The listing is in the form of a 48-page A5-size booklet and includes detailed notes and comments.

Component kits for this design are available from the sources given in the July and August articles.



The calculator displays elapsed time and cost of calls in progress and stores running totals in memory.

Polyphonic keyboard — 2

Digipoly's t.t.l. processor circuit and microcode program.

by D.J. Greaves B.A.

The instrument has two processors — an 8088 microprocessor for control functions and a t.t.l. processor for note generation. There are 18 instructions in Digipoly's microcode program, List1, which execute sequentially and then start again. The final instruction, INCV, causes the program to be run on each sound channel in turn.

Frequency of the master clock is divided by the length of the program and by the number of voices to give the sample rate at the audio output d-to-a converter. With a 5MHz master clock rate this is

$$5\,000\,000/(18\times8)=35\text{kHz}.$$

An assembler written for the microcode language in BCPL produced the code in List 1, but microcode can easily be manually assembled using the instruction set described last month.

The first three instructions of the microcode increment the P-register low-order section and the next three the high-order section. At address six, the wave from the waveform table is sampled and this is multiplied by the VOL, V register in the ramaining instructions. At address 16, the computed result is sent to the output d-to-a converter.

Each channel sends its output to the same converter and the value is latched there until the next channel sends a value.

This gives a discontinuous waveform. Summation of the eight channels into a single continuous audio wave is performed by the integrating behaviour of the analogue low-pass filter following the converter.

Features and software availability

Digipoly is an eight-note polyphonic digital musical instrument with a five-octave keyboard transposable over a nine-octave useful range. It includes

- Comprehensive envelope generator controls
- Vibrato and tremolo control
- Midi interface
- Hundreds of front-panel selectable waveforms
- Battery-maintained memory for 16 user-defined voices
- Rotary control for adjustment of many parameters

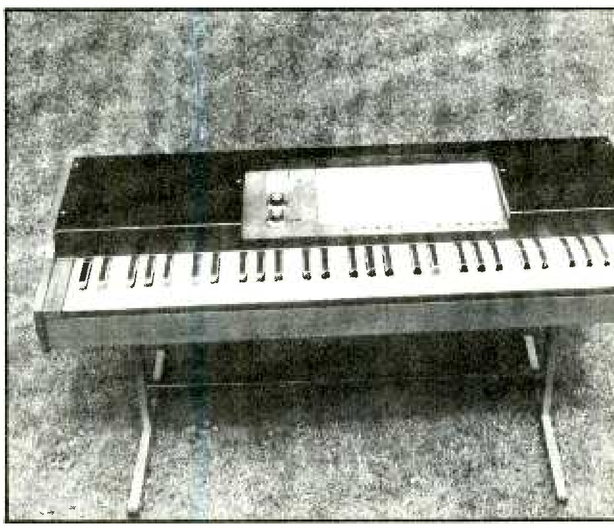
Note frequencies are not rigidly locked as in divider type organs. A detune facility introduces a variable amount of scale error.

Digipoly can be built for around £175 excluding case. Software is available iin various forms from the author at 5 Grovely Way, Crampmoor, Romsey, Hampshire SO5 9AX. A fifty-page listing of the 8088 source program is £3 and a 40-track disc for the BBC microcomputer, holding source, object and related files, is £4 (single density). Programmed 2764 eproms containing the 8088 object code and a bipolar prom containing the t.t.l. processor code are £6.50 and £4.00 respectively. Please include £1 for UK postage and make cheques payable to D.J. Greaves. Brave readers can obtain a copy of the hexadecimal listing by sending a large stamped addressed envelope and a cheque for £1.35 to our editorial offices. Please make this cheque payable to Business Press International.

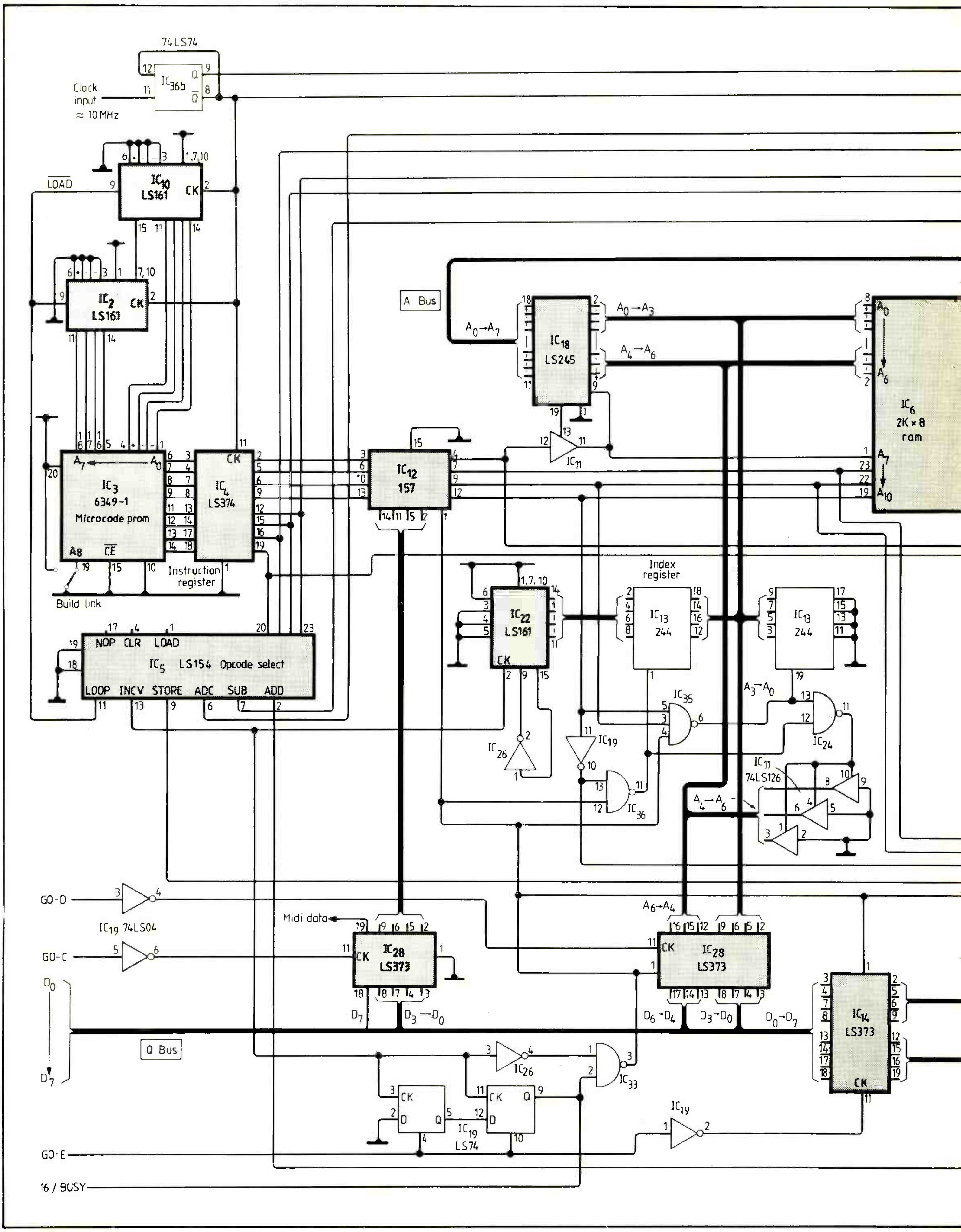
List 1 **Microcode of t.t.l. processor is only eighteen bytes long.**

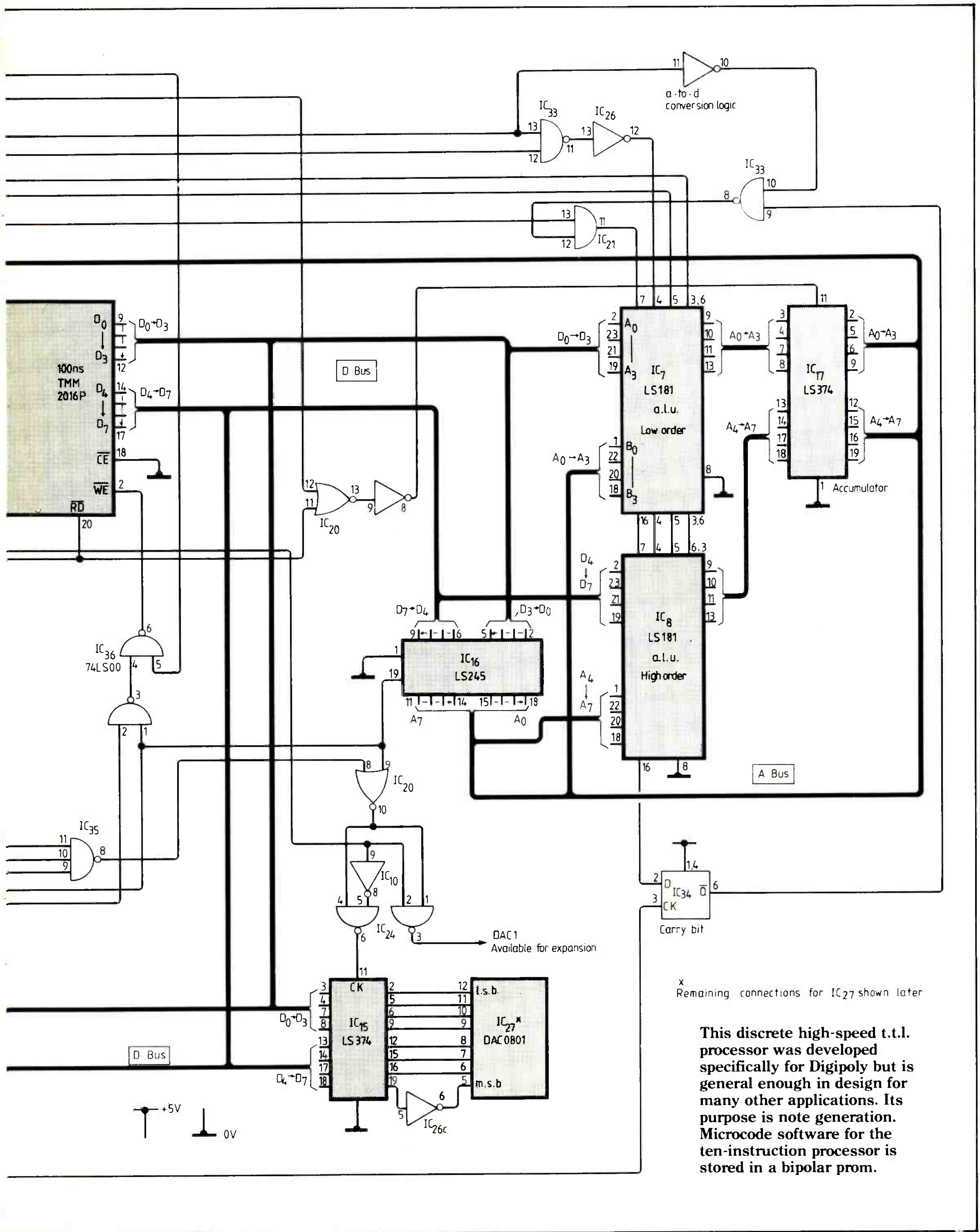
```
        *===================================================*
        * Microcode software for the DigiPoly TTL processor. *
        *===================================================*
        *
        * a) This version uses the wrap around on the V
        *    register to set the number of oscillators.
        * b) The instuction after LOOP is assumed to execute.
        * c) The HOST instruction is assumed to be performed
        *    as a side effect of the INCV instruction.
        *
        *===================================================*
        *
        * The multiplication is performed using a quarter
        * squares algorithm.  The amplitude value is 0..63 and
        * the waveform table ranges -64 to 64.
        *                        2          2
        * A x B x 4 = (A + B)   - (A - B)
        * The square table is indexed -128 to + 127
        * and gives values in the range 0 to 63
        *
00 00   LOAD   PL,V        get low order part of note phase
01 12   ADD    FL,V        add on the frequency (Intergrate)
02 80   STORE  PL,V
03 01   LOAD   PH,V        repeat with high order
04 53   ADC    FH,V        including the carry from the low order
05 81   STORE  PH,V
06 0A   LOAD   WV,A        look up the result in the waveform table
07 8F   STORE  E3
08 04   LOAD   VOL,V       get the amplitude of this oscillator,
09 6F   SUB    E3          take the difference,
0A 08   LOAD   SQ,A        and square it.
0B 8E   STORE  E2          Save in register 2.

0C 04   LOAD   VOL,V       Now calculate
0D 1F   ADD    E3          the sum of them,
0E 08   LOAD   SQ.A        square the answer,
0F 6E   SUB    E2          plus the square of the difference
10 86   STORE  DAC0        giving the answer.
11 A0   LOOP
12 B0   INCV               move to next voice and perform HOST
        *                  instruction.
```



The large circuit has left little space for text in this issue. We hope to find room for more description in the next article which includes details on the Midi bus.


74LS74
IC36b
Clock input ≈ 10MHz
LOAD
IC10 LS161
IC2 LS161
IC3 6349-1 Microcode prom
IC4 LS374
Instruction register
Build link
IC5 LS154 Opcode select
NOP CLR LOAD
LOOP INCV STORE ADC SUB ADD
A Bus
A0→A7
IC18 LS245
A0→A3
A4→A6
IC6 2K×8 ram
IC11
IC12 157
IC22 LS161
Index register
IC13 244
IC35
IC24
IC26
IC19
IC36
IC11 74LS126
A4→A6
A3→A0
GO-D
IC19 74LS04
GO-C
Midi data
IC28 LS373
A6→A4
IC14 LS373
D0
D7
Q Bus
D7
D3→D0
D6→D4
D3→D0
D0→D7
IC26
IC33
IC19 LS74
GO-E
16 / BUSY



This discrete high-speed t.t.l. processor was developed specifically for Digipoly but is general enough in design for many other applications. Its purpose is note generation. Microcode software for the ten-instruction processor is stored in a bipolar prom.

Electronic mailbox

by Martin Allard
B.Sc.(Hons)

Construction tips and line interface circuits complete the description of a self-contained electronic message system.

A plated-through printed circuit and the three roms are available to constructors. The printed circuit is designed to fit into an RS cabinet type 509-620. This board, the mains transformer, and the line-isolation transformer are all attached to the front panel, leaving only the backup battery fixed to the base of the cabinet. Other components fixed to the panel are the three leds indicating 'power', 'on-line' and 'attention', two push buttons to manually open and close connections if required, and a switch for the battery backup supply.

The relays are RS type 346-851 and the switch for the clock is RS type 336-674. The only components not mentioned in the circuit diagram are numerous 100n decoupling capacitors which should be monolithic ceramic types. They are shown in the layout drawing which will be supplied with the printed circuit.

The 64K rams can be any type except the Texas variety which has different refresh requirements; the slowest available devices will be suitable for the application. This also applies to the roms and the interface chips. To reduce dynamic consumption, the system runs at a relaxed clock speed but this does not limit its operation in any way. The 1nF capacitor in the receiver monostable should be polystyrene; other capacitors are not critical.

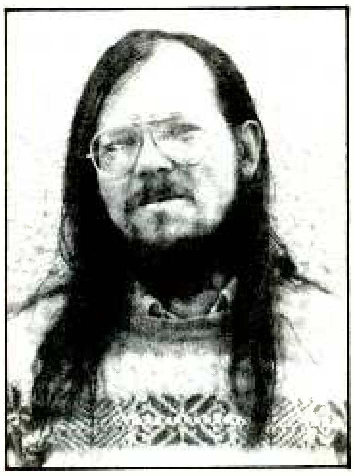
The mailbox can be connected directly in parallel with a telephone by using a dual-outlet adaptor. There is no need for the line to the telephone to be switched as in a normal modem, because any sounds picked up by the handset cannot cause data errors.

There are only two adjustments to be made in the modem circuit. Inject a sine wave of 10mV peak-to-peak at 1700Hz across the line side of the transformer, and monitor test point one. Adjust the offset potentiometer to obtain a symmetrical square wave, and confirm that the shape does not change when the input level is raised to 1V. Monitor test point two and adjust the timing potentiometer so that the logic level is on the point of changing states.

The clock is set by use of a special command and an internal switch which protects it from being changed inadvertently. The command format is

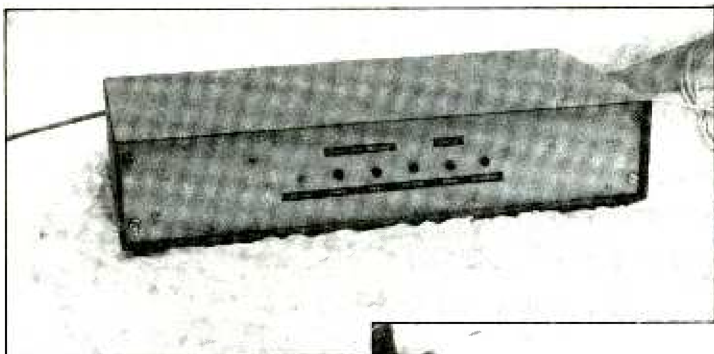
t0000‹units mins›‹tens mins›‹units hrs›‹tens hrs›‹units days›‹tens days›‹day of wk›‹units months›‹tens months›‹leap status›10 ‹magic switch on› ‹cr› ‹magic switch off› ‹cr›

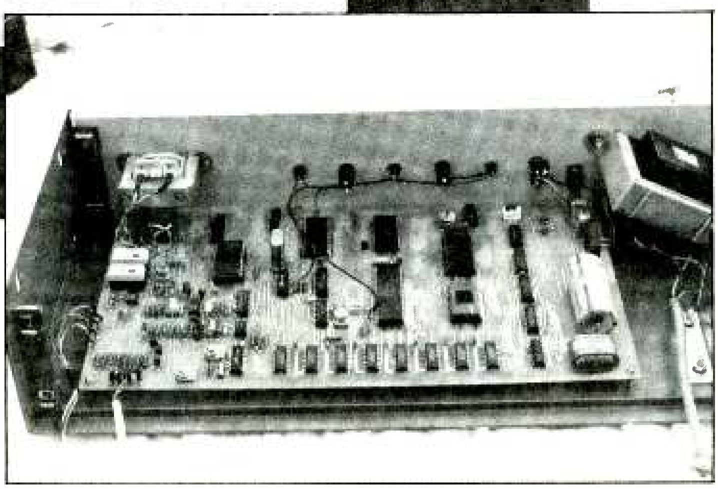
where leap status is eight for leap year, four for leap year + 1, two for leap year + 2 and one for leap year + 3. For example, to set the clock to 23:57 GMT on 9 December 1984, the string would be t0000753290021810. The trimmer on the clock crystal should be adjusted at intervals of a few



Martin Allard has an honours degree in computing science from Essex University. Over the years he has worked in psychology research, gas pipeline instrumentation, operating systems design and digital video, including the single-handed design of a digital PAL-NTSC standards converter, all done from his cottage in Devon.

He recently left that business, convinced that it is the road to madness, and is now an independent broadcasting and communications consultant. One of his current projects is the construction of solar-powered community f.m. radio stations in Nepal and Sri Lanka, in conjunction with UNESCO and Arthur C. Clarke. Martin still owns the working automatic telephone exchange which he designed at the age of 11.





Messages entered into the mailbox from a computer or terminal are sent immediately or later on while you're asleep. The message can even be held until the destination caller rings you.

Principles of the electronic mail system were discussed in the August issue and hardware in the September issue.

days, and the clock should be reset until it is found to be running accurately.

Uses of the system

Computing appears to many people to be a solitary pastime, but when the power of modern data communications is added it becomes an interesting social activity.

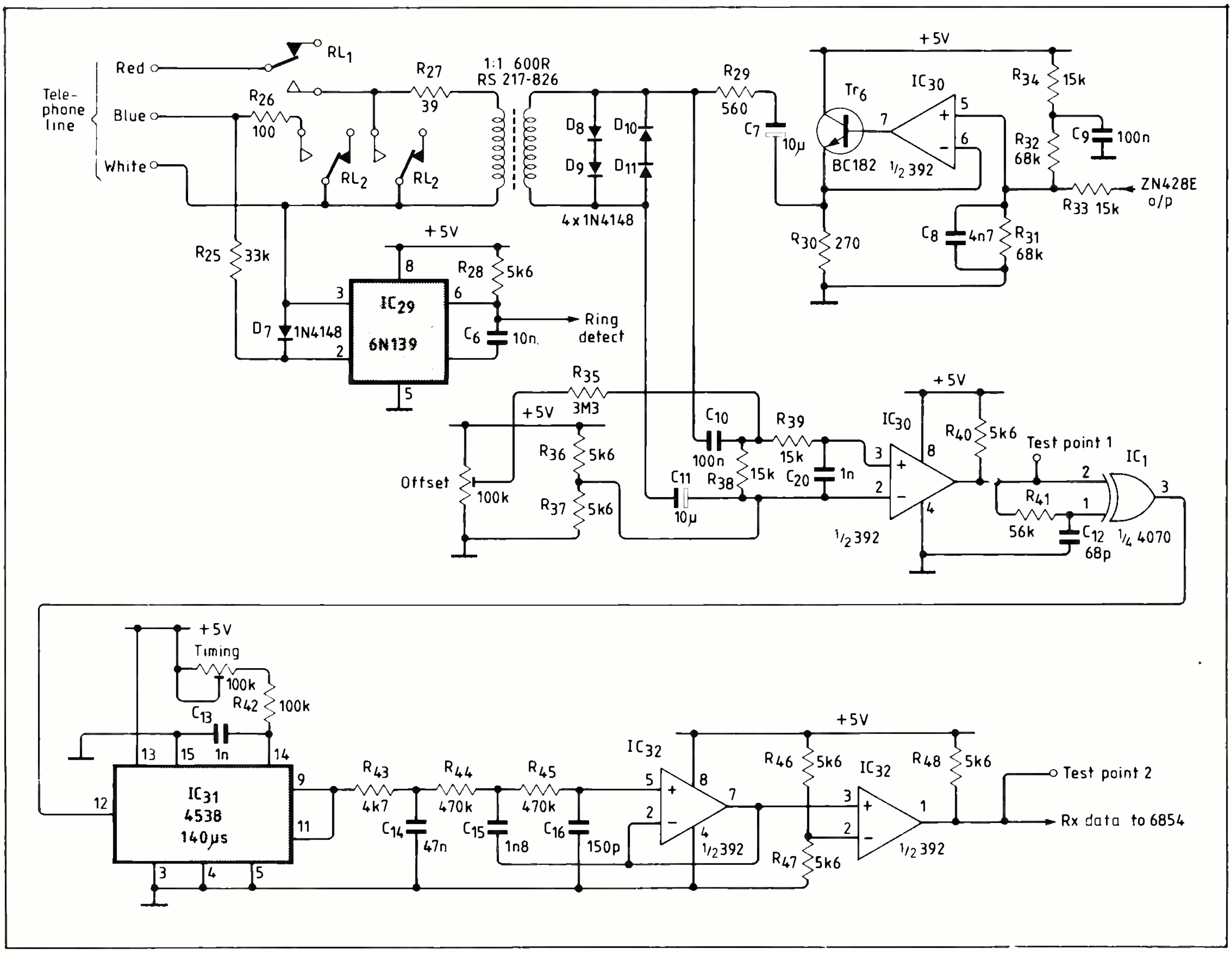
This system is intended to provide a mail service and a remote terminal service which are sufficiently reliable and easy to use that one can concentrate on the message being sent, and forget about the way that it is being delivered. Because the writing and reading of mail is all performed off-line at no cost in communication time, messages tend to be much longer and more leisurely in style than conventional electronic mail. There are no arguments about whether or not the message was received — the sender always knows the answer. One doesn't know whether it has been taken notice of however.

The control wire called DCD is in fact a far more reliable form of remote control than anything provided by a simple modem, and it is being used to switch computers on and off when an incoming call is received. As with all other aspects of the system considerable attention has been paid to making it fail-safe.

Fundamentally, the mailbox provides a cheaper, faster and more reliable way of getting messages to a specific destination than centralized systems such as Prestel, Telecom Gold, Easylink, and the hobbyist bulletin boards. It does have the social disadvantage that one cannot spend one's telephone bill idly browsing through other people's correspondence. However it is a general purpose real-time communications system as well as a way of delivering private mail, and as such is well suited as a means of accessing a common database. I am considering setting up a bulletin board specifically for users of this design if interest justifies it, and would therefore like to hear from prospective users. The firmware rom has plenty of space for enhanced facilities in it, and one use of the board would be to arrange for firmware upgrades. It is my belief that the underlying standard is sufficiently sound to remain compatible with potential future versions possessing many more features.

A double-sided plated-through printed circuit for this design is available from Combe Martin Electronics, King Street, Combe Martin, North Devon EX34 0AD, for £23 including UK/overseas postage and v.a.t.

A set of three programmed roms is available from Mallard Concepts Ltd, 13 Southdown Avenue, Brixham, Devon TQ5 0AP for £34.50 including v.a.t. and postage. A guide giving more detailed information on the use of the system is also available free of charge from the same address on receipt of a large s.a.e.



Analogue signal paths. On the receive side, the limiter is followed by an exclusive-or gate generating pulses on both edges of the waveform. These pulses are integrated and sliced after passing through a monostable i.c. Data for transmission is buffered after passing through a simple filter.

CIRCLE 48 FOR FURTHER DETAILS.

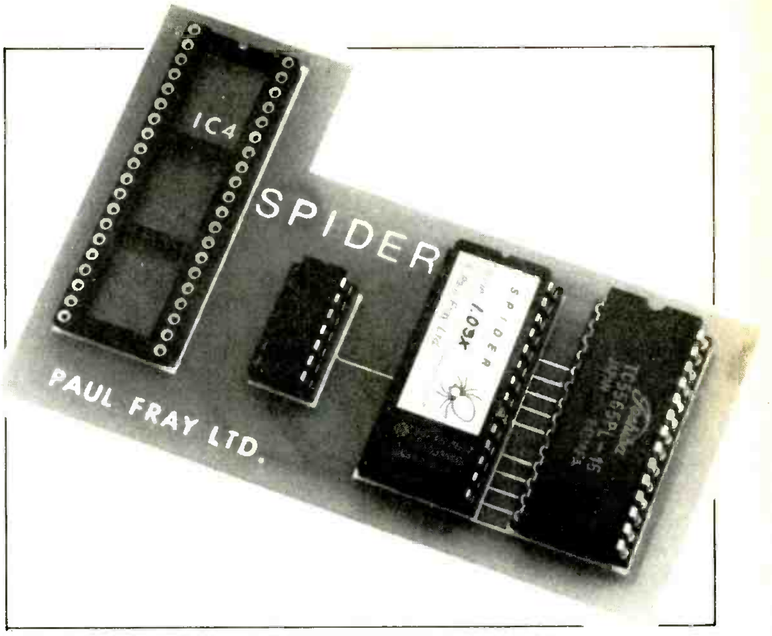
CIRCLE 40 FOR FURTHER DETAILS.

CIRCLE 34 FOR FURTHER DETAILS.

Ram-rom input/ output controller

A combination of 'sideways' ram and rom-based software expands the capabilities of the BBC Micro into control applications. The Spider adds a number of commands to BBC Basic to allow easy access to external devices and has uses in laboratories or in industry for real-time control. Applications include measurement and recording systems, burglar alarms, aids for the disabled and energy optimizing systems for industry and the home.

The device is provided on a butterfly board which plugs into the 6522 user v.i.a. socket. Parallel processing is possible, which is why it is called the Spider: if an event is caught in the 'web' it is acted upon, another event triggers the system and its presence noted. The first event has its data fully secured and the processor is then free to deal with the second or subsequent events. Different versions are available from the simplest, Spider-B at £65, which communicates through the user and printer ports to Spider-X at £115, working through the 1MHz bus. Spider-E, also £115, interfaces with the Control Universal range of Eurocard control and monitoring devices. Paul Fray Ltd, Willocroft, Histon Road, Cambridge CB4 3JD. EWW201



Modular workstation

A choice of central processing units, displays, application software, programming languages and peripherals are a feature of the Hewlett-Packard series 300. The modular approach enables the user to start on an entry-level system at relatively low cost and upgrade as and when required by the addition of a faster c.p.u. or a higher-resolution display. All of the software, and the peripherals, remain compatible. The c.p.u. is either a 10MHz Motorola 6810 or a 32-bit 16.6MHz 6820. A megabyte of ram is standard with either processor and may be expanded to 7.5Mbytes. Four bit-mapped v.d.us are available medium or high resolution, monochrome or colour.

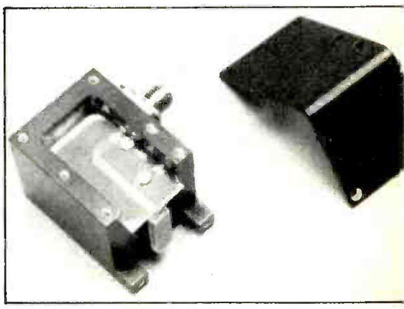
Like most of the H-P range, these computers are particularly designed for control and measurement applications and a number of analogue and/or digital interfaces are available along with the appropriate software. Series 300 will run most of the series 200 applications software and an integrated word processor/ spread-sheet/database package is available as well as electrical and mechanical engineering programs. Peripheral devices include digitizer tablets, mice, mass storage, printers and plotters. The workstations can be networked together and can communicate with H-P series 200 and 500 systems over a 10Mbit/s lan. Two IEEE 802.3 Standard cabling options may be used: The first can link up to 30 systems over a distance of 185m, the second can provide connections to 100 computers at distances of 500m.

A typical entry-level system will cost about £5164 while the top of the range costs ten times as much; lower than the Series 200 which are superseded by these computers offering better performance. Measurement Design and Manufacturing Systems, Hewlett-Packard Ltd, Miller House, The Ring, Bracknell, Berks RG12 1XN. EWW206

Frequency spotting laser

Instantaneous measurement and analysis of any number of incoming r.f. signals is possible with the use of the Bragg cell developed by Marconi Research labs at Great Baddow and available through GEC Research. The Bragg cell uses acoustic energy generated by the incoming signal to deflect or modulate a laser beam passing through a lithium niobiate crystal. The angle of deflection of the beam is proportional to the frequency of the signal and thus it is a simple process to determine that frequency.

The cells are said to have much potential in optical signal processing and spectrum analysis. It could also be used to unscramble the signals from a frequency hopping radar or radio, or to follow the frequencies in order to jam them. The cells are available in various versions with bandwidths from 60 to 2000MHz and centre frequencies from 0.16 to 2.9GHz. GEC Research Ltd, East Lane, Wembley, Middlesex HA9 7PP. EWW211

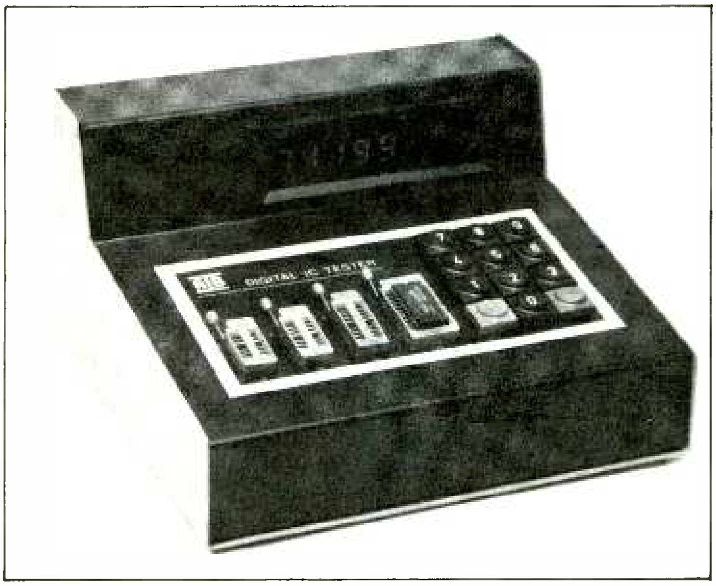


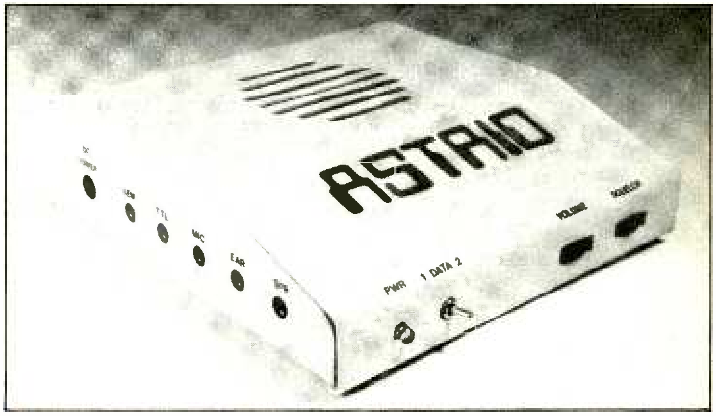
Digital i.c. tester

Many i.c. testers need 'personality' modules to tell the instrument which i.c. it is testing, but an instrument from ABI Electronics includes test algorithms for a wide variety of i.cs which are held in memory and can give instant results on all the 74 series of t.t.l. devices, the 4000 range of c-mos devices and a number of memory and interface chips. The instrument can identify the device and test it, thus enabling the identification of unmarked devices. It can also test itself. Any new device or custom chip can be accomodated as ABI will supply the appropriate software.

The i.c. tester emulates in-circuit conditions and provides the correct supply and input voltage levels. The test may be repeated indefinately to simulate soak testing and for the detection of intermittent faults. The makers claim that it is possible to test 1000 devices in a hour on the instrument and is therefore ideal for 'goods inward' testing, while the price (£573), the makers say, is within the means of many educational establishments who may wish to test a 'job-lot' of i.cs purchased for students' designs.

The makers also manufacture a low-cost 16-channel logic analyser (£299). ABI Electronics Ltd, Unit 21, Aldham Ind. Estate, Wombwell, Barnsley, S. Yorks S73 8HA. EWW209





Data from space

Automatic satellite telemetry receiver and information decoder is represented by the acronym Astrid and describes the functions of Astrid — a complete satellite receiving system with built-in decoder, enabling signals to be received and data displayed on a home computer.

In operation, it receives all the data transmitted by the Uosat satellites and automatically records it on a standard tape recorder. The recorded signals are then fed back into Astrid to be decoded into ASCII format which may be read through the RS232 serial input on a computer. Signals may also be decoded 'live'.

Information transmitted from the satellites include news bulletins, satellite status data, experimental data, messages on an electronic mailbox, and orbit information. There is an experimental speech digitizer giving telemetry information on board Amsat 2 and c.c.d. tv camera signals.

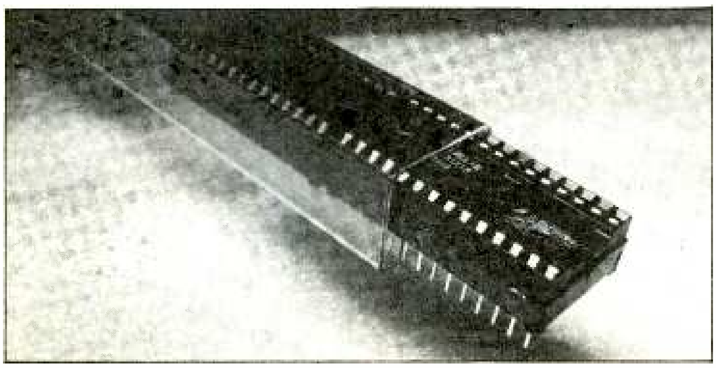
Using suitable software, which is available from Amsat UK, the data can be decoded to allow the graphic display of satellite tracks over maps, error detection of received data, disc storage of data for computer analysis and data presentation of particular telemetry channels. The software also allows the inclusion of the latest orbit information to enable the accurate prediction of satellite positions.

Astrid comes complete with an aerial and feeder, power supply unit, test tape, manual, and connecting leads. It costs £149 from MM Microwave Ltd, Thornton Road Ind. Estate, Pickering, N. Yorks YO18 7JB. EWW207

Amsat UK is at 94 Herongate Road, London E12 5EQ.

Lithium-backed memory

Over 10 years is the quoted retention of these memory modules when c-mos static ram is used in the DS1213 'smart' socket. The socket incorporates a lithium cell and a control circuit. The socket may be used with 2Kbyte and 8Kbyte static rams and may upgrade existing boards for memory retention without any change in the design. Manufactured by Dallas Semiconductors, the DS1213 sockets are available from Joseph Electronics, Westminster House, 188 Shirley Road, Solihull, W. Midlands B90 3AQ. EWW203

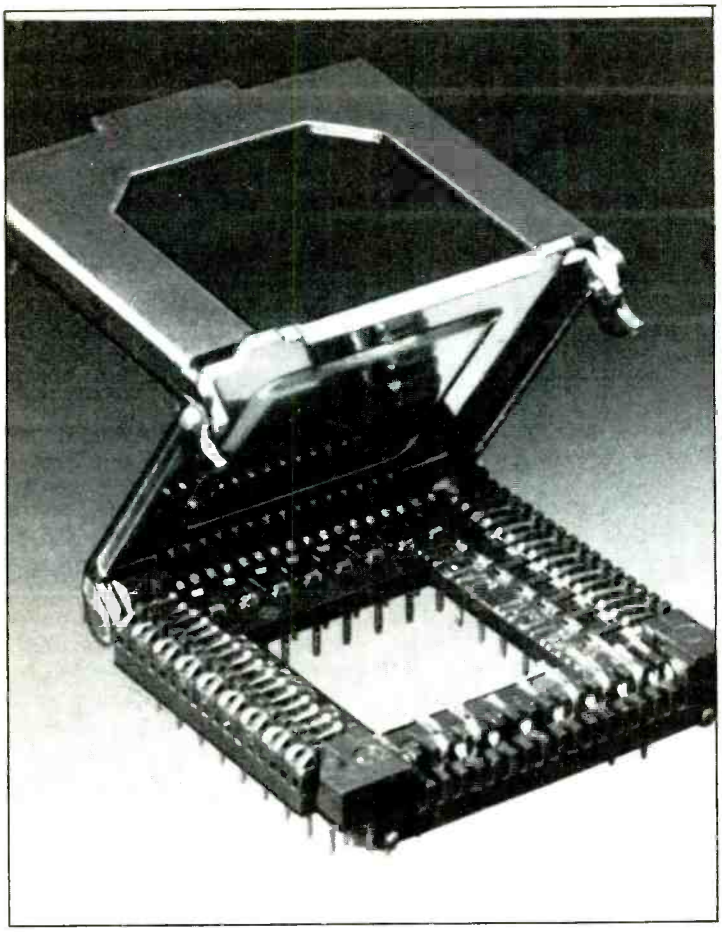


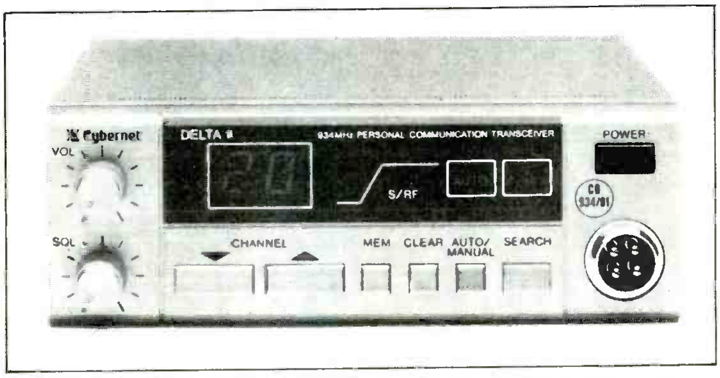
Miniature v.h.f. amplifier

Working over a range from 5 to 250MHz, the Watkins-Johnson EA51 can provide a typical gain of 17dB with less than 3dB noise. The v.s.w.r. output is 1.2:1 and the direct current required at 5V is 12.5mA. The amplifier is housed in a TO-12 package and will work as specified over a temperature range of from −54 to +85°C. Watkins-Johnson International, Dedworth Road, Oakley Green, Windsor, Berks SL4 4LH. EWW202

Socket for the leadless

A low-profile socket, type IC75, is only 7mm high and 33mm square and may be used for any Jedec A or B 68-way leadless chip carrier. The contact design and cantilever-action lid ensure good electrical performance we are told: the contacts are rated at 1A with a maximum resistance of 30mohm at 10mA. All 68 contacts are accessible from the sides of the socket to enable testing under loaded conditions. The socket may be used at up to 150°C. Radiatron Components Ltd, Crown Road, Twickenham, Middlesex. EWW210





CB at 934MHz

934MHz never caught on as rapidly as the 27MHz band for CB, partly because at this wavelength the equipment needs to be more precise and therefore more expensive. It is seen by many to be the more discerning band, free from the many 'cowboy' operators who dominate the 27MHz band. A CB transceiver, the Cybernet Delta 1, offers 20 channels at this frequency. It has an automatic search facility with a memory for the positions of 8 specific channels as well as manual selection of any channel. The receiver is claimed to be highly sensitive with 20dB quieting sensitivity of less than 0.7μV and a signal/noise ratio better than 40dB. made by Kyocera in Japan for Mike Devereux Music Ltd, it is distributed at £355 by Telecomms, 189 London Road, Portsmouth, Hants PO2 9AE. EWW220

Commodore upgrades

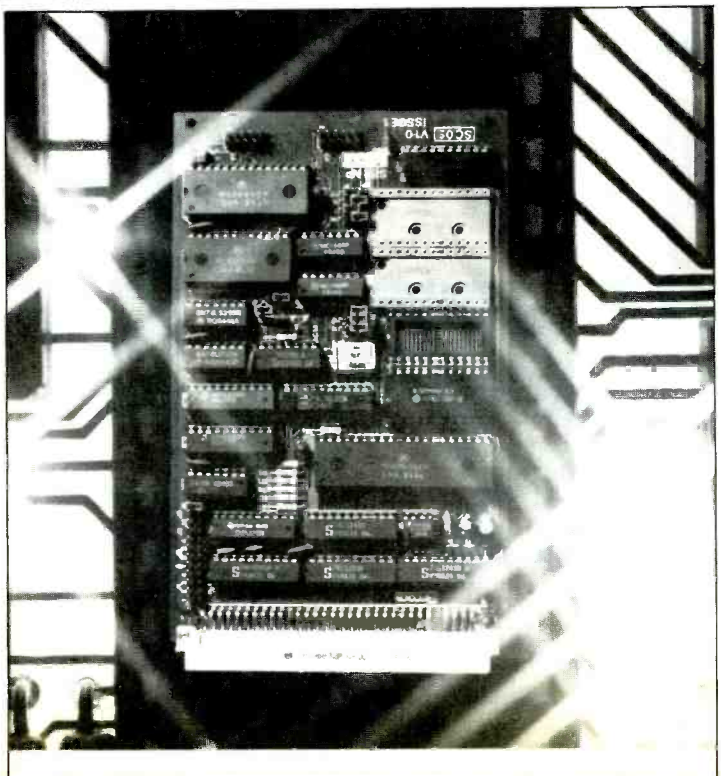
The Commodore C16 computer can be augmented to a 64K machine by the addition of a ram board from MCT of Norwich. The board plugs into the computer internally, leaving the cartridge part free, and enables the extended memory to be used with Commodore C16 and Plus-4 programs (but not those for the CBM64). At £59.95 inclusive, MCT claim the 64K machine represented the best value for money of any home computer.

The same company has also produced their own extended Basic, MCT Basic, for the CBM64 which incorporates the commands found in the much improved Basic of the C16. The product is available on cassette for £10.95 and on disc for £14.95; a rom version will be available "in the not too distant future." Micro Component Trading Co. Group House, Fishers Lane, Norwich, Norfolk NR2 1ET. EWW217

Multi-tasking OS9 board

A development board, the SC09 from Arcom, brings together the STE bus with the 6809 processor and the OS9 operating system. The single Eurocard includes four memory sockets, three 16-bit programmable timers, an a.c.i.a. for RS232C communications, and an STE- bus arbiter.

The OS9 is a multi-tasking system which can access a disc controller through the bus or communicate with a target rom-based system; it can be replaced with a machine-code monitor. The memory sockets take two 24-pin and two 28-pin devices and may be used with any combination of rom and ram. Ram may have power back-up from the STE bus standby power line.

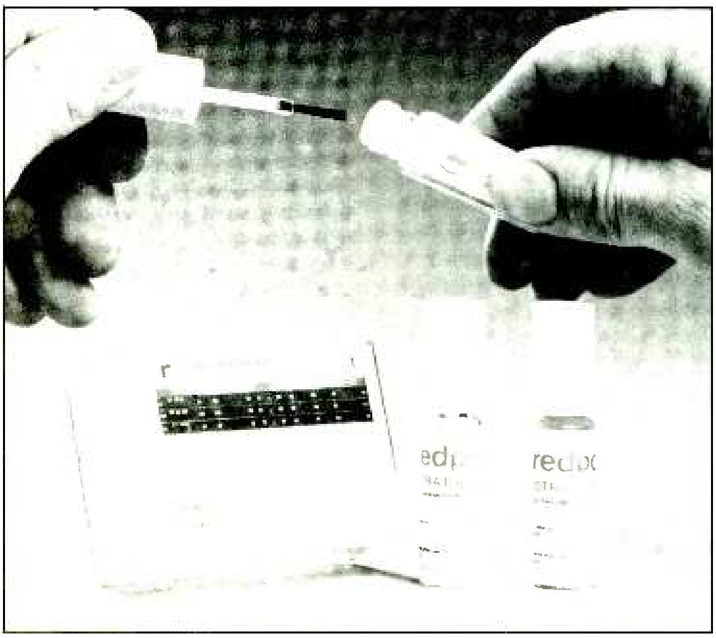


The STE bus has access to 64 pages of 56Kbyte ram and 1K of input/output locations any of which may be accessed by the 6809. The i/o is memory mapped and code running in any of the STE pages may have access to peripheral devices.

Interrupts are accepted from any two of the bus's attention request lines. The processor acts as a 'master' on the bus, using its arbiter to grant access to one or two other temporary masters. The control system includes facilities for the processor to scan the bus and deduce the amount of memory available and identify the connected modules on start-up. Arcom Control Systems Ltd, Unit 8, Clifton Road, Cambridge CB1 4BW. EWW204

Heat-sensitive paint

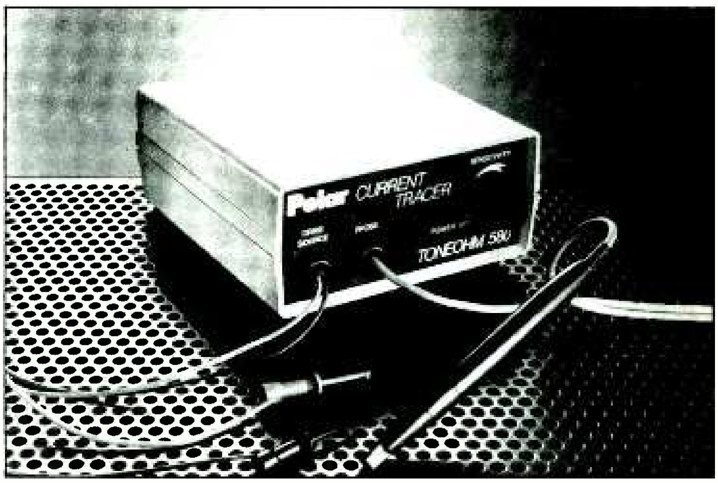
A three-bottle kit of liquid crystal thermographic paint provides temperature coverage from 58 to 117°C to non-destructive thermography. Spectratherm may be applied to any dark and preferably non-reflective surface. Semiconductor packages in shiny finishes may be darkened with a black felt pen before applying the liquid crystal paint, thus allowing the colour change to show more clearly. The right combination of liquids to give the required temperature colour-change can be applied on a test piece and assessed against a printed calibration spectrum provided. Temperature can be resolved to within 0.5°C under laboratory conditions. The kit costs £25.30 from Redpoint Ltd, Cheyney Manor, Swindon, Wilts SN2 2PS. EWW219



Current tracer

Unskilled operators can trace faults in complex circuits with the Polar Toneohm 580. Such is the claim for this instrument which has a sensitive magnetic-field probe that can detect small currents such as the flow through an i.c. substrate or within the layers of a multi-layer p.c.b.

The instrument also has an internal power supply that provides a test current of about 0.55V at 50kHz which can then be traced with the probe. Shorts and partial shorts can be traced by following the current path around the circuit. It gives an audible tone so the operator can concentrate on the circuit under test without needing to look at the instrument. £176 from Antron Electronics Ltd, Hamilton House, 39 Kings Road, Haslemere, Surrey GU27 2QA. EWW212

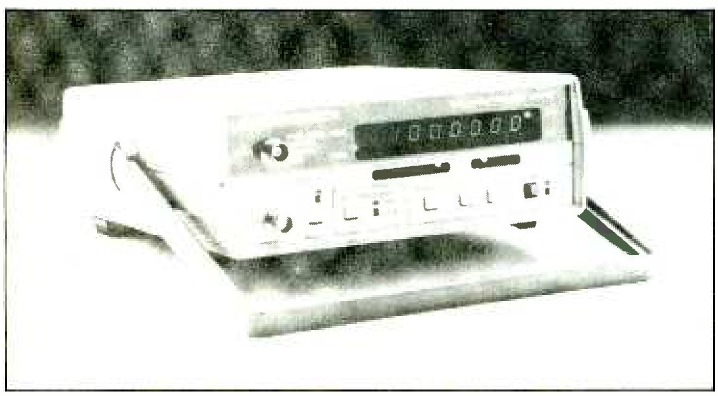


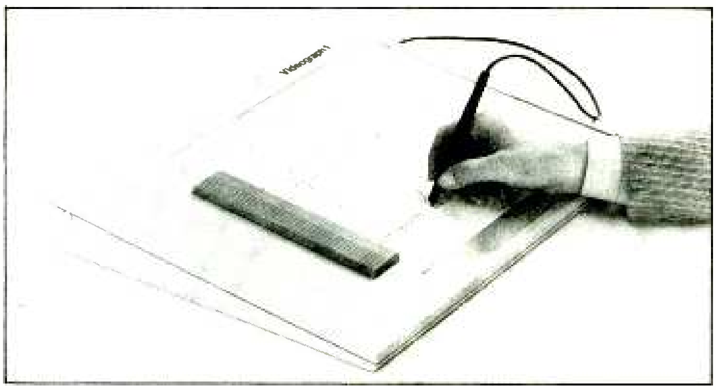
Give it a tweek

A liquid that is claimed to cut down or eliminate problems caused by poor contacts is called Tweek. It is not a cleaner, says the distributor, but a non-conductive fluid that works by filling in the surface imperfections and improving the metal-to-metal contact and 'dramatically' reducing the contact resistance. It is claimed to offer improved reliability in any electrical or electronic equipment. It comes in a 7ml dispenser for £15 and, as it needs to be used sparingly to give of its best, 7ml should go a long way. Fulcrum (Europe) Ltd, Valley House, Purleigh, Essex CM3 6QH. EWW208

Count up to 100MHz

Capable of measuring frequency, period, frequency ratio of input channels, time intervals and unit count, the Circuitmate UC10, may be used in audio and computer servicing, cordless telephone repair and for calibrating function generators. With a frequency range of 5Hz to 100MHz, the instrument is also provided with four time-gate selections from 0.01 to 10s. A built-in 10:1 ratio attenuator reduces h.f. noise components to prevent false counting. Input sensitivity is 20mV up to 100MHz. The period function averages periods for three cycles before displaying a value. A self-check function test the internal timebase generators and counters. £216 from Beckman Industrial Ltd, Electronic Technologies Division, Mylen House, 11 Wagon Lane, Sheldon, Birmingham B26 3DU. EWW215





Digitizing tablet

Initially designed for Siemens as a high-quality, low-resolution input device, the Videograph 1 is now available in the UK. The working area is 320mm square with a resolution of 0.1mm. The output can be binary or ASCII, serial or parallel, up to 19200baud, point, stream or switched stream, at 1 to 200 coordinate pairs per second. A single 12V supply is taken in through the RS232 connector. Typical configuration of tablet, stylus and RS232 interface costs £499. Dicoll Datasystems Ltd, Bond Close, Kingsland Estate, Basingstoke, Hants RG24 0QB. EWW216

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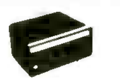

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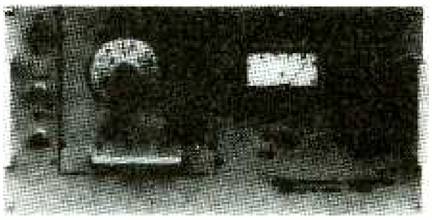

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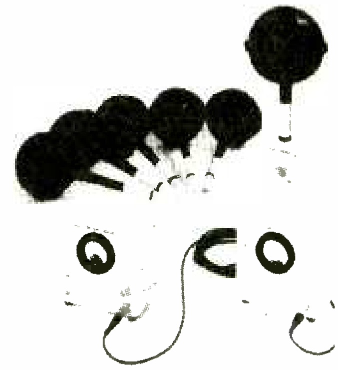

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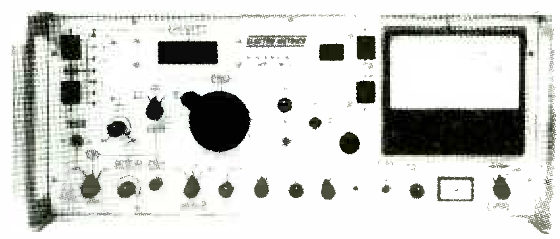

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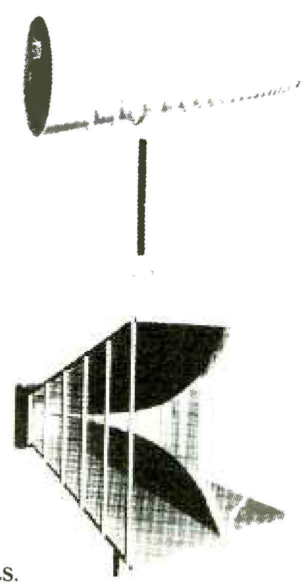

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Communications receivers

Some additions to last month's survey

Philips have launched two multiband synthesized portables, each covering 150kHz-30MHz plus the f.m. broadcast band.

The D2935 (£170), styled as a portable, is a double-superhet with a liquid-crystal display, keypad frequency selection giving storage for up to nine stations, a b.f.o. for s.s.b. or c.w. reception and an r.f. gain control. It can run on mains or battery power and it weighs 2.45kg.

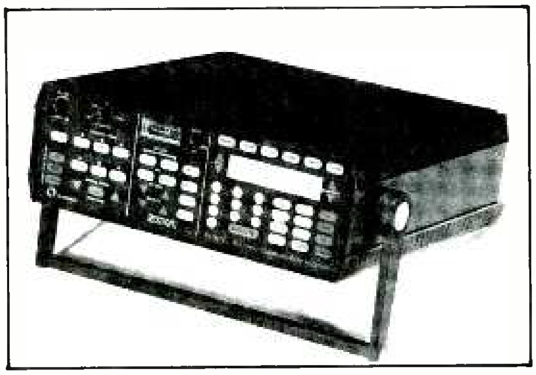
Among the additional features offered by the D2999 (£300) are three-speed electronic tuning using a knob as an alternative to the keypad, a digital field-strength meter, seven more memories, a search-tuning facility and a switchable dual loudspeaker system. This model, which is described as a transportable, weighs 4.11kg.

The Danish manufacturer **Eska** is returning to the market after a reorganization, and among the h.f. products announced by the company is the RX99PL transportable receiver.

Frequency coverage is 15kHz to 29.999MHz plus a.v.h.f. range of 144-176MHz and an unusually wide f.m. broadcast band of 60-109.9MHz. Modes available are s.s.b., f.m. (broad and narrow-band), radio-teleprinter, a.m. and phase-locked a.m., with true passband tuning. This versatile set has a two-line, 20-character alpha-numeric l.c.d. read-out, 99 memory channels, scanning, four independently-selectable a.g.c. time constants and nine receiver bandwidths ranging from 500Hz to 240kHz. Remote control and data transfer are possible via a passive 20mA current loop.

Also from Eska is a modification kit for the JRC NRD-515 receiver pictured last month. The kit includes extra filters to improve the set's selectivity and is claimed to increase the signal-to-noise ratio by 10dB. It also provides a phase-locked a.m. detector for distortion-free reception of a.m. stations even during severe fading and interference. Eska Communications Systems A/S, Frederikssundsvej 274D, DK2700 Brønshøj, Denmark.

The D2935 from Philips



Eska's RX99 PL receiver

From page 36

ence here is that in the newer devices there is no onus on the system to provide the refresh address.

This 'CAS-before-RAS' signal mechanism — just one of the advances being made in dynamic memory development — requires the slightly more complex RAS signal.

To keep the system simple, no code is executed within the silicon disc memory; it is purely a store into which and from which data is transferred. This means that access to it will always be interleaved with access to other areas of memory.

The timing controller generating RAS and CAS for the silicon disc produces conventional memory cycles when the disc is actually being accessed. It generates CAS-before-RAS cycles whenever accesses at other addresses occur or when the silicon disc is mapped out of the system. Thus refreshing is guaranteed while the microprocessor runs and yet minimal control signals are required.

Component IC_1 buffers the data bus to and from the host system. It is permanently active and normally faces off the system bus toward the silicon disc. Page selecting latch IC_2 is treated as an i/o port clocked by an external signal which, in the case of the SC84, comes from the i/o board through pin c25. The lower seven bits stored in this latch combine with the lower 11 bus address lines to form inputs to a nine channel two - input multiplexer, IC_{3-5}, providing row and column addresses to the dynamic memory array.

It doesn't matter which address lines are paired up, or which multiplexer outputs go to which dynamic memory address inputs. Upper system address lines A_{11} to A_{17} go into an eight-bit comparator formed from $IC_{6,7}$ which gives an active output when the address matches the switch settings and the SDSEL line is active. This line is the signal which maps the silicon disc into memory and may be selected to be active high or low by switch S_8. Output of the comparator is used to gate the inverted RD signal into the dynamic memory W pins.

In SC84 an inverted read signal rather than the conventional write one was used as the write strobe to the memories. The advantage of this is that an 'early write' is always generated. This type of write cycle is particularly useful in that the write operation for these dynamic memories can take two forms, dependent on the state of the W line when CAS goes low.

Most microprocessors still have their write signals high at the point when CAS goes low, so a conventional cycle is generated where the memory outputs the present state of the bit, i.e. the cycle begins as a read one. By setting W low before CAS goes low an 'early write' cycle occurs in which the output pin of the memory stays in a high impedance state throughout the cycle. This allows the data input and output pins on the memory to be connected together without any fears of bus contention — an arrangement which suits the bidirectional system data bus.

The main control signal indicating a memory cycle passes through buffering and a series of time delays to produce a slightly delayed version for the RAS signal. A further delayed version switches the address-line multiplexer and a yet further delayed one acts as the conventional CAS. Note that these signals are all gated with the original one so that all signals go to their inactive state promptly at the end of the memory cycle.

The memory control signal also feeds forward, bypassing the delay chain. This is the early version of CAS, made available for the 'CAS-before-RAS' refresh cycles mentioned earlier. Selection of the CAS type takes place in a dual 4-to-1-line multiplexer, IC_8. Here the comparator output and the higher order bit from the page register combine to select which type of CAS, early or conventional, is passed to which 256Kbyte memory block.

In using a silicon disc, one rule must be adhered to. Remember that the 'disc' is silicon and not magnetic and so should the power fail you will lose all of the data. The rule is to regularly make back-up copies of any master files on magnetic disc.

A version of the SC84 operating system, version 2.1D, is available which treats the silicon disc as drive E. For readers patching their own CP/M Bios, a DPB exists. The DPB sets the number of sectors per track as 16 (sixteen 128 byte sectors yields the 2Kbyte of page/track) and zero offset, i.e. no tracks reserved for system use as you would never boot the system from a silicon disc! Other parameters are by choice, although the system uses a block and 16 checked directory entries.

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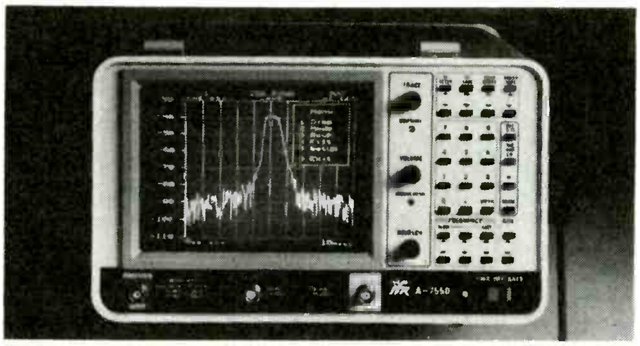

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ELECTRONICS & Wireless World

EDITORIAL FEATURES 1985/86

ISSUE DATE	PUBLICATION DATE	FEATURE
Nov. 1985	Oct. 16th	Modems
Jan. 1986	Dec. 19th	A to D & D to A Converters
Mar. 1985	Feb. 20th	Computer Aided Design Equipment
May 1986	April 17th	Fibre Optics

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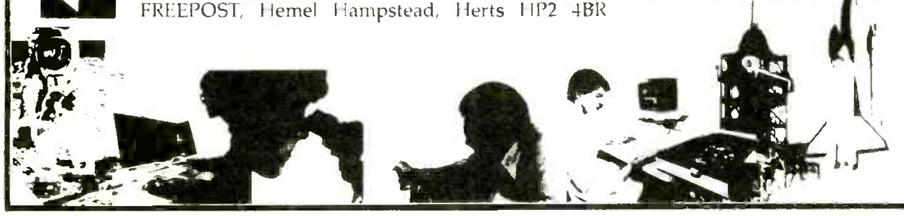

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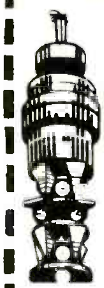

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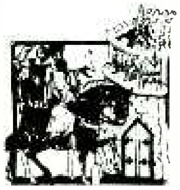

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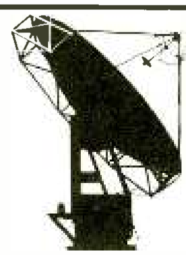

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