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Wireless world

August 1985 85p

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August 1985
Volume 91 number 1592

FEATURES

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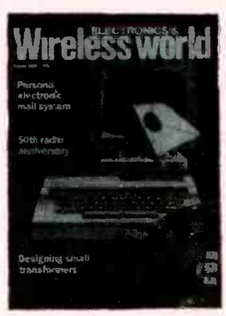

Front cover illustrates the personal electronic mail system, designed by Martin Allard, which is described in the article starting on page 33. Cover design by Paul Davies.

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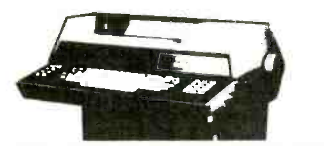

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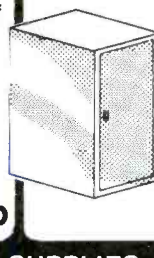

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Don't forget, ALL TYPES and QUANTITIES of electronic surplus purchased for CASH

CIRCLE 84 FOR FURTHER DETAILS.

Combined research for GEC Marconi

Three different research establishments are to come under a single umbrella — GEC Research Ltd. These are the Marconi Research Centre at Great Baddow, The Hirst Research Centre at Wembly and the Engineering Research Centre at Whetstone and Stafford. This will enable the research efforts to be more easily coordinated. GEC has found that with converging technologies, work done at the research centres has wider applications throughout the organization. Another reason has been that with the collaborative research ventures with other UK companies and in Europe (especially with Alvey and Esprit) it has been found necessary to establish a corporate, legal, identity. The new company employs 2500 people of whom over half are graduate scientists and engineers.

GEC took advantage of the occasion of the launch of the new company by displaying some of the subjects of their latest research. There is a very wide range and include such areas as compound semiconductors, including gallium arsenide; v.l.s.i. c.mos and silicon-on-sapphire circuits; computer-aided i.c. design; many areas of materials science including the development of high-grade quartz, amorphous alloys and the use of organic material in electro-optics and piezoelectric devices.

Telecommunications had several projects under way including a low cost analogue telephone with the dialling and speech circuits integrated into one chip; a teletex messaging service for several simultaneous users; a 140Mbit/s optical fibre trunk transmission system and a 2400bit/s full-duplex modem.

Much research is being carried out in computer-aided design, particularly in antenna design, p.c.b. and integrated circuit design.

Perhaps of particular interest are those long-term projects carried out by the Chief Scientist Unit. One of these projects is an active matrix l.c.d. and they plan to fabricate a thin film, portable A4 size display with half a million pixels. Each pixel will incorporate a field-effect transistor and this requires the development of thin-film transistors onto glass, a completely new technology. The Unit is also working on an organic liquid indicator that will show if a frozen food package has been defrosted after it was first frozen. Superconducting cryogenic electronics devices or Squids are extremely sensitive to magnetic fields and may be used for the non-invasive monitoring of heart and brain activity. Also in the Unit is a team investigating liquid-crystal polymers for use in optical memories. Liquid crystal polymers combine the electro-optic properties of conventional liquid crystals with the mechanical properties of solids. Data points may be written using a focussed laser beam to heat the previously aligned, transparent film. On cooling the heated spot become scattered and opaque. Subsequent applications of an electric field can erase the scattered regions.

Every word a pearl?

Authors frequently tell us how pleased they were with the presentation of their work. Some of them have said that, at first, they were incensed that their work had been "edited" (the process is called sub-editing) but that, on maturer consideration, had decided that it was fully justified.

It is natural to feel resentment when someone else fiddles about with your painfully composed writing and one's instinctive reaction is to describe the tamperer as an illiterate fool, particularly if one had slipped a merry jest of some kind in the original which was subsequently excised.

There are several reasons for subbing an article. It may be that the author stands too close to the writing and is completely unable to see that it contains ambiguities, repetition, omissions or even errors. The algebra can be inconsistent, the style of writing is sometimes almost impenetrable and often the punctuation is of the variety that continually finds one on the wrong foot.

Many of our authors are very highly qualified people who have worked for years in a particular discipline. They are so familiar with it that its groundwork is second nature to them. Consequently, it sometimes happens that their writing carries the assumption that everyone else is similarly well versed in the subject. On these occasions, it is essential to modify the article simply to make it understandable.

It is a truism that there are literates and there are numerates, but not very many literate numerates. Most of the (relatively) illiterate numerates accept this and gladly proffer their work, knowing that sub-editing will polish it smooth, but recently a letter arrived from a published author complaining bitterly that routine subbing had made his writing unrecognizable as his own. In fact, his style had not been changed excessively (we do try not to interfere with authors' writing style), but in this case the author was rather more fortunate that he realised, because the original was so amorphous, ungrammatical and loaded with weird constructions that it would not have increased his standing had it appeared in that form. Indeed, when shown the original, side-by-side with the published version, he agreed with the decision and, in fact, suggested that this comment should be written.

There is no reason to feel insulted should one's work for publication be subjected to normal sub-editing. All writers, including members of *WW* staff, have to submit to it and realise that not every single word is a pearl, even though one might have gone through fire and water to write it.

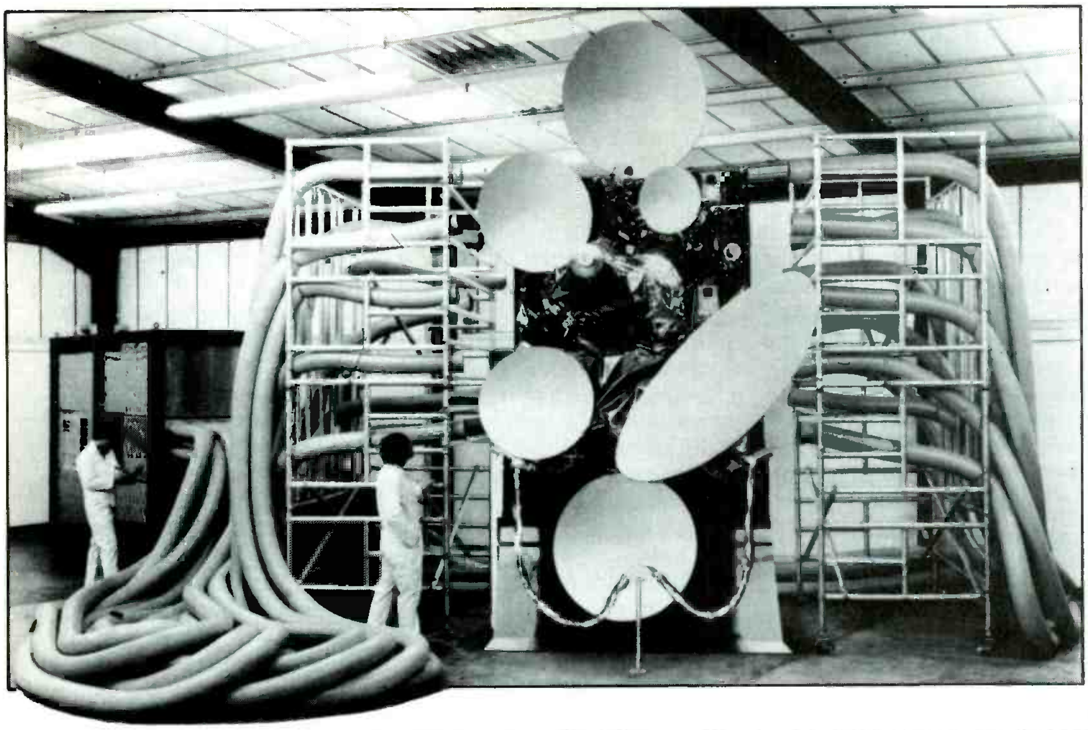
Amstrad in the US

Following the successful launch of the Amstrad CPC464 computer in the UK, Amstrad are now attempting to enter the US market with a 128K home computer. The CPC6128 is to be available in America in Autumn but as yet there are no plans to sell it in the UK. The machine is to be imported and marketed by an established American company, Indescomp, and Amstrad are not making any investment in the US.

The Amstrad CP464, a 64K computer with a colour or monochrome monitor and built-in cassette player and a very comprehensive Basic, was followed recently be the CP664 which incorporated a disc drive. It is likely that the 128K micro will be available in the UK next Spring.

Satellite radio

A demonstration will take place at the Montreux Television Symposium of the simultaneous reception of nine Wegener subcarriers added to one video carrier on the ECS F1 satellite. The nine extra carriers can be used for audio or data reception. The same sevice was used by the BBC during last Summer's Olympic Games to carry three radio programmes on satellite link from Los Angeles in addition to the tv coverage. The BBC and Capital Radio are investigating the possibility of using the Wegener sub-carrier equipment, supplied in Britain by Megasat, for expansion of their radio networks through Europe and cheaper transmission within the UK. Megasat are showing 1.1m dishes at Montreux and the equipment and the leasing of sub-carriers without the video signals is relatively very low cost. For the reception of data services the dishes can be even smaller. The 1.1m dish can accomodate data rates of up to 128Kbit/s, a 90cm dish can cope with 56Kbit/s.



Medusa is a complex of heaters and coolers which can offer a satellite under test all the temperature changes that it is likely to encounter in space. It is shown here with a mock-up of the Olympus communications satellite from BAe which will be tested in this way. Medusa comes from Dynam Engineering in Blackburn.

First international-standard network

A British company, LDR Systems of Aldershot, are claiming the first independant implementation of the ISO standard for Open System Interconnect (OSI). Isonet is a software package that enables telecommunications users and system builders to design and install data communications networks.

The system is portable and may be implemented within a very short time on the majority of computers from micros to mainframe. The system works on the IBM PC and those computers compatible with it. It also runs on the Burroughs B20 range, the VAX-11 and the Apricot and Sirius computers from ACT. There are CP/M86, MS-DOS and Concurrent DOS versions and many other implementations are in preparation.

The system is written in ISO-Pascal and also in "C". The package comprises a number of building blocks which provide the various services and protocols defined in the ISO OSI standard. It can be used over a wide variety of communications media for both local and wide-area networking and can enable the interconnection of l.a.ns and w.a.ns using X.25 protocols.

Isonet will also form the basis of a range of applications facilities, including an electronic mailbox system and for file transfer.

The system was developed with the assistance of a grant of £244 000 from the Software Products Scheme of the National Computing Centre. The managing director of LDR Systems, John Divers, believes it to be a major breakthrough for the future of computer networks and explained that it had taken 15 man-years to develop which would be a large amount of effort for any competitor to catch up with.

● In a completely different announcement, IBM has announced its increase in support for all European customers who are considering implementation of the OSI standards. IBM participated in the national and international standards committees that were involved in the development of the standards. They have several products that support OSI-related standards and tests are to begin this year on software that will provide support for selected functions of OSI layers 4 and 5.

Breadboarding on silicon

Texas Instruments have developed electron-beam lithography to a stage where they can write the metallisation pattern on to individual integrated circuits within a slice. This enables them to provide individually programmed arrays in a very short time, i.e. down to a week from a customer's data base design to a tested product.

The process eliminates the photomask which is both costly and time-consuming to produce and requires large numbers to be manufactured to make it worthwhile. Using the E-beam technology it is possible to have number of different circuits on the same slice of silicon and so enable the production of small numbers, down to, say, ten integrated circuits. This in turn allows the designer to experiment, follow hunches or second thoughts before being committed to full i.c. production. This process has been dubbed by TI 'breadboarding on silicon'. The new facility is at TI's plant in Bedford.

Talking *Wireless World*

Electronics & Wireless World is included amongst the electronics and radio magazines recorded onto tape for use by blind radio hams. QTI (Questions of Technical interest) is a talking newspaper that is now five years old. Each issue takes the form of three hours of readings from the technical pages of the magazines. The main emphasis is on the new and most interesting ideas in equipment and electronic design.

Advertisements are scanned and any item of particular interest to the blind is picked out for special mention. Originally free to subscribers, lack of funds have forced QTI to charge a joining fee of £3.50 and an annual subscription of the same amount. Subscribers are sent two C90 cassettes with the latest issue which they must return to get the next issue. QTI have fast copiers to prepare the editions.

The fast copiers are a retired outfit from the Harrow Talking Newspaper who kindly let them have the equipment at a knock-down price which still exhausted their funds. QTI has had generous contributions from the electronics industry, and from individuals but they are in need of help. Whether it be reading into a tape recorder, assisting by providing a stall at the many ham rallies that take place or just cash.

All contributions gratefully received by QTI Talking Newspaper Association, 2 Cartmel Walk, North Anston, Sheffield S31 7TU. Telephone: 0909 566301.

"Anyone, anywhere" — communication goal

The world's future mobile communications should be organised to enable a traveller anywhere on the globe to communicate with any other person or place. This objective was expressed by Inmarsat Direcor Olof Lundberg, at the Spacecom conference in Paris.

Satellites would, of course, play a big part in this aim. The maritime community had solved its problems by forming the Inmarsat co-operative but the same need for remote communication apply to aeronautical and land-mobile travellers. In highly populated areas the cellular radio network provided the best economical solution and the most efficient user of the spectrum. Satellites for land mobile communications would however be of particular use to the wide-area roaming units such as trans-continental travellers, in low population-density areas and as a high capacity back-up to relieve congestion in cellular or other terrestrial systems, caused by, for example, adverse weather conditions.

The existing Inmarsat network can be used for aircraft, both for air to land communication and for air traffic control. But Mr Lundberg pointed out the shortage of available spectrum for mobile satellite communications. He also made a plea for standardization; "Today's user is not interested in fitting a plethora of communications devices. We can assume that a driver would not wish to fit a different cellular set for each country driven through. Similarly, the farmer outside the town in the US would not like to use an expensive satellite system when in a town where an inexpensive cellular system is available. The airline flying around the world certainly protest very loudly if it were forced to fit electronics compatible with a multitude of international, national and regional satellite systems."

Expert systems are a compilation of the knowledge of specialists in a particular field. Under computer control, they can offer diagnosis, analysis and can offer remedial action. Adept, developed by Marconi Instruments and Allen & Hanbury, is used to diagnose suffers from asthma. It has a touch-sensitive screen for input.

Open up-dates

The Open Tech Unit of the Manpower Services Commission has signed a contract with the institution of Electrical and Electronics Incorporated Engineers (IEEIE) to produce open learning material aimed at supporting an up-dating technician engineers and technicians in industry. The need for this was identified by an extensive preliminary study, and the MSC is to fund £0.5M of development work for the first two years. A feature of the project is the participation by major electronics companies which will be providing support and expertise, working in partnership for the common good of practising engineers and the industry at large.

Learning material produced will asume a good standard of professional education and will attempt to strike a balance between courses for career enhancement and advanced application techniques. The first modules are due early next year with emphasis on electronic structures, systems and testing. The steering committee is chaired by Dr John Brown, President of the Institution and the project is to be managed by G.T. Richardson, formerly of the Royal Navy Weapons Engineering Branch.

Dead in a flash

Photographic flash guns can damage UV eproms. That's the conclusion of work just published by British Telecom's Research Labs at Martlesham Heath *Electronics Letters* Vol. 21 No. 13. The nature of the damage can vary from an unwanted output pulse (soft failure) at low light levels to destructive latch-up at more than 4×10^6 lux, the sort of illumination produced by a direct flash from a close-range gun. Moreover, it seems that the usual stick-on labels to not always provide adequate protection from this sort of light intensity.

The most critical parameter, it seems, is peak visual illumination, not ultra-violet radiation which in the case of flash guns is low. The accumulated UV output of several hundred flashes from a typical gun was shown to be far below the levels normally needed to erase data. The BT research found that the degree of damage varied between different chips; a p-well c-mos device was the most seriously affected of the various types they tried. The extent of soft failure was also shown to be dependent on the chip logic levels at the time of the flash. Additional experiments showed that above 4×10^6 lux, permanent destruction of the chip can occur at any logic level. So a memo, perhaps, to any budding David Baileys in the Computer Room?

In Brief

Although it has not been necessary to have a licence for metal detectors and pipefinders for the past four years, the DTI is continually receiving applications and fees for the renewal of such licences. The only regulations that now apply are related to frequency ranges, field strength and spurious emissions and may be found in the Schedule to the Wireless Telegraphy (Exemptions) Regulations 1980 (SI 1980 No 1848).

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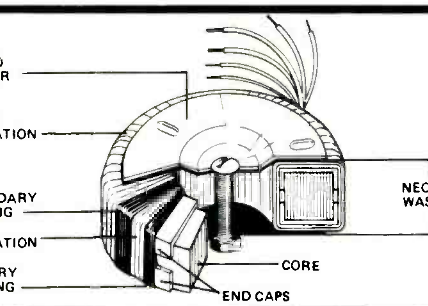

15 VA — 62 x 34mm — 0.35Kg — Regulation 19%

SERIES No	SECONDARY Volts	RMS Current
0x010	6+6	1.25
0x011	9+9	0.83
0x012	12+12	0.63
0x013	15+15	0.50
0x014	18+18	0.42
0x015	22+22	0.34
0x016	25+25	0.30
0x017	30+30	0.25

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30 VA — 70 x 30mm — 0.45Kg — Regulation 18%

1x010	6+6	2.50
1x011	9+9	1.66
1x012	12+12	1.25
1x013	15+15	1.00
1x014	18+18	0.83
1x015	22+22	0.68
1x016	25+25	0.60
1x017	30+30	0.50

50 VA — 80 x 35mm — 0.9Kg — Regulation 13%

2x010	6+6	4.16
2x011	9+9	2.77
2x012	12+12	2.08
2x013	15+15	1.66
2x014	18+18	1.38
2x015	22+22	1.13
2x016	25+25	1.00
2x017	30+30	0.83
2x028	110	0.45
2x029	220	0.22
2x030	240	0.20

80 VA — 90 x 30mm — 1Kg — Regulation 12%

3x010	6+6	6.64
3x011	9+9	4.44
3x012	12+12	3.33
3x013	15+15	2.66
3x014	18+18	2.22
3x015	22+22	1.81
3x016	25+25	1.60
3x017	30+30	1.33
3x028	110	0.72
3x029	220	0.36
3x030	240	0.33

120 VA — 90 x 40mm — 1.2Kg — Regulation 11%

4x010	6+6	10.00
4x011	9+9	6.66
4x012	12+12	5.00
4x013	15+15	4.00
4x014	18+18	3.33
4x015	22+22	2.72
4x016	25+25	2.40
4x017	30+30	2.00
4x018	35+35	1.71
4x028	110	1.09
4x029	220	0.54
4x030	240	0.50

160 VA — 110 x 40mm — 1.8Kg — Regulation 8%

5x011	9+9	8.89
5x012	12+12	6.66
5x013	15+15	5.33
5x014	18+18	4.44
5x015	22+22	3.63
5x016	25+25	3.20
5x017	30+30	2.66
5x018	35+35	2.28
5x026	40+40	2.00
5x028	110	1.45
5x029	220	0.72
5x030	240	0.66

225 VA — 110 x 45mm — 2.2Kg — Regulation 7%

6x012	12+12	9.38
6x013	15+15	7.50
6x014	18+18	6.25
6x015	22+22	5.11
6x016	25+25	4.50
6x017	30+30	3.75
6x018	35+35	3.21
6x026	40+40	2.81
6x025	45+45	2.50
6x033	50+50	2.25
6x028	110	2.04
6x029	220	1.02
6x030	240	0.93

300 VA — 110 x 50mm — 2.6Kg — Regulation 6%

7x013	15+15	10.00
7x014	18+18	8.33
7x015	22+22	6.82
7x016	25+25	6.00
7x017	30+30	5.00
7x018	35+35	4.28
7x026	40+40	3.75
7x025	45+45	3.33
7x033	50+50	3.00
7x028	110	2.72
7x029	220	1.36
7x030	240	1.25

500 VA — 140 x 60mm — 4Kg — Regulation 4%

8x016	25+25	10.00
8x017	30+30	8.33
8x018	35+35	7.14
8x026	40+40	6.25
8x025	45+45	5.55
8x033	50+50	5.00
8x042	55+55	4.54
8x028	110	4.54
8x029	220	2.27
8x030	240	2.08

625 VA — 140 x 75mm — 5Kg — Regulation 4%

9x017	30+30	10.41
9x018	35+35	8.92
9x026	40+40	7.81
9x025	45+45	6.94
9x033	50+50	6.25
9x042	55+55	5.68
9x028	110	5.68
9x029	220	2.84
9x030	240	2.60

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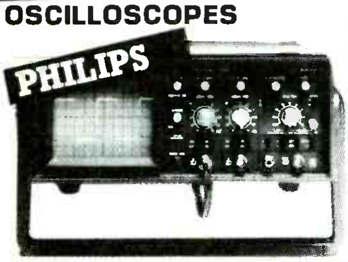
CIRCLE 23 FOR FURTHER DETAILS.

Electronic Brokers Test & Measurement Instrument Distribution Disvision

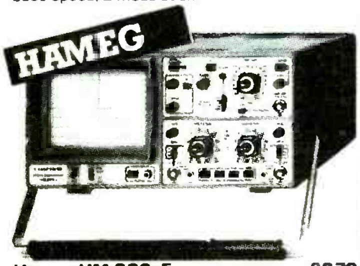
AUTHORISED DISTRIBUTOR
For the Leading Brands of Electronic Test & Measurement Equipment

From Philips, Fluke, Hameg, ICE, Thandar, Thurlby, GP Industrial, Claude Lyons, Coline, Compact Instruments

OSCILLOSCOPES



Philips PM 3206 £286
15MHz, compact portable, dual trace, 5mV sensitivity, auto and TV triggering, variable time base speed, Z modulation.



Hameg HM 203-5 £270
20MHz, dual trace, add and invert, maximum sensitivity 2mV, automatic and normal triggering, X-Y operation, component tester.

Thandar SC 110A £175
10MHz, battery powered portable, bright line and economy triggering for battery conservation. TV frame and line triggering. Sensitivity 10mV to 50V.

BENCH & HANDHELD DMMs

Philips PM 2519/01 £299
4½ digit, LCD with analogue bar graph, auto/manual ranging, frequency to 1MHz, true RMS, dB, relative reference.

Philips PM 2518X/11 £199
4 digit, LCD with electroluminescent display, auto/manual ranging, true RMS, dB, relative reference, current to 20A. PM 2518X/01 without illumination £145.

Fluke 8010A £243
3½ digit, LCD, 10A current range, seven functions include conductance, diode test, true RMS, DC accuracy 0.1%. 8010A Ni-Cd battery version £279.

Fluke 8060A £306
4½ digit, LCD, ten functions include conductance, diode test, continuity, dB, frequency, true RMS. DC accuracy 0.04%, relative reference mode.

Fluke 8062A £245
4½ digit, LCD, seven functions include diode test and continuity, relative reference, DC accuracy 0.05%, true RMS, self diagnosis test.

Fluke 8024B £220
3½ digit, LCD, eleven functions include peak hold on voltage and current, audible and visual logic level detection, DC accuracy 0.1%.

Fluke 8026B £172
3½ digit, LCD, eight functions include conductance, audible continuity, true RMS, DC accuracy 0.1%, all 20 series DMMs have 2 year warranty.

Fluke 8020B £173
3½ digit, LCD, eight functions include conductance, diode test, audible continuity, DC accuracy 0.1%, extensive over-load protection.

Fluke 8021B £139
3½ digit, LCD, seven functions include diode test and high speed audible continuity, DC accuracy 0.25%, safety test leads provided.

Fluke 8022B £114
3½ digit, LCD, six functions include diode test, DC accuracy 0.25%, optional accessories available to enhance all DMM measuring capabilities.

Fluke JF 77 £110
3½ digit, LCD with analogue bar graph, auto/manual ranging, DC accuracy 0.3%, touch and hold facility, supplied with carrying holster.

Fluke JF 75 £88
3½ digit, LCD with analogue bar graph, auto/manual ranging, DC accuracy 0.5%, seven functions include diode test and audible continuity.

Fluke JF 73 £72
3½ digit, LCD with analogue bar graph, auto ranging, DC accuracy 0.7%, six functions include diode test, all 70 series DMMs have 3 year warranty.

Fluke JF 25 £193
3½ digit, LCD with analogue bar graph, sealed ruggedized construction, auto ranging, DC accuracy 0.1%, touch-hold facility, extensive overload protection.

Fluke JF 27 £216
3½ digit, LCD with bar graph, ruggedized construction, auto ranging, DC accuracy 0.1%, touch-hold facility, min-max and relative mode operation.

Thandar TM 351 £115
3½ digit, LCD, 29 ranges of measurement, DC accuracy 0.1%, diode test, battery life typically 4000 hours, complete with batteries and test leads.

Thandar TM 451 £195
4½ digit, LCD display with function legends, auto/manual ranging, DC accuracy 0.03%, sample/hold facility on all ranges, audible continuity.

Thandar TM 355 £85
3½ digit, 0.5" bright LED, 29 ranges of measurement, DC accuracy 0.25%, battery or mains operation, diode check, supplied with test leads.

ANALOGUE MULTIMETERS

Philips PM 2505 £165
62 measuring ranges, 10MΩ input impedance, linear resistance ranges, audible continuity, automatic polarity indication, low power consumption.

I.C.E. 680R £32
80 measuring ranges, sensitivity 20KΩ/V, DC accuracy 1%, 12cm mirror scale, overload protection.

I.C.E. 680G £25
48 measuring ranges, sensitivity 20KΩ/V, DC accuracy 2%, 10cm mirror scale, overload protection.

I.C.E. M80 £19
40 measuring ranges, sensitivity 20KΩ/V, DC accuracy 2%, wide range of accessories extend measuring capabilities.

PULSE, FUNCTION, PATTERN GENERATORS

Philips PM 5503 £155
Pattern generator, 5 test patterns for mono and colour, video output for CCTV and monitors, RF output in VHF and UHF range, 1kHz tone for sound checks.

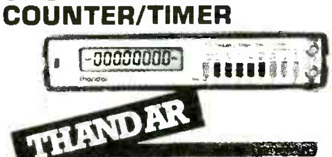
Thandar TG 101 £110
Function generator 0.02Hz to 200kHz, sine, square, triangle, variable DC offset, TTL output, external sweep, 10Vpp output into variable 600Ω.

Thandar TG 102 £160
Function generator 0.2Hz to 2MHz, sine, square, triangle, TTL output, variable DC offset, external sweep, 20Vpp output into variable 50Ω.

Thandar TG 105 £105
Pulse generator 5Hz to 5MHz, 10nS, amplitude 0.1V to 10V into 50Ω, free-run, gated or triggered modes, TTL output, pulse width variable 100nS to 100mS.

Thandar TG 501 £295
Function generator 0.005Hz to 5MHz, sine, square, triangle, ramp, pulse, TTL, variable DC offset, variable start/stop phase, 20Vpp into variable 50Ω.

COUNTERS & COUNTER/TIMER



Thandar TF 200 £175
Counter, 10Hz to 200MHz, 8 digit LCD, battery powered, 10mV sensitivity, time average period, totalize and reset. TP 600 pre-scaler, 40MHz to 600MHz available at £45.

Thandar PFM 200A £76
Counter, 20Hz to 200MHz, 8 digit bright LED, battery powered, 10mV sensitivity, resolution 0.1Hz, selectable gate times, mains adaptor and TP 600 pre-scaler available.

POWER SUPPLIES

Thurlby PL 154 £159
0 to 15V, 0 to 4A, bench power supply, twin LED displays meter voltage and current, high stability and resolution, remote sense facility.

Thurlby PL 320 £155
0 to 30V, 0 to 2A, bench power supply, constant current or constant voltage, precise current limit control and monitor system, ripple and noise <1mV.

Thurlby PL 310 £125
0 to 30V, 0 to 1A, bench power supply, meter accuracy 0.1%, resolution 0.01V and 0.001A, DC output switch, load regulation <0.01% for 50% load change.

MISCELLANEOUS PRODUCTS

Thandar TH 302 £80
Thandar digital thermometer, LCD display of °C and °F, range −40°C to 1100°C, resolution 0.1° and 1°, for use with type K probes (bead supplied).

Thurlby OM 358 £179
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.

Tachoprobe £70
Compact tacho-probe for use with DMMs or frequency counters, 2 speed ranges from 100 to 20,000 RPM, accuracy 1%, non-contact range 1m.

EB90 £7
x 1 oscilloscope probe.

EB91 £10
x 10 oscilloscope probe.

EB95 £13
x 1 and x 10 oscilloscope probe.

LINE CONDITIONERS

Claude Lyons LVC 250 £271
2.5A, 600VA rating, line voltage conditioner, fast response (typically 1½ cycles), isolated input/output, compact and portable for easy installation.

Claude Lyons LVC 65 £186
0.65A, 156VA rating, line voltage conditioner, unaffected by frequency variations, transient and noise suppression. All LVC units have 2 year warranty.

EPROM PROGRAMMERS

GP Electronics UV 141 £88
EPROM eraser, variable electronic timer, powerful UV source, up to 14 device capacity, convenient tray loading with safety interlock.

Electronic Brokers are leading suppliers of electronic test & measurement equipment. Our Distribution Division handles the major names in the industry and all products are stocked in depth in our spacious new premises at Camden Town, ready for prompt despatch to all parts of the country.
Electronic Brokers offer full technical support and expert advice on all aspects of electronic test and measuring.

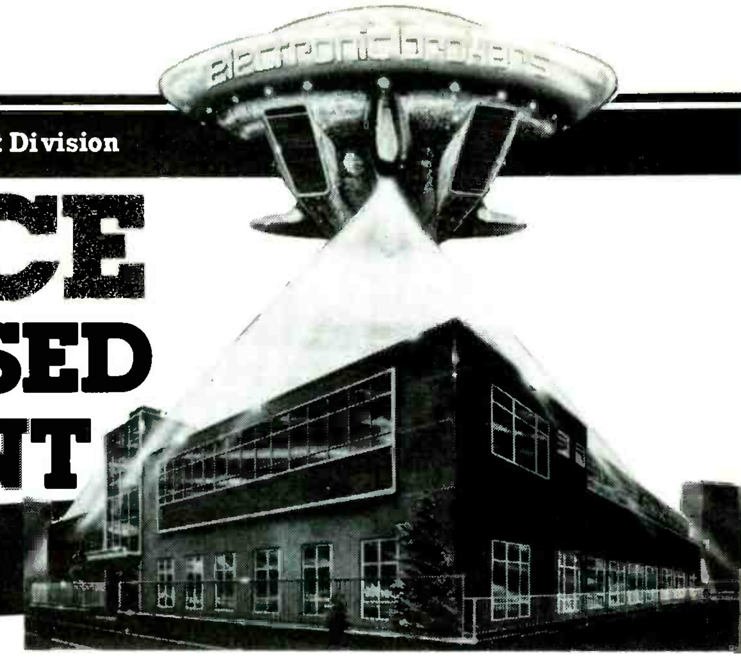
Electronic Brokers

Visitors are welcome to our showrooms where all products are on display and demonstration. For customers wishing to order by phone, we offer a 24 hour answering service.
All prices are exclusive of VAT and correct at time of going to press. Carriage and packing charges extra on all items unless otherwise stated. A copy of our trading conditions is available on request.

Electronic Brokers Ltd
140-146 Camden Street London NW1 9PB
Telephone 01-267 7070 Telex 298694

CIRCLE 204 FOR FURTHER DETAILS.

Electronic Brokers Second User Test & Measurement Equipment Division



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OSCILLOSCOPES

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1332A	Display (As new)	£950
1809A	4 channel p/in for 180	£1250
1821A	Timebase p/in for 180	£750
Philips		
PM3266	Storage Scope 100MHz	£3650
Tektronix		
212	Portable Scope 500KHz	£650
2213	Scope	£675
475	Scope	£2750
485	Scope	£6800
634/1/20	Monitor (As New)	£950
465B	Scope 100MHz	£1650
466	Storage Scope 100MHz	£3500
466DM44	Storage Scope + DMM 100MHz	£4500
434	25MHz Storage Scope	from £1950

TEKTRONIX 7000 SERIES

7603	Scope Mainframe	£1950
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7854	Waveform Processing Scope	£12500
7904	Scope M/F 500MHz	£6950
7A11	FET P/In	£1600
7A18	D T Amp	£800
7A19	600MHz Amp	£1600
7A24	D T P/In	£1950
7A26	D T P/In	£1650
7B50A	Timebase	£575
7B53A	Timebase	£585-£985
7B85	Timebase	£925
7B87	Timebase	£1435
7D11	Digital Delay	£1400
7D14	525MHz Ditigal Counter	£850
7M11	Delay Line	£750
7S11	Sampling Plug In	£1850
7S14	TDR Sampler	£4500
7T11	Sampling Timebase	£4000
S1	Sampling Head	£950
S54	Pulse Generator Head	£600

ANALYSERS

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332A	Distortion Analyser	£850
3580A	Spectrum Analyser	£3250
1615A	Logic Analyser	£2500
Marconi		
TF2300A	Modulation Meter	£795
TF2330A	Wave Analyser	£1095
TF2331	Distortion Factor Meter	£695
TF2337A	Automatic Distortion Meter	£295
Tektronix		
308/01	Data Analyser	£2500
308	Data Analyser	£2250
7D01/DF2	Logic Analyser	£1900
491 opt 02	Spectrum Analyser 1.5GHz+from	£3000
TR502	Tracking Generator	£3500
TR503	Tracking Generator	£4250
7D02 opt 01	Logic Analyser	£3000
PM102	Personality Module	£500
PM108	Personality Module	£850

RF SIGNAL GENERATORS

E H Labs		
139B	Pulse Generator 50MHz 10V	£750
Hewlett Packard		
214A	Pulse Generator 100V	£750
612A	UHF Generator 450-1230MHz	£950
8011A	Pulse Generator	£625
8007B	Pulse Generator 100MHz	£1650
8015A	Pulse Generator Dual 50MHz	£1950
8018A	Serial Word Generator	£2000
8601A	Sweep Generator	£1950
8600A	Digital Marker	£950
8616A	Signal Generator 1.8-4.5GHz	£4000
Marconi		
6058B	Signal Source 8-12.5GHz	£850
TF2002AS	AM/FM Signal Generator	£950
TF2002B	AM/FM Signal Generator	£950
TF2016A + TF2173	AM/FM Signal Generator + Synchroniser 120MHz	£1350

AF SOURCES

Hewlett Packard		
4204A	Decade Osc (New)	£595
Marconi		
TF2000	Signal Source 20Hz-20KHz	£450
TF2120	Waveform Generator	£650
Wavetek		
185	Sweep Generator	£650
184	Sweep/Function Generator 5MHz	£750
166	Pulse/Function Generator 50MHz	£1950

TEKTRONIX GP T & M EQUIPMENT

AM501	Op Amp	£300
DC508A	Counter 1.3GHz	£995
DC509	Counter/Timer 135MHz	£995
DD501	Digital Delay	£500
DM 501/02	DMM	£200
FG501	1MHz Function Generator	£325
FG502	11MHz Function Generator	£565
FG503	3MHz Function Generator	£395
FG504	40MHz Function Generator	£1650
MR501	X-Y Display	£200
PG501	Pulse Generator	£330
PG502	Pulse Generator	£1650
PG505	Pulse Generator	£450
PG506	Calibration Generator	£1950
PG508	Pulse Generator	£1250
RG501	Ramp Generator	£250
SC501	Scope	£500
SC502	Scope	£900
SC504	Scope	£995
SG502	Signal Generator	£525
SG504	Signal Generator 245-1050MHz	£2100
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TG101	Time Mark Generator	£1750
TM501	Mainframe	£275
TM504	Mainframe	£375
TM515	Mainframe	£400

COUNTERS & TIMERS

Fluke		
7220A	Communications Counter 1.3GHz (Quantities available)	£595
1900A	Counter 80MHz	£150
Hewlett Packard		
5341A	Microwave Counter 10Hz-4.5GHz	£1500
5300B + 5305B	Counter 1.3GHz	£650
Marconi		
2431A	200MHz Counter	£295
2437A	100MHz Counter/Timer	£395
2438	520MHz Counter/Timer	£650
Racal		
9514	100MHz IEEE Counter/Timer	£750

BRIDGES

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4271B	Digital LCR Meter	£3950
4342A	'Q' Meter	£2100
Marconi		
TF1245A	'Q' Meter	£1200
TF1246	Oscillator	£650
TF1247	Oscillator	£650
TF1313A	LCR Bridge	£775
TF2700	Bridge	£350
TF2702	Inductor Analyser	£1500

GENERAL PURPOSE T & M

Avo	Multimeters model 8's & 9's	£80-£85
Fluke		
887A8	Diff. Voltmeter	£1500
731B	Std Cal	£750
931B	Diff Voltmeter	£850
Hewlett Packard		
410C	Voltmeter	£950
4815A	Vector Impedance Meter	£3950
3437A	Systems DMM	£1750
3465A	DMM	£350
3406A	Sampling Voltmeter	£1500
8405A	Vector Voltmeter	£2000
467A	Amplifer	£725
11692D	Direct Coupler	£1500
Marconi		
6460/1	RF Power Meter	£1500
TF2603	RF Millivoltmeter	£650
TF2905/8	TV Pulse Generator	£750
TF2333	Trans Test Set	£850
TF2356 + TF2357A	S.L.M.S.	£3600
TF2807A	PCM Tester	£1350
TF2904	Colour Gain Test Set	£495
TF2950/5	Radio Test Set	£1550
TF2809	Data Line Analyser	£950
TF2828	Simulator	£1250
TF2829	Digital Analyser	£1250
TF2915	Data Monitor	£1200
Tektronix		
8540/03	Integrating Unit	£8500
576	Curve Tracer	£9000
178	Fixture	£1500
A6901	Ground Isolation Monitor	£275

HEWLETT PACKARD COMPUTERS

2631B	Printer	£1450
7221B	Plotter	£1200
85A	Processor	£1250
82160A	Interface	£55
82161A	Digital Cassette	£250
82903A	16K Mod	£100
82936A	ROM Drawer	£25
82937A	HPIB Interface	£200
9825A	Desktop	£2950
9862A	Plotter	£750
9872C	Plotter	£750
9885S	Disk Drive	£950

Electronic Brokers are Europe's largest specialists in quality second user test equipment. Established 17 years ago, we have pioneered the second user concept in Britain, and many overseas territories. To support our growth we have a skilled team. This includes trained sales staff, whose role is not only to sell, but provide a helpful information service to our many customers. Backing this team is our own service laboratory where technicians monitor each item of equipment we sell. Our maxim is service, and those who have dealt with us will know that we endeavour to always live up to our reputation.

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Unless otherwise stated, all test equipment sold by us carries a 12 month warranty. When you buy from Electronic Brokers you know the equipment is in 'top notch' condition. It is refurbished in our own service laboratories and checked to meet the original manufacturer's sales specifications. And it's serviced by our own highly qualified technicians.

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Electronic Brokers

Electronic Brokers Ltd
140-146 Camden Street London NW1 9PB
Telephone 01-267 7070 Telex 298694

CIRCLE 201 FOR FURTHER DETAILS.

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System

BBC Computer & Econet Referral Centre

BBC Computers:

Model B: **£299 (a)** B+DFS: **£346 (a)**
Model B+Econet: **£335 (a)** B+Econet+DFS **£399 (a)**
BBC B Plus (available from stock): **£409 (a)**
ACORN 2nd Processors: 6502: **£175 (a)** Z80: **£348 (a)**
TORCH UNICORN: Z80 Card: **£275 (a)** Z80 Disc Pack: **£550 (a)**
TORCH Graduate G800/2 £899 (a)
20 Mbyte Hard Disc+400K Floppy: £1950 (a)

We stock the full range of ACORN hardware and firmware and a very wide range of other peripherals and firmware for the BBC. For detailed specifications and pricing please send for our leaflet.

PRINTERS

EPSON: RX80T **£210 (a)**; RX80FT **£220 (a)**; RX100 **£345 (a)**; FX80 **£315 (a)**; FX100 **£430 (a)**; JX80 Full Colour Printer **£499 (a)**
EPSON LX80 special introductory price **£242 (a)**
KAGA TAXAN: KP810 **£255 (a)**; KP910 **£359 (a)**
BROTHER: HR15 **£340 (a)**; JUKI 6100 **£340 (a)**.
GRAPHICS PLOTTER WORKSTATION Complete **£490 (a)**
Basic Plotter **£270 (a)**; HI-Plotter **£399 (a)**

ACCESSORIES

EPSON Serial Interface: 8143 **£28** (b); 8148 with 2K buffer **£57** (b).
EPSON Paper Roll Holder **£17** (b); FX80 Tractor Attach **£37** (b); RX/FX80 Dust Cover **£4.50** (d). LX80 Tractor Unit **£20** (c); Spare pens for H180 **£7.50** (d).
BUFFALO 32K Buffer for Epson printers **£99** (d).
EPSON Ribbons: MX/RX/FX80 **£5.00**; MX/RX/FX100 **£10** (d).
JUKI: Serial Interface **£65** (c); Tractor Attach, **£99** (a); Sheet Feeder **£182** (a); Ribbon **£2.50** (a).
BROTHER HR15: Sheet Feeder **£199;** Ribbons — Carbonor Nylon **£4.50;** Multistrike **£5.50** (d); 2000 Sheets Fanfold with extra fine perf. 9.5in. — **£13.50;** 14.5in. **£18.50** (b).
BBC Parallel Lead **£8;** Serial Lead **£7** (d).

BT Approved Modems

MIRACLE WS2000:
The ultimate world standard BT approved modem covering all common BELL and CCITT standards up to 1200 Baud. Allows communication with virtually any computer system in the world. The optional AUTO DIAL and AUTO ANSWER boards enhance the considerable facilities already provided on the modem. Mains powered. **£129 (c)** Auto Dial Board/ Auto Answer Board **£30 (d) each** (awaiting BABT approval). Software lead **£4.50**
BUZZBOX:
This pocket sized modem complies with V21 300/300 Baud and provides an ideal solution for communications between users, with main frame computers and bulletin boards at a very economic cost. Battery or mains operated. **£62 (c)**
Mains Adaptor **£8 (d)** BBC to Modem data lead **£7**

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/0 routines. Can be used as an emulator, cassette interface.
Softy II .... **£195.00(b)**
Adaptor for 2764/ 2564 .... **£25.00**

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TECHNOMATIC drives are fitted with high quality slimline Mitsubishi mechanisms and are available with or without integral mains power supply. The dual drive power supplies are switch mode type and are generously rated. All drives with integral power supply are fitted with a mains indicator.

All drives are supplied with all the necessary cables, manual and a formatting disc. All drives are capable of operating in single or double density modes.

Single Drives:
1 × 100K 40T SS: TS100 **£85(b)**
1 × 400K 80/40T DS: TS400 **£125(b)**

With integral psu.
PS100 **£120(b)**
PS400 **£145(b)**

Dual Drives: (with integral psu)
Stacked Version:
PD200 2 × 100K 40T SS **£190(a)**
PD800 2 × 400K 80/40T DS **£265(a)**

Plinth Versions:
PD200P **£215(a)**
PD800P **£289(a)**

3.5" Drives: TS35 1 × 400K 80T DS **£99(b)**
TD35 2 × 400K 80T DS **£175(b)**

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Data Recording Products
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3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee Discs in packs of 10

40 Track SS DD	**£13 (c)**	40 Track DS DD	**£18 (c)**
80 Track SS DD	**£22 (c)**	80 Track DS DD	**£24 (c)**
3½" discs. Pack of ten	**£38 (c)**		

FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. **£14.50** (b)

DRIVE ACCESSORIES

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30/40 Disc Lockable Box **£14** (c) | 100 Disc Lockable Box **£19** (c)

MONITORS

MICROVITEC 14in. & 20in RGB
1431 Std Res **£165 (a);** 1431 Ap std Res PAL/Audio **£205 (a);**
1451 Med Res **£240 (a);** 1441 Hi Res **£389 (a);**
Swivel Base for Plastic 14"Microvitecs **£20 (c)**
2030CS Std Red **£380 (a);** 2040CS Hi Res **£685 (a)**
Plinth for 14in. Monitors **£8.50.**
Microvitec Monitors with TTL/Linear Inputs also available.

KAGA TAXAN 12in. RGB
Vision II Hi Res **£225 (a);** Vision III Super Hi Res **£325 (a)**
Green Screens; KAGA 12G **£99 (a);** SANYO DM811 112CX **£90 (a);**
Swivel Stand for Kaga Green **£21 (c)**
BBC Leads: KAGA RGB **£5** Microvitec **£3.50;** Monochrome **£3.50 (d)**
SANYO CD 3125 NB 14in. RGB Std Res **£169 (a)**

UV ERASERS

UV1T Eraser with built-in timer and mains indicator Built-in safety interlock to avoid accidental exposure to the harmful UV rays.
It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. **£59 + £2 p&p.**
UV1 as above but without the timer. **£47 + £2 p&p.**
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms. UV141 has a built in timer. Both offer full built in safety features UV140 **£61,** UV141 **£79, p&p £2.50.**

PRINTER BUFFER

This printer sharer/buffer provides a simple way to upgrade a multiple computer system by providing greater utilisation of available resources. The buffer offers a storage of 64K. Data from three computers can be loaded into the buffer which will continue accepting data until it is full. The buffer will automatically switch from one computer to next as soon as that computer has dumped all its data. The computer then is available for other uses. LED bargraph indicates memory usage. Simple push button control provides. REPEAT, PAUSE and RESET functions. Integral power supply. **£205** (a).
Cable set £30.

ATTENTION
All prices in this double page advertisment are subject to change without notice.
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Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

ACORN IEEE INTERFACE

A full implementation of the IEEE-488 standard, providing computer control of compatible scientific & technical equipment, at a lower price than other systems. Typical applications are in experimental work in academic and industrial laboratories. The interface can support a network of up to 14 other compatible devices, and would typically link several items of test equipment allowing them to run with the optimum of efficiency. The IEEE Filing System ROM is supplied **£282**.

INDUSTRIAL PROGRAMMER

EP8000.
This CPU controlled Emulator Programmer is a powerful tool for both Eprom programming and development work. EP8000 can emulate and program all eproms up to 8K×8 bytes, can be used as stand alone unit for editing and duplicating EPROMS, as a slave programmer or as an eprom emulator **£695**(a)

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

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

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	—
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
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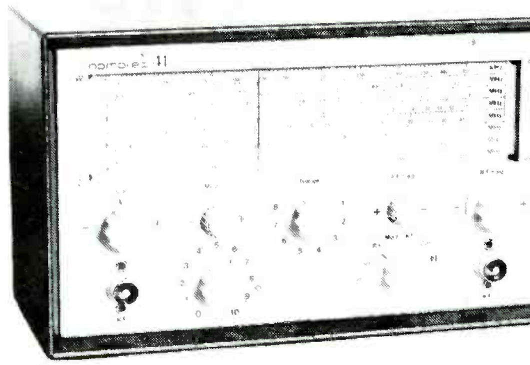

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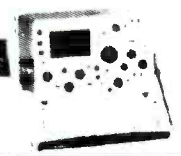

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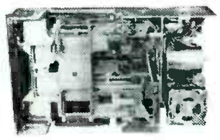

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Designing small transformers

by D. Baert *

The design of power transformers reveals one or two interesting observations

Although power transformers are plentiful, it is often necessary to design and construct a transformer to suit one's own needs. It is also very tempting to reuse the materials many amateurs already have, not only with conservation in mind, but from the cost point of view.

Winding transformer coils is not as difficult as one would think, since it can be performed with a simple drill and a lot of patience: mechanically or electronically counting the number of turns is necessary in order to avoid errors. The average amateur should be well able to solve all the practical problems.

I will describe a method for the calculation of small transformers which I have used for several years and which, in my view, gives more satisfaction than the methods commonly in use. Further, I will call attention to certain facts about transformers which are not well known.

Design

In general, the design of small transformers departs from that derived from the VA product to be delivered by the transformer. The VA product determines approximately the cross-section A of the core by means of formulas [1,2] of the form

$$A(\text{sq cm}) = C\sqrt{VA\ (\text{watt})} \quad (1)$$

with $C = 1.0 - 1.25$. If a guess is made of the transformer efficiency it becomes possible to determine approximately the primary and secondary turns, etc.

The constant C has something to do with the ratio of the weight of iron to the weight of copper. It has to be changed according to the application, for example 1.2 for constant full-load transformers to 1 for intermittent use. The formula gives an approximation of the core size and it is therefore useful. From the cross-section A it is possible to determine the number of primary turns n_1

$$E_1 = \sqrt{2}\,\pi f A n_1 B = \alpha n_1 \quad (2)$$

where f is frequency and B the maximum induction in the core material: a generally accepted value for B is 1 — 1.2 Tesla. For low-quality or unknown iron it is safe to take 0.8 Tesla to avoid excessive zero-load losses. Once B has been chosen, the constant α in (2) is fixed; α is the induced voltage in one turn of the primary. Equation (1) suggests that A is solely determined by the VA product, but one feels that this cannot be true, since in this case it would not be worthwhile to use high-induction materials.

The next step is to calculate the number of secondary turns n_2

$$n_2 = E_2/\alpha \quad (3)$$

Since the primary and secondary currents cause an internal voltage drop in the windings, it is normal practice to increase n_2 by a certain percentage, depending on the dimensions of the core or the VA product. A further step is to choose an allowable current density J in the coils. In general, J lies in the range 3.5 to 4 A/mm² for small transformers and it is taken smaller as the VA product increases.

Table 1 : current density

VA	0	50	100	200	500
J	4	3.5	3	2.5	

Once J is chosen it becomes possible to calculate the wire gauges d_1 and d_2. The final step is to make an estimate of the total area that will be occupied by the windings with their insulation. If this section is larger than the effective window space, a bigger core is necessary. Eventually it is possible to calculate the coil resistances.

The procedure for voltage-drop correction looks a bit like putting the cart before the horse because it is not very likely the result will be correct. The power in equation (1) is an average power and therefore, in systems with nonsinusoidal currents (rectifiers) or with intermittent current (filaments of gas-discharge tubes, impulse relays), the real voltage drop will be higher.

A different approach. The method I will demonstrate here is valuable, since it gives a more correct insight in the problem. As already noticed equation (1) is not exact. For intermittent operation, it is clear that (1) gives too big a tranformer. The question following from this is : what is the maximum power that can be delivered by a given core on the assumption that heating is not important?

Surprisingly enough, one finds that the most important part of the transformer is its window and not the iron.

Transformer design formulas

This method has been developed for the standard E-I laminations, but there is no reason why it might not be adapted to other core forms. As can be seen from Fig. 1(a), the dimensions of an E-I core are entirely determined by the width k of the central leg and the height h of the lamination stack. In order to get an idea of the process involved we calculate the total transformer resistance R'_2, referred to the secondary

$$R'_2 = R_2 + R_1\left(\frac{n_2}{n_1}\right)^2 \quad (4)$$

$$= \frac{4\rho}{\pi}\left[\frac{n_2 l_2}{d_2^2} + \frac{n_1 l_1}{d_1^2}\left(\frac{n_2}{n_1}\right)^2\right] \quad (5)$$

where n_1 and n_2 are the number of primary and secondary windings, d_1 and d_2 the respective wire gauges, l_1 and l_2 the mean length of turn (m.l.t.) and ρ the specific resistivity of the wire (1.72×10^{-8} Ωm at 20°C for copper).

If the lamination window is completely filled with the windings, one can obtain a transformer with minimum resistance. However, there is always a part of the window area lost because of the insulation and the winding former. Therefore, we introduce a filling factor V which takes account for these losses

V = total wire section/window area

$$= (n_1 d_1^2 + n_2 d_2^2) \,/\, \tfrac{3}{4}k^2 \quad (6)$$

It is assumed that the wire behaves as having a square section, since it is difficult to obtain winding configuration showed in Fig. 1(c). From (5) it follows:

$$R'_2 = \frac{4\rho}{\pi} n_2^2\left(\frac{l_1}{S_1} + \frac{l_2}{S_2}\right) \quad (7)$$

where $S_1 = n_1 d_1^2$ and $S_2 = n_2 d_2^2$. Due to (6) we can say that $S_1 + S_2 = S$ is constant for a given window area.

If it is assumed that m.l.ts of primary and secondary are equal, it follows that the minimum resistance occurs for $S_1 = S_2$: the copper areas of the primary and secondary coils have to be equal. The conditions of $S_1 = S_2$ also means that the current densities in both windings are equal. The minimum resistance follows from this fact

$$R'_{2min} = \frac{16\rho}{\pi}\,\frac{l_2}{S}\,n_2^2 = \frac{64\rho}{\pi}\,\frac{l_2}{k^2 V}\,n_2^2 \quad (8)$$

From Fig. 1(b) it can be seen that m.l.t. is $l_2 = 2\,(h + 2k)$, if the rounding-off at the corner of the coil is neglected. If the corners were rounded-off with circles this would become $l_2 = 2(h + 1.785\,k)$. Since neither formula is correct, the coefficient of k will lay somewhere between 1.8 and 2, but we have chosen 2. Mostly, transformers are wound with

* University of Ghent.

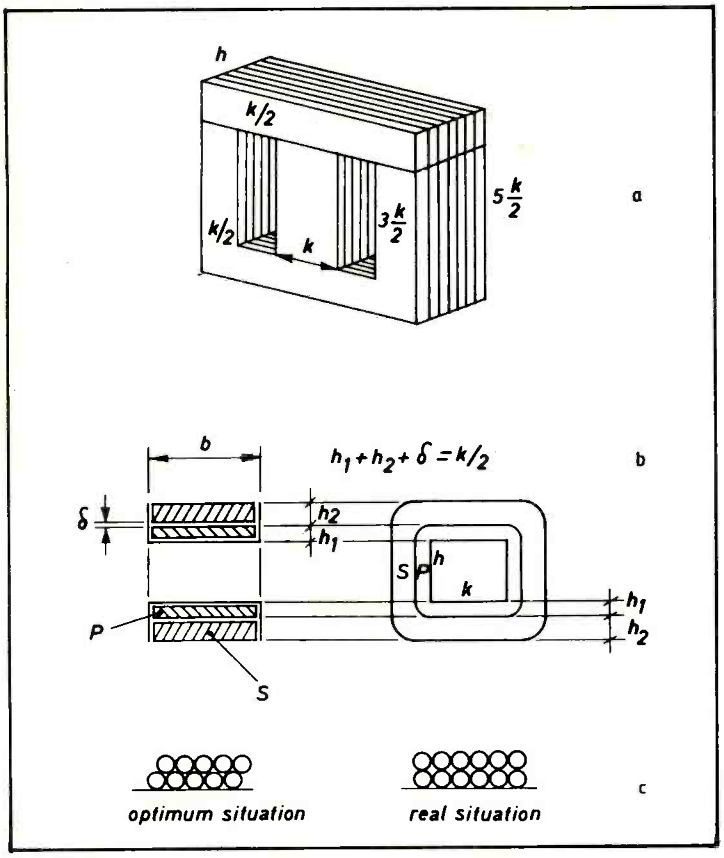

Fig. 1. **Typical E-I stack of laminations at (a). Calculating mean turn lengths shown at (b), and at (c) are the ideal and practical lays of turns.**

copper and eq. (8) becomes

$$R'_{2min} = 2.34.10^{-7}\ \frac{h + 2k}{k^2V}\ n_2^2 \quad (9)$$

$$\triangleq K_1 n_2^2 \quad (10)$$

For the more general case where we want to reckon with different m.l.ts l_1 and l_2, it can be proven that the primary and transformed secondary resistances have to be equal, so that S_2 has to be slightly greater than S_1. It appears, however, that the results only slightly differ from those obtained with equal m.l.ts. Equation (10) gives us a means for calculating the exact number of secondary turns that gives the required secondary voltage at a full-load secondary current I_2.

The secondary output voltage E_2 follows from the open-circuit voltage $E_{20} = \alpha n_2$

$$E_2 = \alpha n_2 - K_1 n_2^2 I_2 \quad (11)$$

The α-factor for the EI lamination is

$$\alpha = \sqrt{2}\ \pi\ Bfkh \quad (12)$$

One way to deal with a lamination stacking factor is by simply multiplying B with a constant factor. For instance, for 0.36 mm (14 mil) lamination, the stacking factor is about 0.9^2 and therefore we put 1.1B into (12). Note that B has to be expressed in Tesla or Wb/m^2.

The effect of n_2 on E_2 can easily be visualized (Fig. 2). For a given secondary current I_2, the output voltage is a quadratic function of n_2 with a maximum at $n_{2m} = \alpha/2KI_2$ and this maximum has a value of $\alpha^2/4KI_2$ volts. This is also the greatest possible output voltage that can be obtained at a current I_2 with the given core. However, the efficiency

$$\eta = E_2I_2/E_{20}I_2 = 1 - n_2KI_2/\alpha \quad (13)$$

is extremely poor under this condition, i.e. only 50%. Equation (11) determines the number of secondary turns needed for obtaining the voltage E_2 at a load I_2 by the intersection of the horizontal line E_2 with the parabola. For the two possible solutions for n_2, the one with the smallest n_2 also has the highest efficiency and therefore we take:

$$n_2 = \frac{2E_2}{\alpha + \sqrt{\alpha^2 - 4k_1E_2I_2}} \quad (14)$$

From Fig. 2 it is seen that E_2 cannot be higher than $\alpha^2/4KI_2$ volts i.e. the ultimate output power P_M is $\alpha^2/4K$

$$P_M = \frac{\pi^3}{256}\ \frac{B^2}{\rho}\ f^2\ V\ \frac{k^4h^2}{h + 2k} \quad (15)$$

The induction B and the specific resistivity ρ are material constants of the iron and the copper; the frequency is an operation parameter; k and h are dimensions. The maximum found above is an absolute maximum and it neglects factors such as heating. It is the output that can be obtained from a generator under matched conditions.

In practice, the current density will be limited and this determines the core cross-section. The only unknown factor is the value of V. The filling factor depends on the amount of insulation, wire gauge, wire insulation, winding formers, wire tensions, etc. In practice, V lies between 0.45 and 0.6. The smallest value holds for small transformers (e.g. k = 3 cm), because the amount of window area needed for the insulation etc. is relatively smaller for large transformers. It is wise not to overestimate V since, in that case, the window area could be too small for containing the windings. From a guess of V it is possible to determine approximate values of n_1, n_2, d_1, d_2. This gives a better guess for V since it becomes possible to determine the number of layers, the amount of wire insulation, etc. and the value of V will give better results.

The minimum resistance R'_2 follows from the fact that the available window area has to be filled completely, so that $n_2d_2^2 = S_2V$ and $n_1d_1^2 = S_1V$ and, with $h_1 = h_2 = k/4$,

$$d_2 = k\sqrt{\frac{3}{8}\frac{V}{n_2}}$$

$$d_1 = d_2\sqrt{n_2/n_1} \quad (16)$$

As already mentioned, the current density in the wires is equal for both windings and therefore it has the value

$$J = \frac{4\ I_2}{\pi d_2^2} \quad (17)$$

Example. Suppose $E_1 = 220$ V, $E_2 = 79$ V, $I_2 = 3$A, B = 1.1 T, f = 50 Hz. Choose h = 0.03 m, k = 0.035 m and a filling factor V = 0.5. Then $n_1 = 857$, $n_2 = 368$, $R'_2 = 4.94\ \Omega$, $E_{20} = 93.8$ V, $d_2 = 0.79$ mm, $d_1 = 0.52$ mm, J = 5.2 A/mm^2. Without the need for iteration the wire gauges can be rounded off to 0.8 and 0.5 mm. This will barely change the filling factor, since a variation δ of a diameter in (6) will give the variation in V :

$$\delta V = \frac{8}{3k^2}(n_1d_1\delta d_1 + n_2d_2\delta d_2).$$

If, for example, $d_1 = 0.52$ mm were rounded-off to 0.50 mm, we obtain a variation

$$\delta V = \frac{8}{3k^2} \times 857 \times 0.52 \times 0.02 = 0.0194.$$

This means that the only effect of the rounding-off is a small increase in primary resistance. However, for the transformers with very small wire sizes the δV is large since δd is comparable with d. Further on it becomes difficult to fulfill the second equation (16) and thus the departure from the minimum resistance case will also be larger.

In this example the current density is too high for continuous operation, hence a larger core is necessary.

Transformer with leakage inductance

It can be shown that for the type of winding under consideration the leakage inductance L_0, referred to the secondary (Fig. 1(b)), is

$$L_2 = \mu_0 n_2^2\ \frac{1}{B}\left(1 - \frac{a}{\pi b}\right)\left(\delta + \frac{h_1 + h_2}{3}\right)$$

where l = m.l.t. and $\mu_0 = 4 \times 10^{-7}$, the permeability of free space. Although the amateur seldom reckons with leakage inductance, it is possible to extend the previous theory. It is interesting to note that both R'_2 and L_2 are proportional to n_2^2. One can therefore define a time constant L_2/R'_2 for a given E-I transformer core

$$\frac{L_2}{R'_2} = ct.k^2.$$

The equation explains why L_2 is neglected for small transformers: L_2 is proportional to the square of the central-leg width. High-power transformers are therefore specified by their short-circuit impedance which is always inductive. The same reasoning holds for the inductance to resistance ratio of pot-cores and other inductors. It seems that the time-constant is in fact a fundamental quantity of transformers, coils, relays... Since in some way the same reasoning is true for straight filaments one can see that the smaller a system becomes the faster it operates.

Since the current density is the factor that determines the nominal transformer power it is possible to increase the transformer output for the same core cross-section by using a larger window.

It is well-known that the E-I lamination is used because it is generated by an economical cut of the iron sheet. But if we depart from this requirement it should be possible to make laminations with a very large window which allows a high current density. The cooling surface of the coil can be sufficiently increased by using a small but long window. There are of course practical limits : the magnetizing current increases since it is inversely proportional to the magnetic path length. In combination with a greater core volume this gives bigger zero-load losses. Otherwise, from the same reasoning, it follows that it should be possible to use a very small core-area with a large window area for a given power. The drawback here is that the leakage inductance increases because a lot of lines of force close the magnetic path through the air (especially for the part of the coil outside the window). The question that now arises is : "what is the real function of the iron"? At a first sight one is tempted to say that the power is transferred from the primary to the secondary through the iron, but since the lamination window seems to be more important it is doubtful if this is true. Equation (2) partly gives an answer : the induction in the iron is only determined by the primary voltage, frequency and turns number. This means that the conditions in the iron are independent of the loading conditions of the transformer! In other words, no power at all is transferred through the core. The only reasonable way to get out of the problem is to accept that the power is transferred outside the core in the air between the coils. As strange as this seems, it can be explained by referring to Poynting vectors and the electric and magnetic field outside the core. It has several times been stated in *W.W.* that the electric energy transported by wires is found between the wires and not in the wires and the transformer is the magnetic analogue for this situation.

Multiple secondaries

Frequently, the transformer has multiple secondaries. It is difficult to perform the calculations as before because each secondary current has its effect on the others through the common primary resistance. By neglecting the effect of the currents on the secondary output voltages the following rules can be found:

- the total primary copper cross-section has to be half the window area or $S_1 = \frac{1}{2} S_W$.
- the secondary cross-sections S_j are taken proportionally to their powers :

$$S_j = S_1 . \frac{P_j}{P_1} .$$

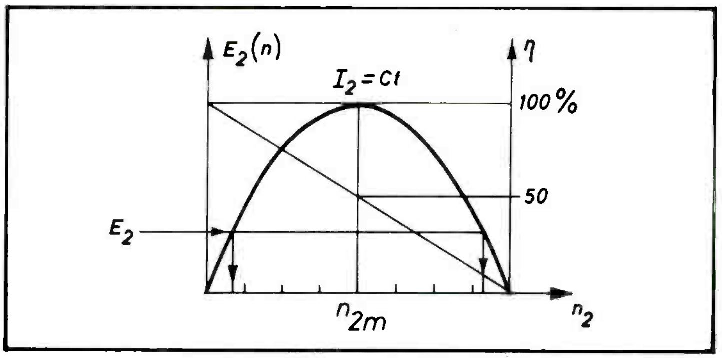

Fig. 2. **Variation of secondary turns on secondary voltage, for a given secondary current.**

In the same way as before the secondary turns can be found by imposing secondary output voltages at the given currents. It is a pity that the more practical cases of transformers used for rectifiers cannot directly be handled in this way. First, the currents are only partly sinusoidal and the conduction angle of the rectifier depends on the load, ripple capacitor and the transformer resistance. Secondly, if several secondaries are used, each with different rectifiers, the conduction angles are different. The amateur using steady-state transformer data is often disappointed by the results in stabilized rectifier circuits. The experienced amateur knows that choosing a transformer rating based on the sum of the d.c. powers is not sufficient. In many caes, the minimum value of the ripple voltage is too low in order to obtain good stabilization and increasing the ripple capacitor is of no help. These effects are of course due to the transformer resistance. The design of a transformer for such pulsed waveforms can only be correctly done by using the rectifier design curves of O.H. Schade[3]. It is possible to combine a part of the method above with the rectifier curves in order to obtain the correct number of secondary turns.

References

1. Langford-Smith : "Radio Engineers Handbook", Iliffe, 4th ed., p. 233-241.
2. ITT Reference Handbook, 4th ed., p. 273-282.
3. Schade, O.H., "Analysis of rectifier operation", *Proc. IRE*, pp. 341-361, july 1943.

BOOKS

Lisp, the language of artificial intelligence by A.A. Berk. Collins, 160 pages, soft covers, £9.95. A useful introduction. Examples are based on the Acornsoft implementation for the BBC Micro.

Assembler routines for the 6502 edited by David Barrow. Best of PCW series, Century Communications, 180 pages, soft covers, £7.95. Easy-to-use, documented assembly-language routines contributed by readers of *Personal Computer World*. Topics include mathematical routines, delays, extra instructions, searching and sorting, check sums and parity coding, data compression.

Assembler routines for the Z80 edited by David Barrow. Best of PCW series, Century Communications, 192 pages, soft covers, £7.95. The mixture as above but in Z80 code and with some extra graphics routines.

Introducing Amstrad CPC464 Machine code by Ian Sinclair. Collins, 184 pages, soft covers, £8.95. Getting started in Z80 code on Amstrad's home micro.

Introducing MSX Assembly Language and Machine Code by Ian Sinclair. Collins, 184 pages, soft covers, £8.95. Same again but adapted for the Japanese MSX micros, thanks no doubt to the search-and-replace facility on the author's word-processor.

The Amstrad CPC464 Disc System by Ian Sinclair. Collins, 120 pages, soft covers, £7.95. Discs for beginners, using Amstrad's DDI-1 3-inch drive, with details of the AMSDOS and CP/M operating systems. Program examples include a selection of disc utilities and a database. A chapter on printers shows how to use some popular models.

The Century Computer Programming Course for the Commodore 64 edited by Peter Morse and Brian Hancock. Century Communications, 340 pages, soft covers, £10.95. Thorough treatment of Commodore Basic from a team at the Central London Poly. Attractively presented, with many useful example programs and exercises.

Commodore 64 Omnibus by Peter Lupton and Frazer Robinson. Century Communications, 502 pages, soft covers, £9.95. Omnibus edition of the authors' two previous C64 handbooks, covering Basic, sound, graphics and disc storage.

Principles and Practice of Multi-frequency Telegraphy by J.D. Ralphs. Peter Peregrinus on behalf of the Institution of Electrical Engineers, 205 pages, hard covers, £25 (abroad £32). Designing and using multi-frequency-shift-keying communications systems, by the leader of the design team of the first Piccolo equipment. Chapters cover history, basic principles, theory, design procedure, synchronisation, practical matched filters, error coding and special m.f.s.k. systems.

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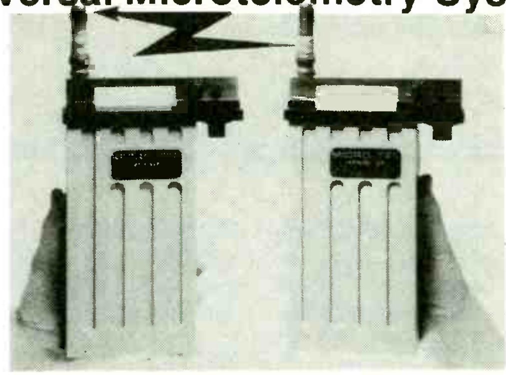

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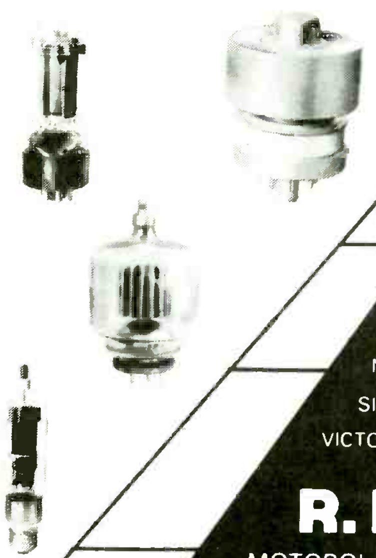

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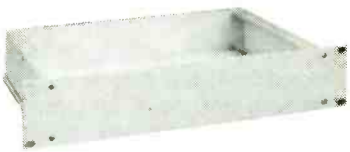

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Video displays — 2

More on text/graphic displays together with a brief product selection.

The cathode ray tube's broad range of resolutions and screen sizes, high luminous efficiency, and proven performance and reliability, competitive pricing per character, as well as the capability of both full colour and grey scale, give it a position so strong that it will be difficult to dislodge. Also, anti-aliasing and windowing techniques are much more effective with cathode ray tubes.

The trouble with computer graphics is that its images are only two-dimensional. A variety of computer-driven applications would benefit from the additional realism of a third dimension, not least the modelling of engineering components, flight simulation, medical imaging, scanning electron microscopy, computer games and the representation of large molecules. It was this last-mentioned application that brought authors Harris, Geddes and North of Leeds University's department of biophysics to a recent IERE conference on the latest developments in colour research to describe their technique for 3D visualization of insulinoid proteins. This uses a conventional display, a pair of special switching spectacles and a box of electronics.

Three-dimensional graphics

Stereoscopic vision involves the brain perceiving depth cues from several sources — the focusing and binocular convergence mechanisms, perspective and illumination of the object, image behaviour under object rotation, obscuration of parts of the scene, and binocular disparity. Normally, a weighted combination of these cues is used to construct a three-dimensional representation, but in viewing a near planar screen the focus cues are absent and other cues must be used to give an impression of depth.

Monocular intensity cueing, which works by simulating a light source in front of the observer and increasing the image intensity along the z-axis, is simple to apply on equipment with an intensity control. But some observers see an 'enantiomeric' image, with the brightest parts farthest away. Dynamic depth cueing, achieved by rocking or rotating the object, can give front-to-back ambiguity (though intensity cueing would resolve it). In the perspective approach, where the size of the image is reduced with object distance, judgement of distance is difficult and not very accurate. And the most powerful of the depth cues, obscuration, is far too time consuming for interactive graphics. Though all these monocular effects can be useful, the conflict between cue and the binocular information that the image is really flat limits their utility. Clever tricks can reduce the conflict, but the effects produced by binocular techniques are more powerful.

The thing to do is to emulate stereoscopic vision by generating two images and rotating one through an appropriate angle, contriving to have each viewed by the respective eye. One method is to separate the two images laterally on the screen and to direct light from each onto the appropriate eye using one of a variety of optical systems. But besides the possible inconvenience of attaching these to the screen, it is difficult to cater for more than one observer, and only half the screen is available for each image.

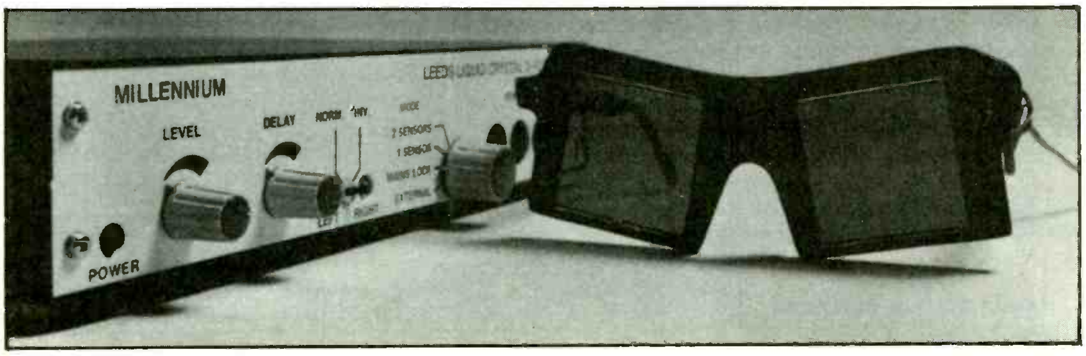
The popular way around these difficulties is to use the two-coloured images — usually red and green — and view through two-colour spectacles. With this the whole of the screen area is available for both images.

But the information content of a full colour image is clearly lost, whilst at the same time requiring a system colour capability.

A frame-sequential technique called tachistoscopy doesn't suffer from this snag; the left and right images are displayed alternately while the unwanted image for a given eye is suitably blocked. Mechanical devices were originally for this purpose but they are generally much too slow. The alternative is an electro-optic shutter. The first kind tried, based on the birefringence of lead-lanthanum zirconate-titanate, suffered from low translight transmission (17%) and an uncomfortably high operating voltage of 500V. But authors Harris, Geddes and North described a fluid crystal cell that operates from only 30V and which doubles light transmission.

A twisted nematic liquid crystal is sandwiched between two crossed polarizers so that incident light polarized by the front polar is transmitted by the rear one, having been rotated by 90° by the cell. An alternating voltage pulse applied across the cell switches it to its opaque state, (a direct voltage would discharge the cell), the pulse being initiated by a photodetector attached to the screen. Two photodetectors operate on alternate cycles, one triggered by a symbol that accompanies one view and the other by a second symbol that accompanies the other view. This opto-coupling avoids the need for access to the screen circuitry; apart from a few lines of software, the method is independent of the v.d.u.

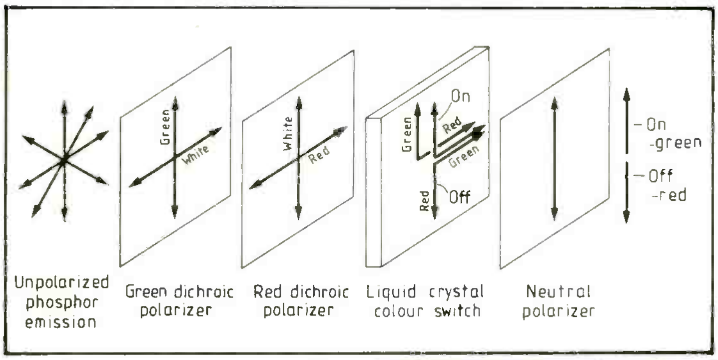
One of the problems with the rapid switching rate of once per refresh, or once per interlace cycle, is the relatively long relaxation time in returning to the clear state, brought about by a kind of kick-back in molecular orientation in the opposite direction. A technique called dual-frequency addressing, developed by Clark & Shanks at RSRE, Malvern, helps out here, increasing speed of recovery by forcing the



Leeds University's 3D viewer can produce stereoscopic images from c.r.t. displays, and in principle could be used for television if flicker were not such a problem.

long axes of molecules perpedicular to the field with an h.f. pulse applied at a suitable time. This is made possible by choosing a material having a permittivity in the direction perpendicular to the molecule greater than that in the parallel direction. (The material actually used, supplied by RSRE, had a $\Delta\epsilon$ of 2.95 at 200Hz and −1.8 at 100kHz, crossing over at 5kHz.)

This idea*, currently being exploited commercially by Millenium of Stevenage, lends itself to multiple viewing — up to four pairs of spectacles can be connected to the somewhat expensive electronics box — but the suggestion of using a single screen-sized cell with polarizer and viewing through passive spectacles fitted with orthogonally polarized glasses is interesting, if impractical at present.



Colour displays from 'mono' tubes

Another use of the switched liquid crystal technology has been pioneered by Tektronix for multicolour field-sequential displays from high resolution 'monochrome' tubes. The tube for use in this scheme is a single-gun type with no shadow mask but has a phosphor with two emission peaks that are typically, but not limited to, red and green. The resulting yellow light is passed through two colour polarizers arranged to transmit only red polarized light on one axis and only green on the other, orthogonal, axis. The liquid crystal cell that follows rotates the polarization plane by either zero or 90° depending on which colour field is selected by the synchronizing circuitry. A linear polarizer is finally required to provide the blocking ability.

The resulting alternating red and green fields integrate in the observer's eye and can create any colour on the red-green line. A different colour-polarizer pair and phosphor mix could produce other colours, though still only based on two primaries rather than three.

Tektronix' cell is different from the earlier kind; called a pi-cell, (it derives its name from a 180° twist during relaxation) its chief benefit is in the simpler driving waveform (no h.f. pulse is required), but it does have tighter manufacturing tolerances. The technique is still only used in the model 5116 colour display oscilloscope and could clearly be applied in other traditionally 'mono' display situations; however Tektronix say their shutter is not available for use outside the USA.

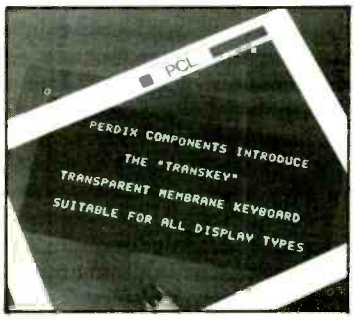
* The same idea has also been suggested for use in television, see *IEEE Trans* vol. CE-31 1985, pp. 82-87, though its not clear how the problem of flicker is overcome.

Versatile touch screen

Interactive displays, in the form of touch-sensitive screens, are especially useful in situations where a simplified man-machine interface is required. A new touch screen, called the Transkey, has been jointly developed by British companies Perdix Components and Global Engraving, a London-based specialist in screen printing. The screen has been initially developed using a Densitron plasma panel that displays 25 lines of 80 characters per line, but its developers say it can be used with wide variety of display technologies, and can be easily customized for specific requirements in the space of about two to three weeks.

Transkey is a transparent-membrane touch panel mounted in front of the display consisting of a normally-open transparent-membrane switch. The basic switch is made of two layers of optical-grade polyester film, with a coating of electrically conductive indium oxide sputtered across the surface of the film. Sputtering of the oxide ensures an even coating, essential, says Rodney Tietjen of Perdix, both to give a repeatable resistance measurement and a good optical finish. Indium oxide has a high transparency and a typical Transkey panel is 85% transmissive.

To manufacture a given switch separate rows and columns are formed onto two sheets of the polycarbonate film by a method devised by Global Engraving. (At this stage is it of manufacture possible to specify the switch operating pressure). The two halves of the switch are separated



by a unique system of transparent dots; silver ink tracks are screened onto the polycarbonate film to form the conductors from the switch matrix to the flexible tail connectors. The two halves of the switch are now laminated together, forming the complete Transkey.

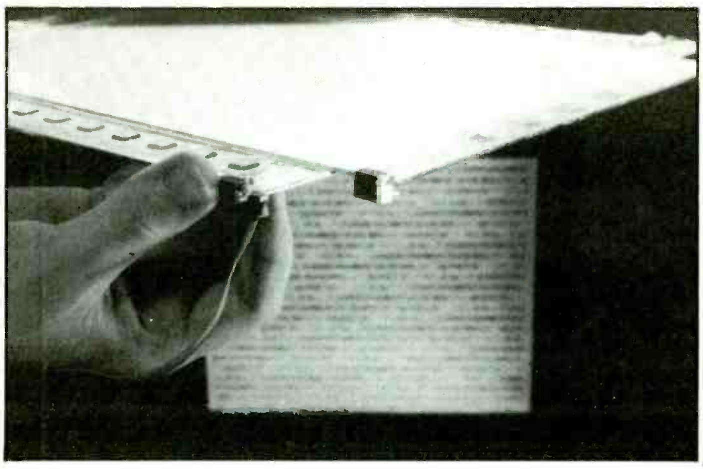
The switch can be unsupported, or laminated onto an acrylic substrate, which can form the colour filter for the display.

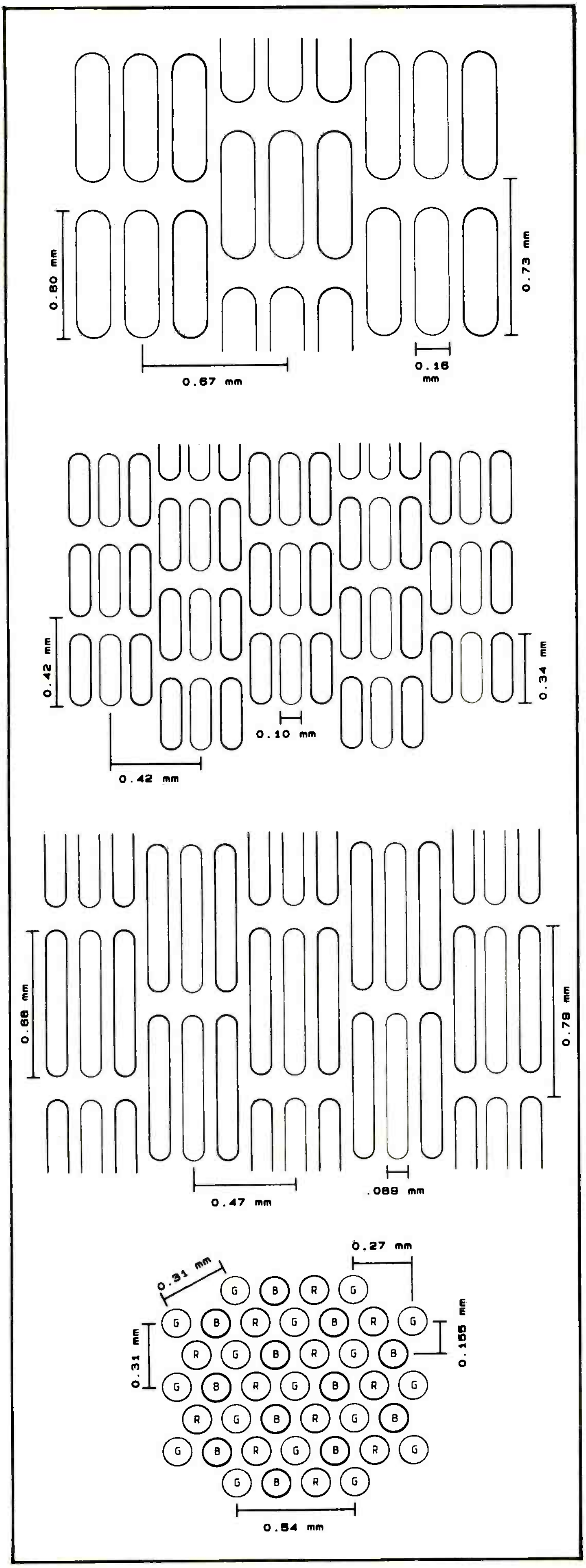
Recent reading

- Colour in Information Technology and Visual Displays, IERE Conference, University of Surrey, 1985. (Results of recent research in colour perception and applications).
- Dictionary of Computer Graphics by John Vince. Francis Pinter, 1984. £15 hard cover. That's 7.5p per entry. . .
- VDU Health & Safety. Tape/slide programmes on health, safety and ergonomics, Audio Visual Services, Loughborough University £395.
- Health Hazards of VDTs? Loughborough University of Technology conference proceedings, 1980 & 1981, edited by B.G. Pearce. Wiley, 1984. (Health hazards, ergonomics, rediation emission, stress, ion generators.)
- Hazards of Visual Display Units, GLC London Hazards Centre at the Polytechnic of the South Bank, London SE1. Information pack £1.
- VDUsers, RoSPA, Birmingham £0.70.
- New Technology: a health and safety report, APEX, 1985. 22 Worple Road, London SW19.
- Health effects of VDUs: a bibliography, Health and Safety Executive, 1984.
- Visual Display Units, Health and Safety Executive, 1983. HMSO £5.
- Limits and measurements of spurious signals generated by data processing and electronic office equipment, BS6527:1984.

Non-multiplexed fluid crystal displays

Increased use of multiplexing as display size is raised results in reduced contrast and restricted viewing angle in plasma and twisted-nematic phase displays. This has resulted in many laboratories, Britain's GEC-Marconi included, persuing the active matrix approach, with the need to deposit thin-film transistors directly onto glass. STL, Harlow, are developing an alternative bistable smectic-phase 760 by 420 display in which the crystals do not degrade back to the liquid but remain in place almost indefinitely. This means that elements are written only once, that contrast is good, and that viewing angle is almost hemispherical. As with other liquid crystal and plasma panels, the driver chips can be cemented directly onto the glass surface.





Screen-centre drawings of a typical range of colour tubes all to the same scale (35 times actual size). Top is of 33cm consumer-type screen, next is a 33cm medium resolution line centre, next a 48cm medium resolution centre, and bottom, a high resolution centre, all from RCA's 1984 industrial and office range.

Switch encoding can be simply carried out using standard row/column multiplexing techniques, and de-bouncing by means of a simple RC filter and c-mos buffers. A purely resistive analogue Transkey is now under development.

Tube developments

A new graphics display designed for 64kHz-based computer-aided design and manufacturing systems features Matsushita's 'overlapping field-gun tube. Available from Cameron Communications, who import Barco equipment from Belgium, the display is a high resolution RGB monitor with 0.31mm dot pitch aimed at graphics workstations costing up to £35,000, where typically the user can specify the monitor.

According to Barco, the starting point for this design was resolution — dependent on c.r.t. technology, memory chip prices, availability of and fast c.r.t. controllers. Controllers scanning at 1065 lines and a non-interlaced rate of 60Hz, chosen to give improved resolution in windows, flickerless pictures and increased light output, dictated the scan rate of 65kHz (variable from 43 to 77kHz).

With a target of 1280 addressable elements per line (1440 for the higher resolution 0.26mm pitch version) a video scan time of 12μs means a pixel time of 10ns, putting clock rate at 100MHz, and which led to Barco setting bandwidth at a conservative 120MHz, achieved by using class — A u.h.f. transistors, generally well-defined modularity with a floating output amplifier on separate boards, minimal interconnections and d.c.-controlled contrast and brightness, and a sharpness booster that allows optimization of risetime to clock rate.

The display's performance is further enhanced by the use of the 'o.l.f.' in-line tube. This tube features an overlapping field gun, developed to improve the resolution of in-line guns whose beams were more spread out than in delta guns. The lens structure chosen has a single aperture of overlapping circles rather than three separate holes, allowing the main lens to be effectively enlarged without widening the beam separation. Edge resolution is also improved by adding an amount of astigmatism to the main lens as a pre-correction for yoke astigmatism, with the result that overall resolution has been was improved by 20% over its predecessor. Since then, the lens has been simplified with the help of computer-aided simulations, and is now an elongated circular aperture, and the gun has also been simplified by making the third and fourth electrodes identical.

The Matsushita tube is also used in Panasonic-brand displays of course, and no doubt others too, as the company claim to be the world's largest maker of display tubes.

Hitachi and Nippon Electric are also at the forefront of high resolution colour tube technology. NEC claim to have the world's first super-high resolution tube in production with a dot pitch of 0.21mm, following its ultra-high res. tube of 0.25mm. The tube, which can display 40 kanji characters per line in a 24 by 24 dot matrix, contains phosphor dots of only 80μm — so small that at a viewing distance of 40cm they are beyond the limits of visibility. Therefore, argue the tube's developers, the ultimate limit in fine-pitch tubes has been reached: tubes with finer pitches would be ineffective besides incurring extremely high cost. The achievement is largely due to the use of a 'tilt array' mask, in which only the vertical pitch is pre-distorted so avoiding the moiré interference with displayed vertical lines that would occur with NECs earlier variable pitch mask. Meanwhile Hitachi have produced a super-high res. tube with a shadow mask of an astonishing 0.15mm pitch. Details are not available but a preliminary spec. for a monitor using it indicates a bandwidth of 240MHz and a resolution of 2448 by 2046.

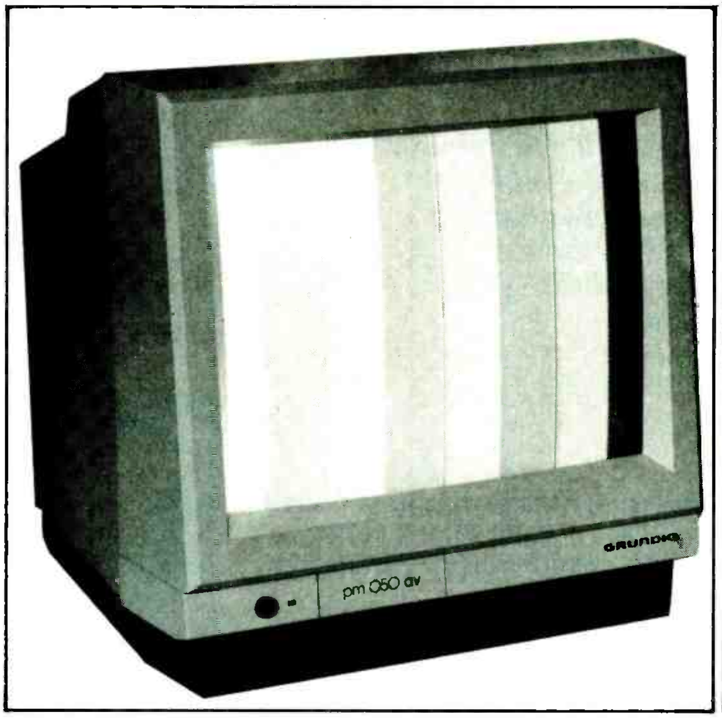
Product briefs

- In excess of 1280 by 1024 lines in a non-interlace mode can be displayed on Mitsubishi's C-9918 monitor. At the forefront of their range of high resolution monitors, the C9918 has a 0.31mm dot pitch and in-line gun. Probably with the highest resolution achived for a colour display in mass production, and have high hopes that it will soon become an industry standard. Though it's not the end of their line: models with resolutions of 2000 by 2000 lines and a video bandwidth of 200MHz are scheduled for introduction in the near future.

But there is more to monitor quality than simply resolution, as Ralph Zariah of Mitsubishi puts it, which should only be taken as a means to an end. Two other areas where Mitsubishi have made inroads are with focus and convergence. A 'multi-step' focus feature, which uses two focusing potentials 28 and 33% instead of one of 20% claims to give noticeably better focus. Convergence error of the 9918 model is quoted as 0.3mm in a central circle equal to the picture height and 0.5mm outside, but a second option uses a digital convergence technique that offers 0.3mm all over the screen. The digital approach to accurate beam positioning allows either factory setting or user setting of convergence: a small keyboard and processor generates the convergence test patterns.

• By now Grundig's new range of FST/Euroconnector monitor/tv sets, to which a 66cm model has recently been added, will no longer be news. But what may be new to many readers is the availability of Grundig's professional and industrial monitors in the UK. The monochrome range includes video monitors with 31 to 61cm screens for 625 or 875-line operation, and 31cm t.t.l.-input o.e.m. data monitors with up to 416 lines per field and 25MHz bandwidth. As well as 51 and 66cm standard-resolution industrial monitors for RGB and composite video inputs and a colour receiver, the colour monitors feature the 36cm PM series for computer use (t.t.l. inputs). The series has 12MHz bandwidth at three resolutions — using tubes of 0.53mm-pitch slot mask and FST, 0.39 medium res. with dot mask for 80-character lines, and 0.31mm high res. for 132 characters. One version (PM050AV, £374), is equipped with a fine array of sockets — 12 in all — whilst another (PM415) features a high res. FST and will be available later in the year. These monitors, most of which are available in cabinets or as o.e.m. chassis, are not handled by Grundig International, but by telecommunication engineers J.O. Grant & Taylor (London) Ltd of Potters Bar, a member of the Cray Electronics Group.

• Data Distributors Ltd of Ascot are sole UK distributor for Taxan-brand monitors made by Japan's Kaga Electronics. Their range includes standard composite video mono in three phosphors, IBM plug-compatibles in two phosphors, three general-purpose RGB monitors in three resolutions, and IBM and QL-specific models. In addition a number of colour graphics cards are available for Apple.



Computer monitor range from Grundig Electronic has models of three resolutions, one with an FST, another sporting 12 sockets, including Scart, BNC, AV, DIN, Japanese standard, and, later this year, a 0.31mm FST monitor. Shown is the PM050. Monochrome monitors are also available for video use and for t.t.l. input. From J.O. Grant & Taylor (London) Ltd. of Potters Bar, not Grundig International.

• The Manitron division of Ficention, an independent company founded six years ago, produces quality high resolution monitors and boasts one of Europe's leading design teams. In addition to making a range of standard products, e.g. the VLR series, the company offers a service of consultancy and custom design. The standard units include both portrait and landscape monitors with sizes from 5 to 26 in, and line rates up to 125kHz and frame rate to 120Mz. Manitron also supply the Indesit range, including an Apricot-compatible AP1200.

• Flat-square high resolution tubes are now supplied by Mullard in development sample form. There are three tubes: a 15in 110° type similar to M38-328, a 12in 90° tube with P31 phosphor resolving 1200 lines, and a 14in 90° type resolving 1300 lines.

• Philips Consumer Electronics have four models in te 8500 series of 14in colour monitors, starting at £200. One model is medium resolution (the rest standard) for 80 character use and the range features adjustable stands and anti-glare screens on some models.

• Radec-brand monitors, presently available only in monochrome, will shortly be joined by colour models. Marketed by Citadel Products of 50 High Street, Edgware, their 12in model 101 has a 1100-line resolution (screen centre, 900 at the edge), a bandwidth of 22MHz, and sells for £70.

• Digisolve specialize in custom design and modification of v.d.u. and graphic display controllers, and

Prototype colour monitor designs

Laboratory reports that include printed circuit layouts are available for a range of new designs developed in Philips application labs. For those who wish to build only a few or assemble a prototype quickly, complete kits for some designs will be available from Hawnt Electronics at Firswood Road, Garretts Green, Birmingham, (021-784 3355).

Code	Dot pitch (mm)	Tube (size)	Scan rate		Video rise time (ns)	Report ref
			Line	Field		
C165	0·42 (in-line)	M34EAQ	16	50,60	37·5	—
C161	0·28	M25-100	16	60	40	EDS 8203
C164	0·29	M37-103/8/11	16	50,60	30	EDS 8051
C242	0·29	M37-103/8/11	24	50,60	12·5	EDS 8402
C322	0·29	M37-103/8/11	32	60,70		—
C323	0·31	M42-106*	32	60,70	12·5	EDS 8306
C452	0·29	M37-103/8/11	45	60,70	9·5	—
C641	0·32	M48JFJ/JGN64	64	60	5	EDS 8401

*Also M51-107

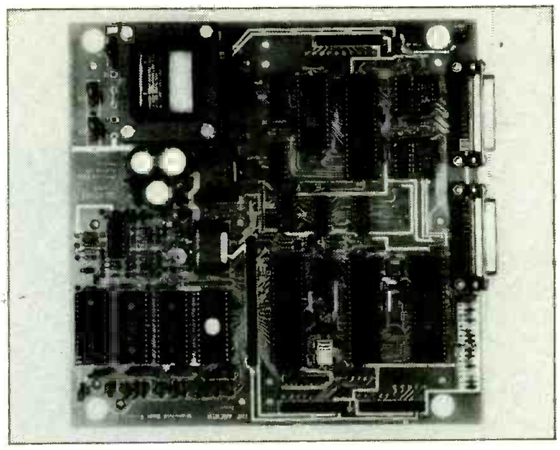
VDU-1 board has formed the basis of a number of terminal designs. The board requires a parallel or serial keyboard, a 15MHz monitor and power supply and with double-Eurocard format fits conveniently on a 12in monitor chassis. Screen format is 80 or 40 by 24 or 12 using an 8 by 12 matrix for 96 acsii plus 32 block characters. Video output is either CCIR or t.t.l. drive and the board accepts current loop and RS232 inputs up to 19,200 baud.

Another standard for which we have to thank IBM is the interconnection between monitor and source, via 9-way D-type plugs and sockets.

Pin	Signal
1	0V
2	0V
3	R
4	G
5	B
6	intensity
7	not used
8	horizontal sync
9	vertical sync

All the signals are t.t.l.-driven, so the length of cable used must be kept down. The intensity bit extends the number of colours to 16.

The Archer Z80 SBC



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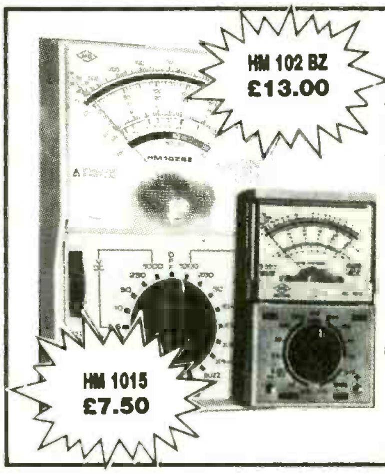

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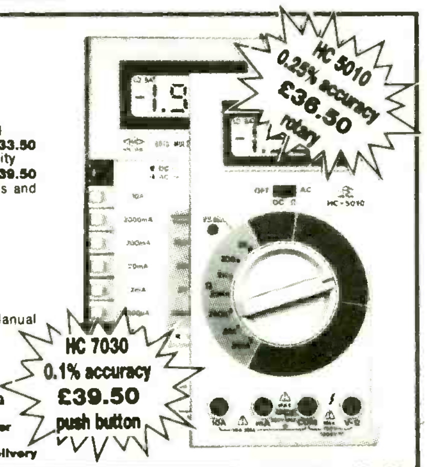

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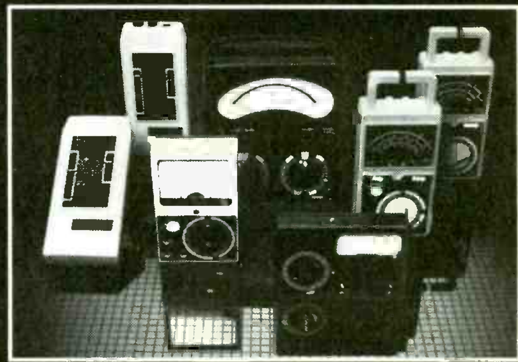

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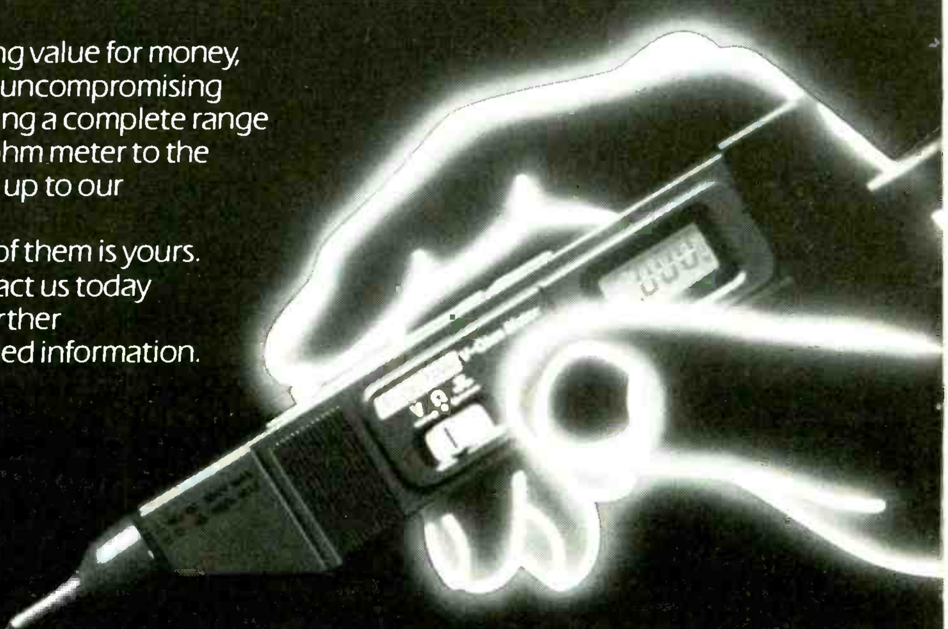

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Test with total confidence

Vehicle electronics and development

by R.E. Young, B.Sc.(Eng.), F.I.E.E., M.R.Ad.S.

British innovation in the development of electronics in road vehicles illustrates the use of high-calibre all-rounders in small teams, rather than the relatively high-cost 'mass-attack' approach.

With the gathering dusk of autumn, the decline in the car's performance began. Switching on the headlamps with overdrive in produced not only a drop in speed but also a tendency for the headlamp beams to become little more than a dull red glow. Clearly the electrics had deteriorated, but fortunately a threshold in the deterioration seemed to have been reached; and the journey was completed *with* headlamps and *without* overdrive and its demand for solenoid operating current.

Such an incident is within the experience of many motorists; but, as will be shown later, was not a simple matter of battery, generator or even charging control. It did, in fact, open up a piece of investigation which formed an early part of the private venture work to be described in the next section.

Some years before, another, but comparable, car suddenly stopped; but after a few minutes, started again and then continued to run without trouble for some thousands of miles before the fault recurred.

In this second case, the stop condition was maintained for a period long enough for a passing road patrol to join in and suggest that almost beyond doubt it was "the Condenser" — the capacitor across the ignition contact-breaker. Moreover, he extended advice into practice (the engine in the meantime having restored itself to life) and pointed out a garage just down the road where apparently they had extensive experience of the problem, and were almost certain to have the correct replacement. This indeed proved to be so: the substitution was made, the engine started instantly, the car moved happily off; and some four hundred yards further on, stopped dead. This time it became quite evident that it had stopped, and that the intermittent fault with a one-shot periodicity of about two years had become 'solid'.

Again, such events are not unknown in the motoring world; but usually the car has either been disposed of or all components in the suspect area changed before any iinvestigation could be carried out. Such investigations — essentially long term — are, however, necessary if the fundamental cause of these obscure-faults is to be determined and something done about them.

Thus, one of the main factors in the choice of these two case histories is that they both proved to be examples of design shortcomings best described as being electro-mechanical in nature; but which — as will be seen — were completely unavoidable in the circumstances.

The more straightforward illustration of how design faults arise and how they fail to come to light, is afforded by the second example quoted. In this instance, once the failure stayed on, it was traced to a break in the connection between two terminal posts on the distributor base and was cleared by putting in a conducting link between the two terminals. This was not quite the simple matter it might appear, since this link had to be made of flat strip; thin enough for the distributor rotor arm to clear it. Possibly in order to give this mechanical clearance, the link had been made of a piece of soft copper wire moulded into the distributor base. Assembly presumably depended on the equivalent of a cold weld being produced when the terminal posts were screwed in to the threaded holes to give an 'interference-plus' fit with the ends of the wires where they protruded through the walls of the holes.

That this was not entirely successful as a permanent form of connection is somewhat surprising; and it says much for the makers that some twelve months later they were found to have substituted a flat (external) link for the moulded-in wire in production distributors, i.e. they had located, and cleared, a fault which, on the face of it, could not have happened.

This question of obscure fault which, technologically speaking, can be dismissed as utterly trivial, but which can be literally catastrophic in effect, runs through the whole of development engineering. An extreme example was seen recently (April 1985) in the failure to bring a multi-million-dollar communication satellite into operation, and its total abandonment, because of a single faulty switch. At a somewhat different level (but with correspondingly large amounts of money being ultimately at stake), the British car industry has demonstrated how far-reaching the effects of the trivial, but obscure, fault can be.

An account of advances made at Jaguar Cars in quality control deals with reliability problems encountered with components obtained from outside suppliers. A large proportion of these fall either into the category of electrics or that of electrically associated electronics. A particularly apt statement is that a new connector had been developed for ". . . linking two wires together

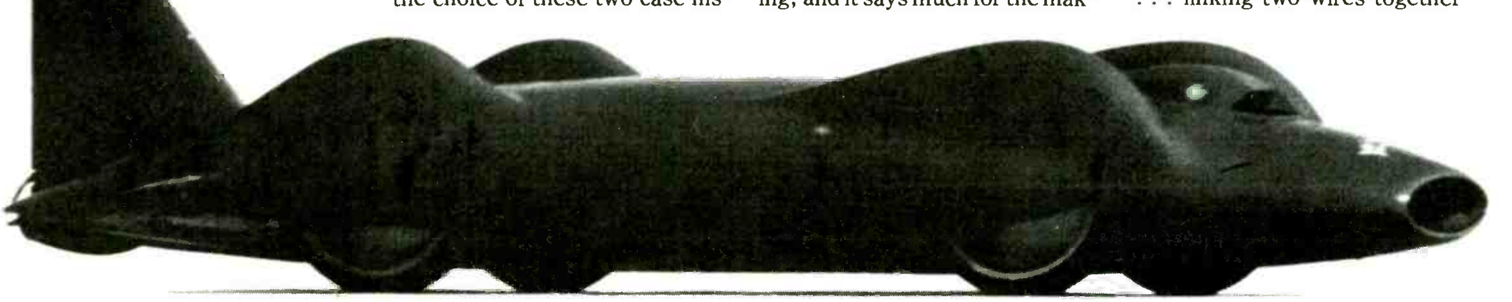


Fig.2. **Campbell's Bluebird at record breaking speed in Australia.**

that cannot shake loose and so lead to those infuriating intermittent faults that are so difficult to trace". Other examples of low-level design faults and their clearance included the changing of contact ramp angles to achieve full reliability of winker/wiper control stalks — not an obvious solution. Neither was the identification and replacement of a switch as the cause of the unserviceability of electric window operation, obvious.

The inherent intractability of so many faults encountered in complex systems has already been brought in at several points in this series of articles, notably in the first of them[2], where it is stressed how long and involved the process can be of solving this kind of obscure, effectively intangible, problem. Furthermore, in stating that the difficulties of reaching a solution are almost invariably under-estimated, it is submitted that one cannot put staff of too high a calibre on such work.

In the end, as with any form of R and D management, which really it is, this comes down to a question of money. Money, in this case, means not only the economics of the operation, outstandingly in terms of the overall time scale but also, in the final analysis, of survival itself. Thus when survival comes into question, assessment of the position has to be carried out as a joint exercise between the technical and financial sides to establish likely future cost — money. The onus here rests entirely on the various sub-project (technical) managers to determine future time scales and effort required. This depends, of course, on all the sources of trouble having been identified and acceptable methods of tackling them arrived at. There is no need to stress the immensity of the problem this represents, particularly as with the motor car, where several technologies meet and interact.

Nevertheless there are methods which can be claimed to give some control of an untenable position where no solutions are in sight: methods which even make it possible to anticipate, at least in part, some of the problems which do arise. Such methods, centred on tthe use of an activity chart, become increasingly apposite as the multi-technology condition is reached where, finally, electronics and electrics come together with automobile engineering to form an R and D team which depends for its ultimate strength on having a number of all-round engineers in each of the constituent groups. This need for all-rounders has already been well ventilated earlier in this series; but in the automobile case it takes on a special significance with the need to avoid false trails and, even more difficult, to obtain an accurate breakdown of the areas where trouble is being encountered. In an extreme case it will become evident that in one or more of these areas, the time required for solution is completely unpredictable; and this is where upper management may or may not be able to fund the work for such an indefinite period.

From the project manager's point of view, the assessment of the extent of individual areas of trouble is a continuous process, assuming that activity chart methods or their equivalent, are being used; and it is from this that he should be able to build up a picture of action being taken that justifies further support. In practice the position is usually far from being so clear-cut. Thus, specifically in the car industry, vehicles and equipment may be in full production and the R and D problems that have to be tackled arrive with no time for evaluation or checking on what is almost bound to be incomplete second hand evidence. Thus the investigators are in a disadvantageous position where there is no possibility of establishing, within an acceptable time, the likely causes of any one of the troubles. Taking this to the ultimate leads to the conclusion that the commercially based (and constrained) British car industry could not be expected to set up an organization with multi-project capability — and on the scale required — to cope with the system engineering needs of full project development. As the electronic content of the project increases so does the technical spread demanded of the management organization.

This build-up can be thought of as being in three phases, the first being to ensure that the maximum compatibility will be achieved between the basic vehicle and the electronics; while the second is an extension of the first with electronics and secondary electronics being covered. The third — the establishment of electronics as the predominant R and D type activity — involves a major change in technical emphasis and viewpoint generally. That such a change is well within the capability of British Industry and its *underlying* resources has been shown by the private-venture programme mentioned earlier.

Private-venture programme

As indicated, this programme has demonstrated that there is a successful alternative to the setting up of a huge organization to deal with the move by the car industry into electronics. The establishment of a mass-attack organization can be seen to be virtually impossible on the score of funding alone, certainly within an acceptable time scale; quite apart from the equally insuperable difficulties of acquiring staff of the standard required.

Clearly, in the face of such a 'no-future' position, one has every reason to say that it is just not possible to produce an alternative to the mass attack organization, particularly an alternative which is low-cost.

This indeed would be so, were it not for the hidden technological strengths of the British as exemplified by the concept of the 'clusters', and as already treated in this series in other connections. Also, as in those instances, these strengths are not far below the surface; and in a sense, the work of this programme has been to bring together small, innovatively minded, groups who still operate in the automobile and associated fields, admittedly on a small, localized basis. A fundamental part of the work has stemmed from the original cluster of Coventry and the West Midlands, with much of the development centred on that unique product of the cluster, the Rover 'P4' range of cars. These cars, probably best known in the Rover 100 version of the 1960s[3] were far ahead of their time, so that they respond to electronically-based updating today. That this can be done carries a number of implications, all of particular interest in the context of providing a source of proven know-how and technical thinking which represent substantial assets not readily available elsewhere.

Before showing how advantage has been taken of these inherited assets, it is necessary to give some account of the original Rover base.

In terms of performance, this ton and a half car, with its 2,625 c.c. engine, is shown in the instruction manual as being capable of "... sustained, high-speed motoring at speeds in excess of 80 m.p.h." (Road tests give a maximum of 100m.p.h. for the '110' version). The key word here is 'sustained', and this takes on a much wider connotion for the Rover 100 as a car which become the symbol of British leadership in this particular prestige field. Thus, in this wider connotation, one synonym for 'sustained' can be given as high technical dependability. The evidence behind this statement (and others in the same vein) can perhaps be best summed up by quoting the senior public utility engineer who was operating his Rover 100 under the "Highlands and Islands" conditions of the North of Scotland. He told the writer that he was going to keep that car until "It fell to pieces round him".

This then is the atmosphere which existed with these cars when production was brought to an end in 1964; and although this decision to stop was almost certainly justified by all the evidence available, it did not, and could not, take into account either the significance or the extent of the electronically orientated features which had been built into these cars. There are two clear divisions of these features. The first consisted of components which in their original (physical) form could be used in principle today without fundamental modification being required. The outstanding example here is the 10V regulator placed in the vehicle 12V supply to give a (maintained) 10V line for current-operated transducers. Apart from the fact that the stabilizing action was provided by a bi-metal strip circuit, this was a conventional series stabilizer unit as known today; and it is relevant to compare this anticipation with the electro-mechanical computer — 'fruit machine' — of the early radar days (article 2), and with the electro-mechanical digital techniques developed by the CEGB in the 1930s (article 5).

The other example to be quoted here, and coming into this division, is the installation on the engine of a small aluminium heat shield under the distributor and between it and the exhaust manifold. At first sight this is an insignificant, even trivial point of design, but it represents a fundamental way of thinking which becomes of overriding importance when electronic equipment is introduced into the high-temperature conditions of the engine compartment.

This question of way of thinking assumes a specal significance for the second division of features which are found in the Rover P4; and which only need electrical/electronic updating (in the development sense) to enable them to be used in advanced new systems now. Such a system is the fuel supply which was evolved round the SU electric petrol pump, which even today has to be regarded as a remarkable development on several counts, not least as a closed-loop, self-regulating (to demand) sub-system. Its progress over the years to its final status is of special interest in the present context, particularly in terms of detailed engineering development.

The SU pump depended on an interrupted electromagnetic (electric bell) drive to the pumping chamber diaphragm. Analysed, say for computer control, it is a fuel delivery system which gives a metered supply to the engine, which is automatically adjusted to demand; i.e. fuel is fed to the engine only when required and at a rate which can be accurately measured from the drive rate.

These properties were, of course, the objectives which were achieved with the original innovative concept but evolved in the non-electronic world of the time. The advantages were such that a large proportion of British cars were equipped with these pumps over a period approaching some 20 years. This was despite the fact that, as with a mechanical ignition circuit breaker, the (diaphragm) drive assembly only had a restricted life due to the burning away of its circuit-breaker contacts.

Thus in meeting the consequent demand for increased life, metallurgical research was required; but it is of interest that another requirement existed in the field. This was with regard to the mechanical stiffness of the back contact as a cantilever arm. It had been found that in many instances, apparent contact life proved to be much less in practice than would be expected from burning away. Inspection of the contact pair suggested that an appreciable improvement might be achieved by reinforcing the back contact arm. This did indeed prove to be so. An auxiliary pressure member made from flash-lamp battery brass (strip) and in the form of a leaf spring with a helical loop end, was brought to bear on the back contact arm. With the consequent positive contact thus established, greatly extended service life was obtained. It is a tribute to the makers' basic engineering that this problem was apparently solved by changes on the materials side without any modification to the original physical arrangement of the drive mechanism having to be brought in.

A similar unobtrusive, but successful, redesign can be assumed to have been carried out with the 'throw-over' (toggle) pump operating linkage assembly. This piece of mechanism, with its unique action, was made to close limits; but in the early days suffered from an intermittent 'top dead-centre' effect which caused momentary, or even longer periods of failure. That this fault was largely eliminated in later models is again a tribute to the engineering ability that was shown in detecting and in analysing this fault with its obscure, almost elusive, characteristics.

In the light of modern electronic techniques, it becomes evident that the contact life problem could be solved by fitting the pump with a power transistor unit as in a switchable transistorized ignition system and using the breaker points purely for trigger signal generation. In parenthesis itmay be pointed out the *Wireless World* has maintained an authoritative information service on such circuits. An early article appeared in 1970[4], with others, for example, in March and August 1982.

Thus, reverting to the electronic updating of the SU petrol pump, this possibility was realised in practice near the beginning of the private venture programme; but it should be added that at least one *individual* had developed a successful version of this particular system some years earlier. This confirmation of the continued existence in Britain of what may be called the model-engineering spirit and drive was especially welcome in ralation to 'climate of confidence'.

Climate of confidence has several facets; and the case histories in this article, and particularly the amount of detail given in them, have been chosen to show the importance of ensuring as far as possible that all the elements being incorporated in a new system development have been engineered and tested out. The increasing difficulty of doing this as the electronics content is made larger has also been brought out in these examples. The picture is perhaps best completed by reference to the way in which the underlying causes of trouble were eliminated, i.e. the way in which system faults were cleared despite their obscure nature.

Thus, taking the first of the case histories seen as an inexplicable deterioration in performance, the solution, withheld until now, was found to lie in the establishment of a very low resistance path between the engine and the battery in the rear of the car. This entailed not only the installation of a heavy cross-section copper cable to replace the earth-return chassis frame, but also improvement of the metallic connections to the supply by changing the thimble-type connector on the battery terminals to a clamp version. With regard to these modifications, it may be added that the performance of the car was more than fully restored by them.

This case is, of course, the classical example of the multiple fault, obscure to the point of not being recognisable, but which, once found, is simple in the extreme. It is, in fact, a microcosm of R and D investigations or the equivalent where the intractability of the problems encountered in the development of a new and complex system reaches such proportions that survival itself comes into question. The build-up of such a situation has already been examined in relation to the British car industry and its increasing adoption of electronics and electronically based equipment (its entry into the Phase 3 condition as defined earlier).

The almost overwhelming extent of the difficulties that are likely to arise in consequence is made clear; but it is submitted that British industry, with its underlying resources, has the capability to deal with them, part of the supporting evidence coming from the private-venture programme. The whole submission depends, of course, on full and effective use being made of "the hidden technological strengths of the British", and which demonstrably exist in other fields. That they do exist, and can be called upon for the car industry, has been indicated for the specific cases already covered; and it is proposed to round off this section with a short survey of a crucial area, vix. that of the operation of electronic equipment at high temperatures, where it does seem that electronic experience and know-how available in Great Britain have yet to make their full contribution.

The linked issues of reliability and equipment cooling take on a special significance with the abnormally high temperatures that can be reached in the engine compartment of a car. In designing for them, allowance must be made for the build-up of heat which takes place under traffic-jam conditions, and for the much higher hot-spot temperatures within the confined engine space.

This assessment does not mean necessarily that unreliability of electronic equipment traceable to high temperatures cannot be countered; and it can be said that the introduction of, for

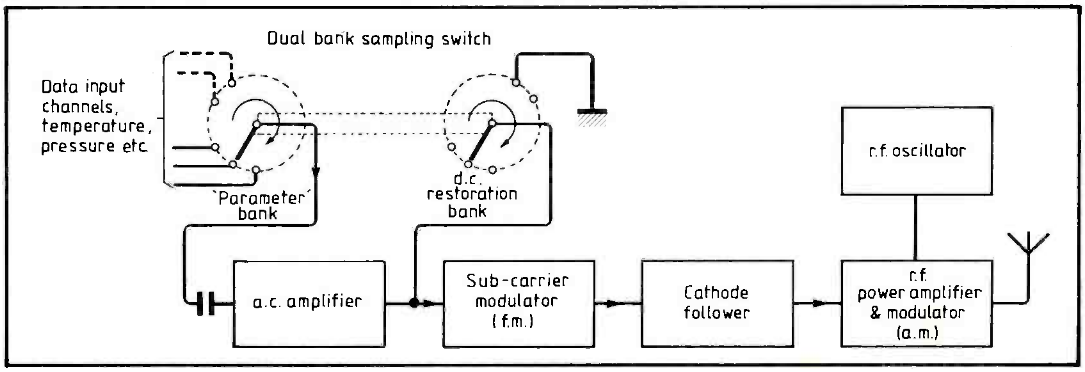


Fig.1. **Vehicle telemetry system — sender block schematic.**

example, heat shields and cold air ducting does help to reduce these effects. Nevertheless it has to be accepted that precautions must be taken in design, as a *joint* exercise between automobile and electronics engineers, to reduce these hazards.

In this context, and to give perspective, advantage can be taken of information given recently that cooling still represents a major source of delay in the engineering development of airborne radar. The size of the problem was brought out some little time ago as a reminder, by a member of the industry, of the working rule that U — the unreliability of silicon devices — is given by $U \propto T^4$ where T is the absolute temperature. The parallel between airborne radar and car electronics is perhaps not close, but it will be seen that experience and know-how exist here which are more than relevant in this connection.

It should be pointed out also, that the release of the state-of-the-art information quoted above represents a service to industry comparable with that given by Jaguar with their Survival/Quality article. Once of the more noteworthy points in the article is the speed with which quality-control methods were apparently brought into operation. Both German and Japanese practice was involved, together with the adoption of Japanese Quality Circle approach. Quality-Circle groups are set up with selected members from shop-floor level upwards and offer a formal method for reporting faults and for putting forward suggestions for clearing them. Now from experience it can be stated that this kind of interchange used to go on almost as a matter of course in most British engineering firms, certainly in the smaller ones, and that this was one of the foundation strengths of the clusters. However, it has to be admitted that such interchange does seem to have diminished over the years and it emerges that, in the Jaguar case, it had ceased to be a continuous process and much vital information failed to reach the design and development staffs.

Seen over the UK, it does seem that this reduction in interchange can be associated, at least in part, with the specialization that usually comes with high technology and the tendency for individual groups to become isolated from each other. With all deference it is suggested that with the adaptability and general flexibility of the British, the position could be reversed almost overnight, and the fully coordinated overall approach — shown to be more than desirable — could be brought to bear on Phase 3. The capability and the will are there.

Telemetry in vehicle development

In general, with world markets in view, the car industry has to carry out its development testing in every kind of climatic condition and over every kind of road surface likely to be encountered in the countries concerned. This entails road testing with a number of vehicles and for extremely protracted periods, and although it is possible to simulate these environmental conditions, the cost of providing all the facilities required is prohibitive.

Nevertheless a variety of work can be effected, within certain limits, on the test track. It was with this application in mind, that vehicle telemetry equipment was developed and was evaluated for commercial use in the UK in 1960[5]. This time-division analogue system followed standard aerospace practice in having 24 channels, but a special, high-speed, mechanical sampling switch was used, running at 12,000 r.p.m., to give a channel sampling speed of 200 per sec. Discussion with the car industry indicated that this rate of sampling and the number of channels matched their requirements; and this was also found to be the case in a more spectacular application — Donald Campbell's car Bluebird for his attempt in 1960 on the world land speed record, made in the US[6].

Campbell was able to achieve his aim in July 1964 at the Lake Eyre Salt Flats in Australia, where he established a new land speed record of 403.1 m.p.h. (648.7 k.p.h.). This was, however, after his 1960 attempt had been made abortive as the result of the car having hit a patch of loose salt on the Utah Flats, going into a mile-long skid and eventually overturning.

Plans to build a new Bluebird were apparently made immediately after the accident; and the success ultimately achieved with it stands as a monument to Campbell and his team.

Further comment on this would be more than superfluous; but in terms of high technology, the Campbell team should be given much more than a passing mention. They — with the unique backing organization set up behind them — represented a formidable high-technology cluster basically as up to date as anything seen today. The foundation for this claim lies in two areas; the first being found in the advanced nature of the car itself: a record attempt of this kind is, in many respects, a development testing project.

The second, in a sense part of the first, is the way in which the new technology of telemetry was absorbed immediately into this engineering endeavour. It will have been made clear that this can be a very difficult process, especially when the two technologies being brought together are widely different in character.

Finally, it is felt that although full documentation exists to justify the inferred statement that the telemetry system used then would still qualify for high-technology rating, some of its salient features should be listed.

First of all, with many of the data signals being d.c., precautions were taken against drift, both short and long term. In the sender, a second bank on the sampling switch provided a d.c.-restoration action at the output of a transistorized a.c. amplifier; while in the receiver, a complementary action was given by clamping to earth on the receiver output.

Transistors were used in much of the equipment, the main exceptions being cases where significant power was being handled and thermionic valves had to be employed, e.g. the output stage of the transmitter was a double-beam tetrode.

Considerable attention was also given to data display and recording, ultra-violet equipment being adopted for graphical presentation; while major development work was put into demultiplexing and 'strobing' of individual data signal channels.

Both transmitting and receiving equipment were given comprehensive environmental testing, the latter for ensuring that it would stand up to transport to various testing sites, as with the first Campbell record attempt where a fully equipped receiving/recording van was taken over to the US.

References

1. Dron, P. et al: Jaguar: Quality Equals Survival, *Motor*, July 8, 1981.
2. Young, R.E.: British invention, innovation and electronics, *Wireless World*, March 1985.
3. Rovers consolidate, *The Autocar*, 4 September, 1959.
4. Marston, R.M.: Capacitor — discharge ignition system, *Wireless World*, January, 1970.
5. Poole, S., Potton, A., and Titley, C.O.: 'Analogue Telemetry Equipment and Systems' (Part 2), *Electronic Engineering*, February, 1961.
6. Runnalls, A.D.: 'Bluebird Racer's Telemetry System', *Electronics* October 28, 1960.

NEXT MONTH

Intarlec is a microprocessor-based controller which functions as a burglar alarm and house-light controller able to deduce when a given room needs to be lit.

DigiPoly — a musical keyboard instrument — generates a composite audio output entirely digitally under the control of an 8088. The sound generator is in the form of software running on a t.t.l. processor.

Prototype kit BPK72A from Intel is used as a 1Mbit bubble memory for the SC84 microcomputer.

Signal analyser provides an oscilloscope display of input, peak or r.m.s. voltages of a waveform, simultaneously, on a single trace.

Long-tailed pair. First of two articles by John Lidgey on characteristics and applications in op-amp and h.f. circuits reviewed.

Fast Fourier transform. A program, running on a BBC micro, to display spectra of periodic waveforms.

Electronic mailbox

by Martin Allard B.Sc.(Hons)

Using a three-class mail concept, this independent electronic mailbox has the potential for drastically reducing telephone bills in small and large businesses, but it is also cheap enough for home use.

This communication system was designed to serve two independent purposes. It is an error-proof high speed duplex data link between a computer and a remote terminal or second computer, and it is also an electronic mail service with off-line message entry and automatic delivery.

When used as a modem the unit provides auto-dial and auto-answer, and the protocol which it uses offers error-free communications even over bad lines. The only trade-off is that the speed falls if the line is of poor quality.

Conventional electronic mail systems depend upon the use of a central computer, accessed by simple dumb terminals over an unprotected asynchronous link. This system requires no central computer, and the messages are delivered directly from one mailbox to another, where they are held in battery-backed semiconductor memory.

A flashing led indicates that mail has been received. There is never any need to call a central bureau to find out whether any messages have been left; the recipient has the message there in his mailbox and the sender has a reliable acknowledgement of the delivery.

Furthermore a message is not marked as 'delivered' in the sender's unit until every character has been checked and confirmed correct in the destination mailbox. Several levels of error recovery procedures, acknowledgements and interlocks are used to make the system very reliable.

The sender and recipient of mail both interact with their mailboxes off-line, Fig.1. Actual transmission of the mail is normally performed fully automatically at night. For a typical short message the telephone call lasts only a few seconds, which at cheap rate means that the cost is less than that of a second class letter. The total capacity available for storage of message text is 52Kbyte.

Apart from being fun to use, this system has considerable potential for business communications, and it could also be a great help to people with impaired hearing in that it allows long messages to be sent using a short telephone call.

All telephone lines are liable to be noisy, and so all simple modem standards are prone to errors which make terminal use frustrating and file transfer difficult, without running special protocol software in the host computer at each end of a link. Electronic mail is a most useful and habit-forming facility to have access to, but it usually depends upon the use of either a central computer or compatible hardware and software at each node.

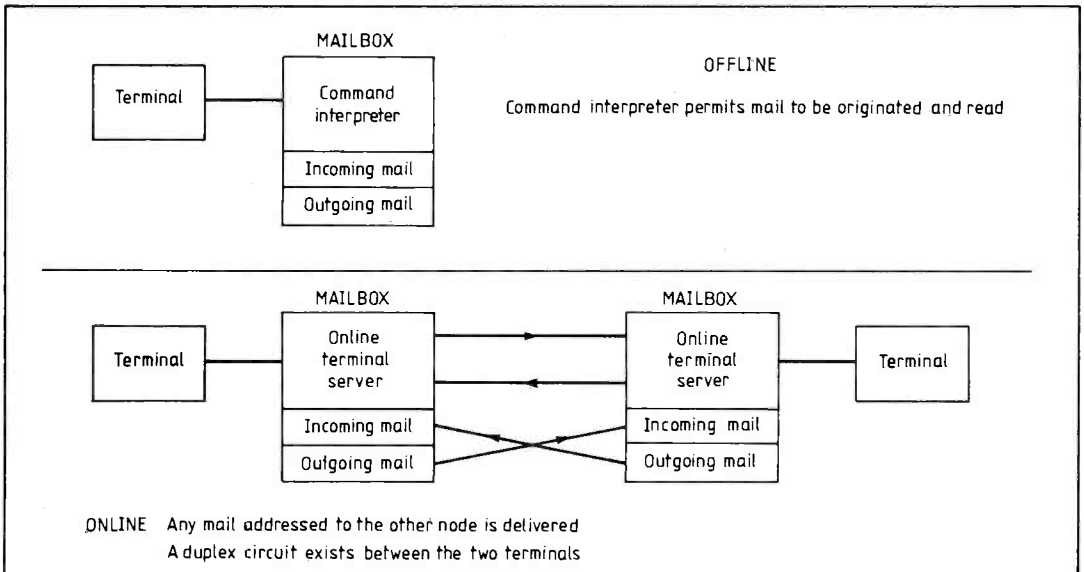
The philosophy behind this project is pragmatic. One must accept that people have all sorts of different computers and terminals which they would like to communicate between. The only facility they may have in common is an RS232 interface.

If an economical means could be found by which the modem could eliminate the transmission errors, then a distant terminal would work just as reliably as a local one and files could be transferred without special precautions. Furthermore, if the mail system was built into the modem itself, and if it was cheap enough, then the differences between computers would not matter because they would all simply be used as terminals for mail purposes.

Given the desirability of such a unit, it must be said that no satisfactory overall standards exist for the services which it provides. This lack of standards is the electronic mailbox's main disadvantage at present. Possible candidates are either much too simple of much too complicated for the purpose.

I hope that my arguments for the choice of 1200 baud and HDLC (high-level synchronous data-link communication) as the lower levels are convincing. Both

Fig. 1. **Mailbox functional diagram. Outgoing messages are entered into the mailbox from a terminal or computer through an RS232 link. Software in the mailbox makes entering the message very simple. One may send the message immediately or leave it to the mailbox to send it later on, when calls are at cheap rate. Using 'third-class', the sending mailbox only sends its message when the destination unit makes contact — which is even cheaper.**



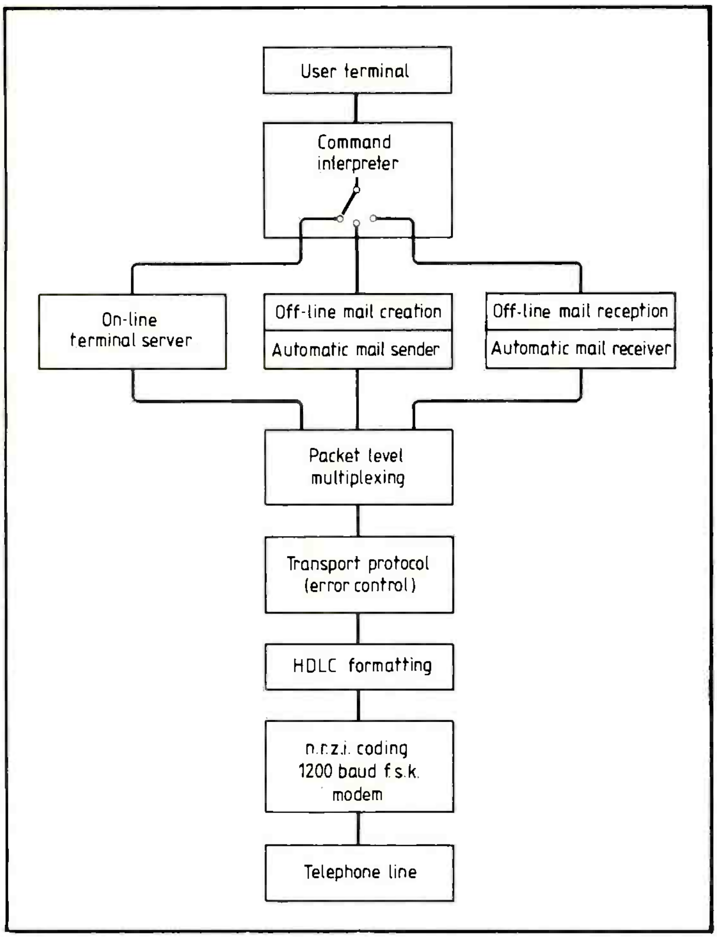


Fig.2. **System hierarchy. The 1200 baud modem is an integral part of the mailbox. Careful choice of protocols and error-checking methods results in efficient and reliable communication.**

of these are CCITT standards. The higher levels of the system were designed specially for the project, and this article is not long enough to completely cover all their intricacies; but they are potentially a public-domain standard, or at least a suggestion for one, which is simple and effective and has built-in compatibility with future more sophisticated versions. Nevertheless the hardware to be described can also run any other protocol using the same lower levels, simply by extending the firmware.

Design

Physically, the system consists of a single printed circuit card which contains a microprocessor with 64Kbyte of memory, a battery-backed real-time clock and a 1200-baud modem. External connections of the unit are mains input, telephone line*, and an asynchronous RS232 line to which either a terminal or a computer can be connected.

Several methods of originating and answering telephone connections either automatically or manually are provided. Whenever the mailbox is on-line to another such system there is a duplex link open between the two terminal connections which is independent of the mail system. When off-line, the terminal line can be used to enter messages (or even binary files) for later delivery to another node, and to read incoming electronic mail.

Each mailbox is given a unique name, and the mail delivery system is based on these names rather than on telephone numbers. Three levels of delivery service are provided. First class mail is sent at once, second class mail is sent overnight, and third class mail is sent only when the opportunity arises.

Whenever two units are connected they exchange names, and each scans its list of mail to see if it has anything to send to the other one. Any opportunity to transmit mail is always taken advantage of.

Standards

Several possibilities were considered before the rather unusual choice of modem standard was arrived at. I rejected the common 300/300 baud standard because higher speeds can easily be obtained using quite simple modem circuit designs. It is not widely realized that British Telecom only guarantee the Datel 200 service at up to 200 baud, and whereas it works well at 300 over short distances, those of us who live out in remote areas find that their caution is justified.

Experiments with a number of different types of modem have suggested that the 1200/75 baud standard is actually more reliable over long lines than 300/300 baud. An asymmetrical-rate standard such as this is suitable for use in a simple terminal-to-computer link in which the data rate in one direction is limited to manual typing speed. It is not so suitable for a general purpose link between two computers or for a two-way mail system, because no such simple assumptions can be made about relative data rates required in the two directions. Even if provision is made for switching the direction of the circuit, it is not easy to decide when this should be done.

Full-duplex communication at 1200/1200 baud over dial-up lines is possible, but the complexity of modem required is significantly greater than for lower speeds, and the reliability doubtful.

I decided to use a 1200 baud half-duplex standard (CCITT V23) with provision for fast direction switching but no low speed reverse channel. Provided that sufficient buffer capacity is available in the modem, there is no noticeable difference between this and a full-duplex system except that the time taken for characters typed to echo back from a distant computer increases to about half a second. This could be avoided, if necessary, by providing a local echo facility in the terminal.

Advantages of this choice are twofold. Firstly it permits the design of a very simple modem without critical filters. The greater part of the function of modem filters is to exclude the high-level signal from the reverse channel. If there is no reverse channel then the filters are merely to remove line noise in the unused part of the channel bandwidth.

Since this standard uses most of the available bandwidth, the improvement in performance gained from filtering out the unused portion is small. Experience has shown that it is far more effective to make the link tolerant of errors that to try to reduce them.

The second advantage of half-duplex operation is that it permits the relative channel capacity in each direction to be dynamically adjusted to suit the rate of data sent.

From the start it was clear that a link which was to be immune to line noise bursts should use an interlocked line protocol with a powerful method of error detection and retransmission. Asynchronous start-stop data transmission as commonly used for terminal lines has only one real advantage which is its simplicity. Against this is the inefficiency of using 10 or 11 bit periods to convey only eight bits of information, and the sensitivity of the system to loss of character synchronization through noise.

The various types of synchronous transmission in use all require some form of phase-locked loop to recover clock information from the data stream, but this in turn provides immunity from loss of synchroniztion through short line disturbances. Figure 2 shows the system hierarchy.

Performance

The HDLC link-level protocol chosen, with a variable packet size of up to 64 bytes, is

* Any apparatus for connection to the public switched network must be approved by the appropriate telecommunications body. In the UK, this is BABT — the British Approvals Board for Telecommunications — Ed.

described later. For the purposes of this introduction, only performance is analysed.

It is difficult to make a general comparison between this and a simple asynchronous data link because the approaches are so different. The most common situation to be considered is that of a terminal operator interacting with a remote computer through the system. In this case the requirement is for the fastest possible transmission of data from the computer to the user, with a relatively negligible data rate in the return direction.

Our half-duplex system requires an extra 32 bytes in order to transmit 64 bytes of user data. This may seem a lot, but it includes the time spent in switching line directions, locking up the receiver clocks, and sending the necessary error detection and link housekeeping information.

In return for this reduction in data rate to two-thirds of the line bit rate, one is guaranteed that the data will be received with an error rate which is independent of line quality, and which is so low as to be for all practical purposes non-existent.

This statement would seem to suggest that the 1200-baud line will give the equivalent of an asynchronous link running at only 800 baud. In fact, performance is better than this by a factor of 10/8 because no start and stop bits are sent; so the link is equal to a conventional asynchronous link running at 1000 baud.

Of course these figures assume that there are no line noise glitches, which cause retransmissions. The worse the line is, the slower the link will become, but errors will not be introduced. This is a far more useful guarantee to have than a fixed high speed with the likelihood of errors.

Since the rate at which data is sent depends on the demand for line time in the opposite direction, and also to a lesser extent on the quality of the line, some means of controlling the supply of data from a computer source is needed.

Standard XON/XOFF characters are used, which are recognized already by most operating systems. Separate provision is made in both the real-time link and the mail system for the transparent transmission of arbitrary 8bit binary files. Under all normal circumstances there is no detectable limitation on the speed at which a terminal user is allowed to type into the system.

Using the mail service

Dialogue which takes place with the mail system is designed to be self-explanatory. The unit is normally in standby mode, in which it is ready to accept incoming calls. In order to enter the dialogue one must first type ‹return› (i.e. press the return key) twice on the terminal. The system responds with its own name, the date and time, and a prompt.

If incoming mail has been received, or if there has been a power failure since the mailbox was last used, a message will indicate the fact. The system returns to standby mode if an 'x' command is given, or if nothing is typed for three minutes. When entering text the time-out period is extended to 30 minutes, but the system will always return to standby mode eventually to allow incoming mail to be received.

All nodes have identical hardware and firmware except for the name, which is contained in the first 16 bytes of the rom. The name can be up to 16 lower-case letters, left-justified and space-filled. I strongly recommend that names should be easy to spell, because mail will not be delivered if the name of the destination mailbox does not match the one specified.

Following this is a directory of known node names and their telephone numbers. This is for convenience, and does not prevent communication with previously unknown nodes or with known nodes on the wrong numbers. The directory contains up to 10 entries, each consisting of a 16-character name field (as above) followed by a 16-character Ascii string which is the telephone number padded with spaces. An asterisk in the number is interpreted as a two second pause during dialling, which may be needed on some PAB exchanges.

The command 'c dent' opens a connection to the node called dent. The name can be replaced by a number if the node is not in the directory. The 'o' command merely puts the system on-line without dialling a number. This is useful when a connection has been established manually.

The 'l' command lists a summary of the incoming and outgoing messages stored. Each entry consists of the source and destination node names, the date and time of origination, the subject of the message (up to one line of text), the number of characters, the message status, and the message checksum status. The message status may be any of the following

```
Incoming mail received.
dent       6 Dec   12:08 gmt       clrsox or h for help > h

c name or c number <cr> - call node
l - list all mail
r - read mail
s - send mail
o - open connection
x - exit to standby mode

dent       6 Dec   12:08 gmt       clrsox or h for help > r

from marvin to dent   4 Dec   00:42 gmt
My poor state of health.
  123 chars           received        ok

r - read, d - delete, space - next entry > r

I have this terrible pain in all the diodes down my left side.
But I know you don't care.

dent       6 Dec   12:09 gmt       clrsox or h for help > s

subject > About your diodes.
Enter text, ^Z to finish.

Keep taking the tablets.
destination > marvin

class - 123 or h for help > h
1 - deliver now
2 - deliver overnight
3 - deliver when next connected

class - 123 or h for help > 2

dent       6 Dec   12:09 gmt       clrsox or h for help > l

from marvin to dent   4 Dec   00:42 gmt
My poor state of health.
  123 chars           received        ok

from dent to marvin   6 Dec   12:09 gmt
About your diodes.
   24 chars          overnight        ok

dent       6 Dec   12:10 gmt       clrsox or h for help > x
```

Example of dialogue between the user and mail system (user input underlined).

- received
- delivered
- overnight (to be delivered)
- 3rd class (to be delivered)
- rejected (by the destination node)

Messages are normally rejected only because the destination node has run out of space. In this case further attempts will be made to deliver the message later. The mail system is heavily protected against transmission errors; the checksum on messages is only to guard against the possibility of the data being corrupted in memory due to alpha-particles. This does not appear to be a significant problem in practice, even when long messages are left in memory for several weeks.

Mail is sent and received by use of the 's' and 'r' commands. Typing 's' to the main prompt initiates a dialogue which first asks for a subject heading for the message. Then the main body of the text is entered, terminated by a ‹control-Z› character. This is followed by a request for the destination-node name and the class

A double-sided plated-through printed circuit for this design will be available from Combe Martin Electronics, King Street, Combe Martin, North Devon EX34 0AD, telephone 027188 2346.

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 user 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.

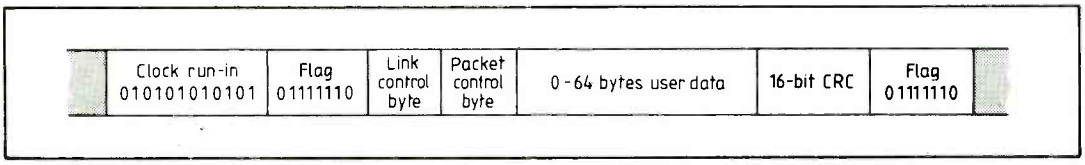


Fig.3. **Packet format. High-level synchronous data link communication, HDLC, is a bit-oriented serial communication protocol. A transmission packet is recognized by a flag at its start.**

of mail (with help if required). If the node is unknown a telephone number is also requested.

To send mail to a known node which has moved, the name is terminated with an asterisk. This overrides the directory and forces an explicit number to be entered. First class mail will be sent at once; other mail is stored and may be examined with the 'l' and 'r' commands.

The system will store up to ten messages. The 'r' command is used to step through them, examining their headers in the same way as for the 'l' command, but with the option of reading the full text of each message or of deleting it before moving on to the next one. At any time within these command sequences a ‹control-C› character will abort the operation in progress and return to the main prompt.

The example of a dialogue with the mail system shows first of all the automatic notification that new mail has been received, then the prompt line and the main help message. The incoming message is read by use of the 'r' command, and a reply is sent with the 's' command, illustrating the delivery options available. Finally the 'l' command is used to list both incoming and outgoing mail.

Link level protocol

HDLC is a bit-oriented serial communications protocol. This means that character synchronization can always be unambiguously achieved by searching the bit stream for a known unique pattern which indicates the start or end of a data 'packet'. The coding rules prevent this bit pattern occuring in any other place.

A transmission packet begins with this special pattern, 01111110, known as a flag, see Fig.3. The next two bytes contain link housekeeping information. After this there is the user data field, which in this case is variable in length from 0 to 64 bytes. At the end of the packet there is a 16-bit cyclic-redundancy-check field for error detection, followed by a closing flag.

The simple coding procedure which permits arbitrary binary data to be transmitted without accidentally producing the above pattern is this; the HDLC transmitter inserts an extra zero after any five consecutive binary ones within a packet. The HDLC receiver ignores any zero which follows five consecutive ones. Thus it is guaranteed that there will never be more than six bit periods in the transmission sequence without a binary zero, see Fig.4.

One of the requirements of this system is that there should be regular transitions in the data stream from which a bit rate clock can be recovered. To consider the two degenerate cases, the above rule assures regular transitions in the case of data which is all ones, but not in the case of all zeros.

If a secondary coding rule of n.r.z.i. is added, this problem is solved. The n.r.z.i. rule is that the serial data remains in the same state to send a one, and changes state to send a zero. Thus the case of all zeros becomes a square wave at half the bit rate, and the case of all ones becomes a square wave at one-twelfth of the bit rate. This assures at least one transition for clock synchronization in every 6 bit periods.

In this system the receiver is programmed to accept only a packet with a valid first byte and a correct c.r.c. It simply ignores all other bit sequences, and does not discriminate between an invalid packet and noise.

Transport level

Above the V23 physical level and HDLC data-link level is a transport level protocol which is purpose-designed to be the simplest way of implementing a two-way error-proof path over a half-duplex point to point link. The state transition table of this protocol is shown in Fig.5.

Most real communication systems, or at least small ones, fit somewhat uneasily into the ISO seven-layer reference model. In this case there is no network level because at any time there is only a single point-to-point link in the path.

The link control byte, Fig.6, in each packet contains a function code which is one of the following

CR - connection request
DATA - normal user data packet
DR - disconnection request
DA - disconnection acknowledge

In addition to the function code, the link-control byte contains a two bit sequence number field, which is only used in DATA packets. When a connection is first established between two of these systems they both send connection-request packets, CR, at random intervals and listen for either a connection-request or a DATA packet with a sequence number of zero in response. In this way an interlocked handshaking protocol is set up which cannot get out of synchronization despite the loss of packets through line noise.

The problem with simple acknowledgement protocols is that when a message has been sent, and no acknowledgement has been received within a reasonable time, the sender does not know whether it was the outgoing message or the acknowledgement which is lost. In the latter case, if the message is sent again, it may be received in duplicate.

The solution is to number the packets. For this system, a modulo-three sequence count would be adequate, but modulo-four is used for convenience. When a DATA packet has been sent with number N, only a reply with number N+1 will be accepted. The original packet is retransmitted until the correct response is received. When this occurs, N is incremented twice (modulo-four).

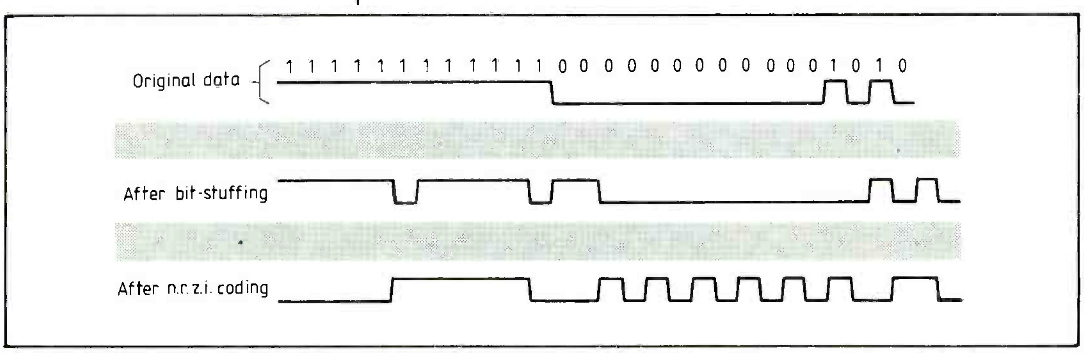


Fig.4. **Data coding example. There are never more than six bit periods in the transmission sequence without a binary zero. A requirement of this system is that there are regular transitions from which the clock may be recovered.**

It can be seen from Fig.5 that there is no way that the two ends can get out of packet numbering sequence however bad the line may be. If either end sends a disconnection-request packet, DR, the recipient will send a discnnection-acknowledge packet, DA, and cut the connection. The disconnection-acknowledge packet is not acknowledged, but is sent twice as a precaution.

The DR packet is repeated a few times before aborting if no DA is received, and so the DA packet type serves only to make closure of the connection more efficient. In fact it is an essential part of the fail-safe nature of the system that all operations eventually time-out if unsuccessful, and separate numbers of retries are permitted before aborting in the cases of CR, DATA, and DR packets.

I have already said that the receiver ignores invalid packets and that the packet length is variable, so the problem arises that the two ends may get into step, transmitting packets of the same length at the same time on top of each other, and thus neither would ever be received.

This hazard is avoided by introducing a random element into the timing of retransmissions. The delay between repetitions of the same packet consists of a fixed minimum period plus a small random element which is accumulated on each retry. So the delay becomes longer by an unpredictable amount on each attempt (until it eventually aborts).

Usually the protocol recovers from any short noise burst within one or two attempts. It is interesting to listen to the two ends handshaking backwards and forwards and then to disturb them by speaking into the telephone. The smooth interchange is heard to stumble and then quickly resume.

The second byte after the flag in each DATA packet contains higher level information about the significance of the following data field, Fig.7. Potentially, this byte could be used to control the statistical multiplexing of a large number of separate applications onto the one physical circuit. At present it indicates either a null packet, a terminal-data packet, or one of several types of mail packet. This byte also contains some individual one-bit flags, each of which is a simple communication channel for a special purpose in its own right.

End to end

Consider this implementation of a terminal-to-computer link from one end to the other. Input is stored in a circular interrupt buffer until it can be transmitted, and flow control is exerted on the data source if the buffer becomes more than half full.

Each time this system is ready to send a new packet it examines the terminal input buffer, and sends as many characters as are available up to a maximum of 64. If there is nothing to be sent the system will call the mail sender, which always takes second place to terminal traffic. If the sender has nothing to send, the packet will be an idle one.

When the user data has survived transmission over the line it is passed from the packet receiver routine to an output buffer. The process which empties this buffer into the distant terminal line runs at a low priority and is called whenever there is nothing more urgent for the processor to do. This process responds to flow control applied by the receiving terminal equipment. If the process causes the output buffer to fill up, it applies backward restraint upon the link using a special 'stop sending' bit present in every packet to inhibit the sending end. If the input buffer at the transmitting end is filling up when this bit is set, it will cause the data source to be inhibited.

Thus an effective means of flow control exists from end to end, and this allows the terminal line speeds of the two ends of the link to be completely different, and unrelated to the actual link rate if required.

Flow control characters sent from the terminal through the system perform two functions. They immediately switch the local output on or off, and they are also transmitted through to the far end in a way which does not conflict with any more urgent constraints imposed by the link itself.

Use of the flow control characters ‹control-s› and ‹control-q› to

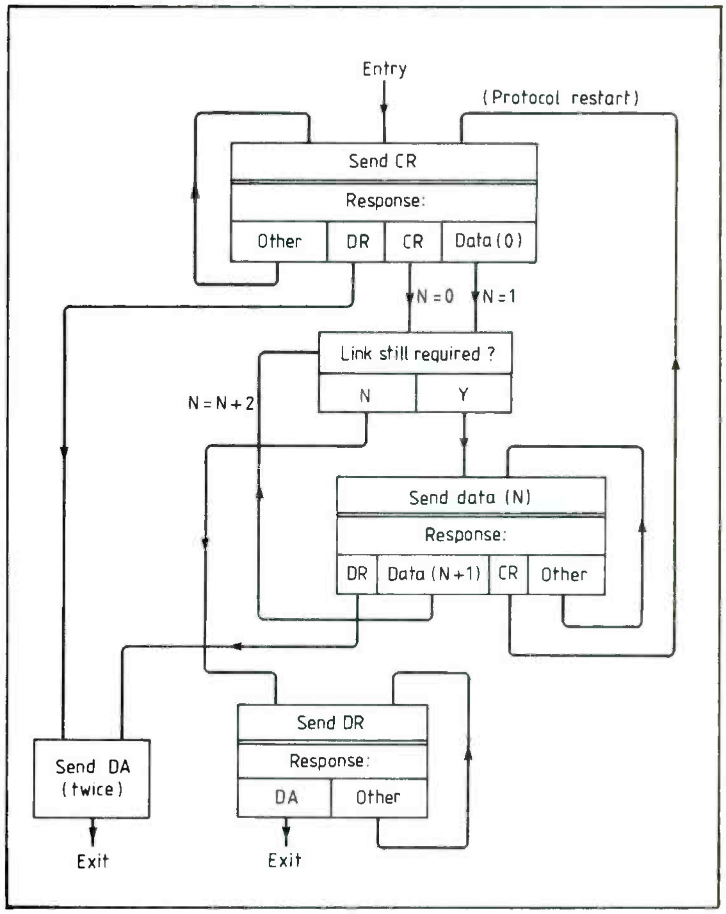


Fig.5. **State transition table of the transport protocol, designed to be the simplest way of implementing a two-way error-proof path over a half-duplex point-to-point link.**

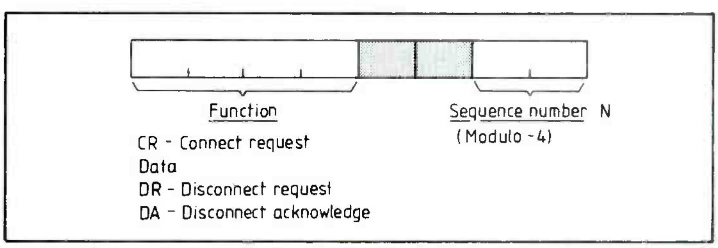


Fig.6. **Link control byte. This byte in each packet contains one of the function codes shown and a two-bit sequence number field which is only used in data packets.**

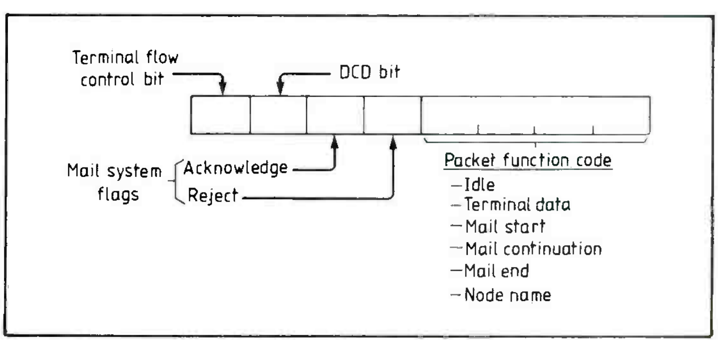


Fig.7. **Packet control byte. The second byte after the flag in each data packet contains higher-level information about the data following.**

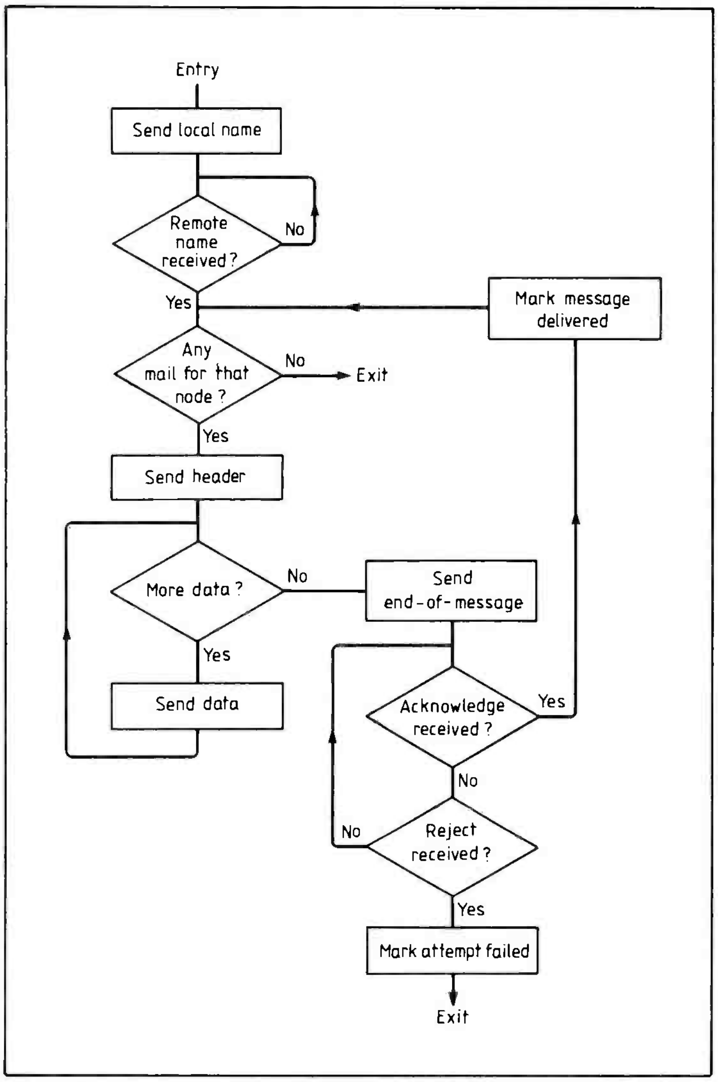


Fig.8. **Simplified flow diagram of the mail sender, which is activated each time that the system is ready to send a new packet and has no terminal information to send.**

regulate the data source is convenient and directly compatible with many terminals and operating systems. But it means that these characters must not occur in any data file being transferred.

To pass arbitrary 8bit binary data through the system the 'data-link escape' character ‹control-p› can be used. Any character following this loses its special properties, and is passed through the system without being interpreted.

The terminal interface DCD (data-carrier detect) line is available as a signal intended to switch a remote computer on and off. It is asserted when an incoming call is received which was originated manually by a 'c' or 'o' command. It is not asserted on calls which were originated just for mail delivery.

Mail transmission

The mail delivery system can be considered to be a one-way communication channel with just a simple method of sending positive or negative acknowledgements of messages in the reverse direction. When two of these units are connected, each pursues its own mail delivery objectives independently without any interference to terminal traffic or to mail being delivered in the opposite direction. So long as adequate space remains in the receiving-unit memory there is no need for flow control because data can be accepted as fast as it can be sent.

Figure 8 represents the mail sending process activated each time the machine is ready to send a new packet and has no terminal traffic to send. The first action when a connection has been opened is to send the name of the local node, and then to wait for the name of the remote node to come in. Using this information the mail sender scans the list of outgoing messages for any addressed to the currently connected destination.

The mail system reverse-signalling channel consists of two flag bits in each packet — acknowledge and reject. The sender waits for both of these to be clear before starting to send the message header. This header contains Ascii strings showing the origin, date, time and subject of the message which appear in the message list display, and also some binary information such as the character count and checksum.

The header is sent in three stages and is followed by the message text. After this an end-of-message signal is sent, and the sender waits for the acknowledge bit to be set. When this happens the status field in the original table entry for the message is changed to 'delivered'. The mail sender scans for any more mail to be sent to the same destination, but waits for the acknowledge flag to clear again before starting the next message header. If at any time the reject flag becomes set, the delivery of mail is abandoned.

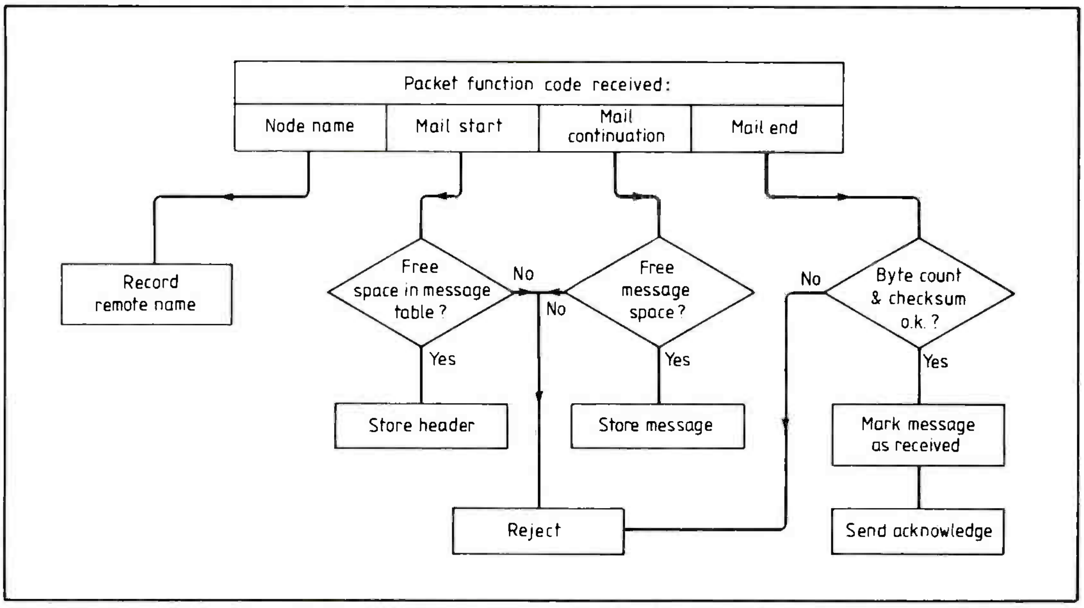
The mail receiver is a process which is activated whenever an incoming packet is delivered with a function code in the second byte which is one of those allocated to the mail system. Figure 9 shows the way in which it is driven by this function code.

The reject flag is set if there is no more space in either the message table or the message text area, or if the number of bytes received or the check-sum do no agree with the information in the header. The acknowledge flag is set only after these tests have been passed, and then an entry is made in the message table of the recipient machine marked 'received'.

If the connection is lost, or anything else goes wrong during transmission of a message, no change is made in the message table of either machine, and another attempt will be made at the next opportunity according to the class of delivery specified.

Hardware is discussed in the next article.

Fig.9. **The mail receiving process is activated when an incoming packet with the right function code in its second byte is delivered.**



ROBOTICS

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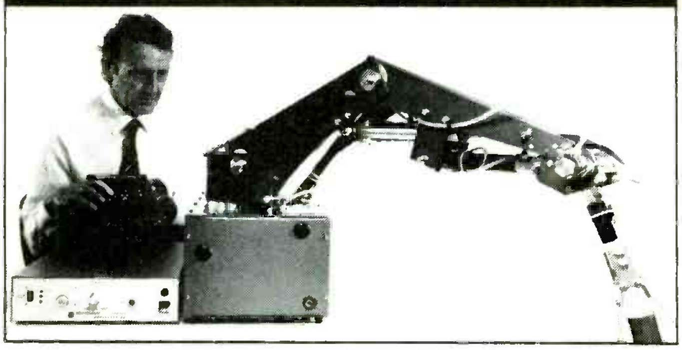

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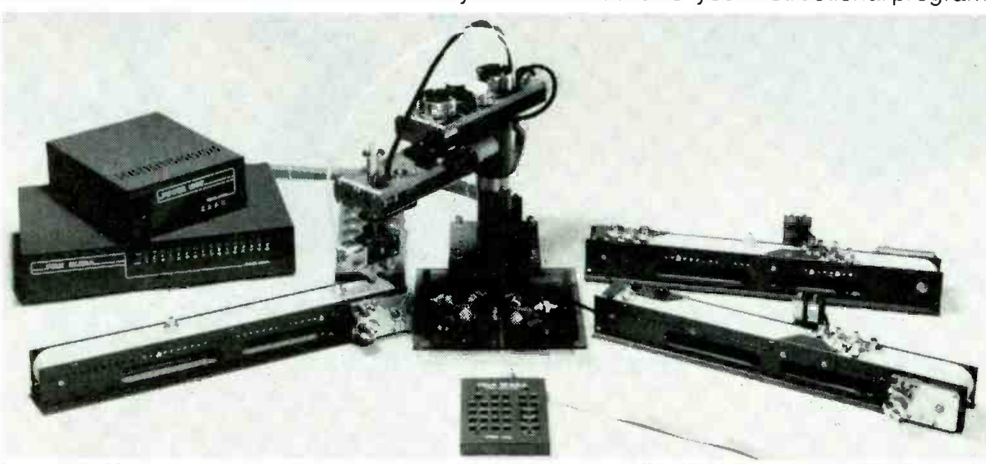

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CIRCLE 34 FOR FURTHER DETAILS.

Robots for learning and fun

Some of the cheapest toy robots can respond to light, sound or touch and illustrate the principles of operation of 'real' robots. Nigel Clark looks at small robots used for pleasure and education.

by Nigel Clark

Robot servants have been the dream of fiction for centuries. Most took the form of mechanical people but attempts for fact to meet fiction has met with little success. However, once it was decided to limit expectations somewhat, it has been possible to produce machines with limited intelligence and suited to specific tasks. The use of microprocessors helped to cut the cost and made possible the appearence of robots in industry. Similar developments have taken place in small robots producing a growing number of increasingly complex machines at affordable prices.

Robots are finding a ready market amongst children, electronics hobbyists and educationists. Children are attracted by the toys which are capable of increasingly complicated manoeuvres. Toys also interest the hobbyist who can adapt them for their own designs and can also use them as building blocks. Some of the toy robots are available as kits and are especially useful for this. The most use for small robots can be found in education: training for those who may use robots; as an aid in teaching a wide range of subjects involved in the whole concept of robotics; and in the teaching of abstract ideas, such as mathematical theories.

In industry, managers need to know the capabilities of robots, engineers need to know how they work and technicians need a detailed knowledge of the machines to ensure proper maintenance. Models and toys enable these aims to be carried out without the wasting of time and use for the robots on the factory floor.

The growing range of small robots can illustrate most of the major principles underlying modern automated production techniques; particularly the combination of feedback and power actuators under the direction of an operation program. Robotics also involves electronic and mechanical engineering, industrial design and mathematics.

Universities are using the more expensive robots to fulfil these aims as they provide the more mechanical and electronic capabilities. In school, the courses do not need to be vocationally based and can use robots as an attractive way to stimulate interest in a wide range of subjects. The cheaper robots are usually aimed at this market. They often come in kit form and need a microcomputer for control. Having learned the basic principles from existing products, school students can go on to design their own robots.

Toys

Robots in this context can be divided into three groups; toys, turtles and small robot arms. The toys often have the appearance of the fictional robot, miniature hominids, but are somewhat limited in their capabilities. The price range varies from as little as £10 up to £200. They are all imported, mainly from the Far East.

Their technology is limited but still interesting. The Dingbot from Tomy Toys costs only about £10 but uses a complex gearing system that will reverse and turn 90° if it hits something and then go forward until it encounters another obstacle. Several sensory inputs are illustrated in the Movit range distributed by Commotion: Peppy is sound activated and a click of the fingers or a clap will send it through its routine. Avoider uses an infra-red sensor to avoid bumps and Navius can be programmed by colouring in segments on a paper disc.

Toys are all mobile and, at their simplest, are only collections of motors, gears, drive shafts and wheels. They are usually driven by two d.c. servomotors, powered by batteries; steering is achieved by having the motors travel at different speeds. The more expensive toys, such as Omnibot or the Memocon Crawler, follow instructions from the user and incorporate feedback to report when the routine has been carried out. Potentiometers of varying accuracy and optical encoders are used for this.

Thus at the simplest level many of the processes used by modern robots can be illustrated, though each individual toy has a limited usefulness. It is possible for them to see, hear and touch. Sound inputs can be clicks or high-pitched whistles but spoken commands do not work very well. Verbot from Tomy Toys claims to recognise a few words but the system is very crude and unreliable.

Vision can be achieved by infra-red or visible light sensors and it is possible to detect obstacles or activate the robots with these. However if vision is needed to distinguish between objects then a much higher level of definition is needed.

Robot vision represents one of the problems of producing a complex robot. Any sort of camera can provide an image of the objects in sight but that image needs to be processed for the objects to be recognised.

There is not yet any useful system that has sufficient

Paul Ritson with his Cyber robot which he controls from an IBM PC.

RTX arm displays the SCARA principle with vertical axes and horizontal movement.

processing power to do this. For example, it would be possible for a vision system to work out that the scene in view was a table and four chairs. The time taken, however would make the exercise pointless. If there had been any change in the scene while it was working it out, as could easily happen in an everyday situation, any action the robot took, based on the information processed, would be incorrect.

The reason why the processing takes so long is the method used. The robot would take a piece of information from the scene and then orient it until a match was found with information stored in its memory. Although it can do this much faster than a human, humans recognise objects more quickly because they do not use this process. Research into artificial intelligence is aiming to replicate human thought processes in machines and this could lead eventually to robots being able to see.

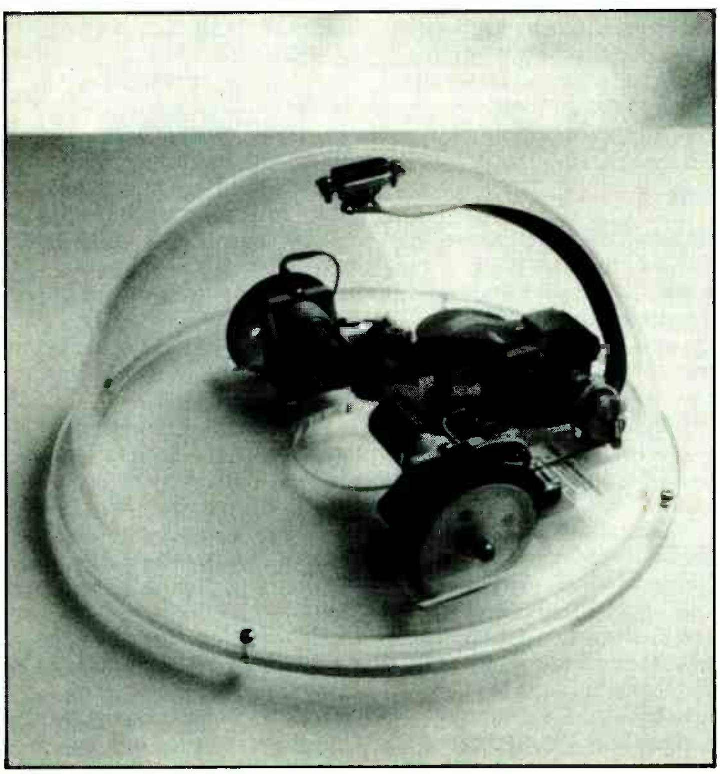
This is still a long way away. In the meantime vision systems have adopted a different policy. They restrict the range of objects and the way that they are presented. Thus it is possible to recognise discrete object on a conveyor belt and it is possible to sort them by outline or colour. In one application mechanisms are used to orient an object so that it is presented to the 'eye' in exactly the same way each time. The system can then recognise the outline of that single object and reject any deviants.

Most forms of sensory inputs have similar problems and restrictions. That is why the commonest form of input is through a keyboard from the simple Forward and Stop keypads on the top of toys such as George and a pendant which does the same for the Memocon Crawler to the full computer keyboard.

Turtles

Turtles are an integral part of the Logo computer language system developed at the MIT under the direction of educational psychologist, Seymour Papert. He believes that children who have difficulty in understanding abstract concepts can grasp them more easily if they are illustrated in a physical form. By working out the instructions to draw a shape, such as a square, the children can learn about distances and angles and then go on to produce other shapes. Geometrical patterns can be easily programmed onto a v.d.u. screen and traced out on the floor by a Turtle, a crawler robot. Most turtles can be positioned quite precisely under computer control. They can raise and lower a pen to draw the design and often have other sensors such as microswitches to detect bumps and/or light sensors to follow a white line on the floor. They have greater accuracy than the toys and can respond to commands of a much greater complexity. They physical parts are basically the same as for the toys: geared motors driving two wheels. They have the memory capacity of the controlling computer and feedback is usually through optical encoders. Many use stepper motors and thus eliminate the need for feedback.

Like most computer languages there has been a proliferation of dialects of the Logo language and usable versions are available for all the popular microcomputers. Typical turtles are the Vaiant, the Jessop and the BBC Buggy.



Traditional design of the turtle is demonstrated by the Jessop turtle. It can draw geometrical patterns.

Robot arms

Arms are designed to simulate their industrial brothers and should, ideally, be programmed in a high-level language. Many only require the co-ordinates of the points they need to reach, and some systems provide help by giving a graphic simulation on the screen so that routines may be tested before being translated into actions on the arm. One of the simplest methods of input is illustrated by the Mentor and Neptune arms of Cybernetic Applications where models of the arms are moved by hand and are reproduced by the arms themselves. Most arms however are governed by the keyboard. Small arms use a wide variety of drive methods. While most are powered by electric motor, the drive can be transmitted by some form of belt, by hydraulics and in one case by screw shafts and pistons. Belts are most popular. Early robots like the Armdroid 1 used a strong nylon cord but this proved susceptible to stretching and slippage. A toothed belt is used successfully by the Atlas and MA 2000 arms.

Dick Becker, while at Powertran Cybernetics, pioneered the use of hydraulics, using oil, in the Genesis range. When he moved to Cybernetic Applications, he designed another hydraulic arm, using water. The Teach robot uses motors to power screw drives which in turn move pistons.

As with turtles, servo motors are commonly used in robot arms and are provided with feedback through potentiometric or optical sensors. sensors.

Arms are classified by the number of axes, or degrees of freedom, that they have. The gripper is not usually counted and arms can have up to six axes which are roughly equivalent to movements of waist, shoulder, elbow and three movements of the wrist; pitch, yaw and roll. Many have five axes with one of the wrist movements being left out. In general, the more expensive the arm the more axes are provided. The Beasty, at about £120 has three axes while the MA 2000 costing more than £3000, has six.

While there is a variety of small robot hardware, there is still a great lack of easy-to-use software. Arms are rarely provided with anything other than the operating software. Cyber produces a small suite of software for the 310 arm, which allows it to execute the Towers of Hanoi puzzle and mimic a number of different types of arm. Cost £150. One exception is the recently launched Trekker. This includes a package of 40 programs for use in education and also full documentation, teachers' notes and much else all for £150.

For the future, there is not much scope for mechanical development of small robots. New designs might be introduced, such as the Scara range which move in a horizontal rather than vertical plane; pneumatics might be used for drive mechanisms but the physical appearence and cost must remain much the same. There is much room for improvement in the electronics. More power for less money will mean that the devices will be able to accomplish more complex routines and process sensor input faster and more efficiently. Research into artificial intelligence could result in operating systems which will allow the robots to react correctly in increasing degrees of complexity.

Some suppliers of robots and their products.

Prices quoted are approximate and are given as a guideline.

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Commotion, 241 Green Street, Enfield, Middlesex EN3 7SJ.
Beasty Truck (controlled by BBC Micro, caterpillar-tracked vehicle) £120
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Wizard (controlled by Commodore 64) £75
Memocon Crawler (controlled through pendant) £35
Navius (programmed by coloured disc) £20
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Kit system, needs interface and micro for control. from £65
Milton Bradley Ltd., Spencer House, 23 Sheen Road, Richmond, Surrey.
Robotix (three kits, with own control system) £20 to £80
Tomy Toys Ltd., Wells House, 231 High Street, Sutton, Surrey.
Omnobot (radio-controlled mobile with two simple arms) £190
Verbot (voice-controlled mobile, see text) £50
Dingbot (bump-sensitive mobile) £10

Turtles

Clwyd Technics Ltd., Unit 4B, Antelope Industrial Estate, Rhydymwyn, Clwyd CH7 5JH.
Trekker (comprehensive software and documentation) £125
Economatics Ltd., 4 Orgreave Crescent, Dore House Industrial Estate, Handsworth, Sheffield S13 9NQ
BBC Buggy (specifically for the BBC-B, light and bump sensors, grabber) £200
IGR, Unit 208, Highbury Workshop, 22 Highbury Grove London N5
Zero 2 (Update of the Zeaker turtle; runs under Logo on many popular micros) Kit £80
Jessop-Ralph Ltd., Unit 5, 7 Long Street, London E2
Jessop Turtle (traditional design) £200
Penman Products Ltd., 8 Hazlewood Close, Worthing, W. Sussex BN14 8NP
Penman Plotter (combines functions of a turtle, a plotter and a mouse for input, three pens) £230

Robot arms

Powertran Cybernetics Ltd., Portway Industrial Estate, Andover, Hants SP10 3NN.
Hebot II (traditional design, controlled by ZX81, amongst others) £100
Valiant Designs Ltd., 'Jnit 14, Park House, 140 Battersea Park Road, London SW11
Valiant Turtle (Infra-red control, runs under Logo, looks like a real turtle!) £150
Colne Robotics Ltd., Beufort Rd, E. Twickenham, Mddx TW1 2PQ
Armdroid (5 axes, stepper motors; one of the earliest designs) £500
Commotion as above
Beasty (3 axes, servo motors; expandable) £115
Cyber Robototics Ltd., Stone, Staffs ST15 0SA
Cyber 310 (5 axes, stepper motors; special software suite) £650
Cybernetic Applications Ltd., West Portway Ind. Estate, Andover Hants SP10 3LF.
Mentor (5 axes, servos; controlled by miniature model of the arm) £500
Neptune 1 (5 axes, water hydraulic) £1600 kit, £2500 built
Neptune 2 (6 axes; touch sensor control) £2200 kit, £3200 built.
Serpent (5 axes, SCARA, Selective Compliane Assembly Robot Arm; moves in a horizontal rather than vertical plane) £2000
Feedback Instruments Ltd., Park Road, Crowborough E. Sussex TN6 2QR.
HRA 933 (5 axes, oil hydraulic; ready-built version of Genesis P101) £2000
HRA 934 (5 axes, oil hydraulic; built Genesis P102) £2700
Pedro (4 axes, servos and steppers; educational workcell SCARA design)
L.J. Electronics Ltd., Francis Way, Bowthorpe Ind. Estate, Norwich NR5 9JA.
Atlas (5 axes, steppers; powerful teaching aid) £1750
Mitsubishi, Hertford Place, Maple Cross, Herts WD3 2BJ.
Movemaster (5 axes, servos; intended for light industrial use) £6000
Powertran Cybernetics Ltd., As above
Genesis P101 (5 axes, oil hydraulic; first to use hydraulics) Kit, £1000
Genesis P102 (more memory than P101) Kit, £1350
Micrograsp (4 axes, servos; one of the earliest low-cost designs) £300
IVAX (4 axes, servos; SCARA design) "under £1000"
Reekie Research Ltd., Beaufort Road, Twickenham, Mddx TW1 2PQ
Cepek 1 (4 axes, servos; SCARA design) £4000
Reekie Arm (5 axes, steppers; similar to Armdroid) £250
Remcon Electronics Ltd., P.O. Box 81, Chislehurst, Kent BR7 6LP
Teach Robot (5 axes, servos; uses screw transmission) £400
Robot City Technology Ltd., 35 Clarke Road, Mount Farm Ind. Est. Milton Keynes.
Alfred (5 axes, servos; many add-ons promised) £200
Robotec Ltd., & Hartley Court, Norton Street, Radford, Nottingham NG7 3AN.
Hero 1 (company specializes in industrial robots)
Syke Instrumentation Co Ltd., 117 Station Road, Liss, Hants.
Teachmover (5 axes, steppers; early U.S. design) £2000
Minimover (5 axes, steppers; smaller version of Teachmover)
Systems Control Ltd., Perry Avenue, Teeside Ind. Est. Thornaby, Cleveland TS17 9LN.
Smart Arm (5 axes, servos; early British design) £1500
TecQuipment International Ltd., Bonsall Street, Long Eaton, Nottingham NG10 2AN
MA 2000 (6 axes, servos; designed for Open University courses) £3600
Universal Machine Intelligence Ltd., Royal Victoria Patriotic Building, Trinity Road, London SW18 3SX.
RTX (6 axes, servos; modified SCARA design with software for control from an IBM PC)

Robot arm axes (or degrees of freedom) do not include the gripper.

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CIRCLE 70 FOR FURTHER DETAILS.

by D.W. Rollema,
PAoSR

Optical communications — 1935 style

Dirk Wietse Rollema was born at Hengelo, Netherlands, in 1929. In 1956 he obtained his degree in electrical engineering from the Technological University at Delft, and is now with Philips Telecommunication and Information Systems at The Hague, working as a project coordinator in the field of maritime traffic control systems.

He has held amateur radio callsign PAoSE since 1951 and is active mainly on 40 and 80 metres, operating home-constructed equipment. PAoSE belongs to a European group of amateurs which uses the old Hellschreiber system of teleprinting over radio.

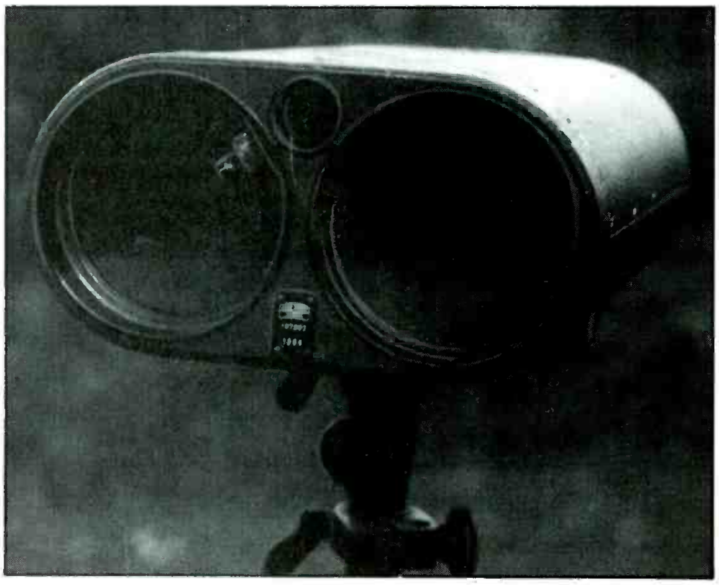
The author has a lively interest in the history of telecommunication and radar. Meeting several radio amateurs, who are also collectors, gave him the opportunity to analyse and describe World War II equipment, mainly of German origin.

Dirk Rollema is married and has two daughters.

Very effective light-beam voice communication was in use by the German military in 1935.

During World War II the German forces availed themselves of pretty advanced telecommunication facilities. The radio equipment, for example, was very effective and of exceptional electrical and mechanical quality.

The optical communication equipment that was in use by the German army since 1935 was a closely guarded secret, but related documents were found during the first German Libyan campaign. It was not until the Battle of El Alamein in October, 1942, that the complete apparatus was found by the British. It was investigated and tested in the laboratories of the Royal Corps of Signals in the Middle East, in November of that year.



A 1938 model seen from the front.

The official German designation was *Das Lichtsprechgerät (80 mm):* the 80 mm relates to the size of the lenses. A larger model also existed and we come back to that briefly at the end of the article. Lichtsprechgerät 80 was developed and produced by the well known firm Carl Zeiss of Jena. The photographs convey a general impression of the equipment, as restored by two Dutch collectors, Messrs Arthur Bauer, PAoAOB and Cas Caspers, PAoCSC. An important feature of the instrument is that it may be operated on white, red or infra red light, merely by selecting the required filter with a knob. The ranges obtainable are given in the operating manual[1] and seem to be conservative, as usual for German wartime equipment. For speech they are quoted as 3 km for white and red light and 2 km for "invisible" (infra red) light. Gifford Hull[2] states the range as five miles (8.25 km) as an average, effective range obviously depends largely on atmospheric conditions: rain and fog will considerably reduce the range. A great advantage over radio is that security is pretty well guaranteed; even at five miles distance the light eliminates the possibility of interception and secures secret communication in the dark, whilst the range is not appreciably reduced[2]. There are, of course, operational restrictions, apart from the limited range. The apparatus functions only over an unobstructed optical path, but it could also be used as an intermediate link in a telephone line connection, and so could be used to bridge a river or a valley.

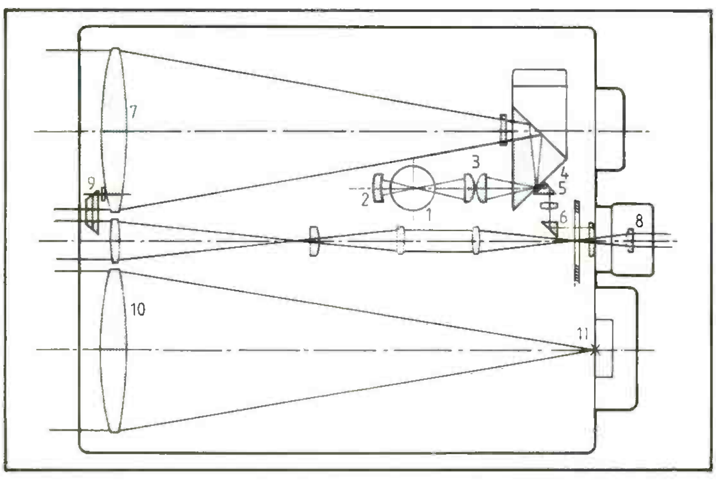


Fig. 1. **Ray paths in the 80mm light telephone.**

Transmitter

The author had access to a reproduction of the operating and technical manual for Lichtsprechgerät 80 from 8 September 1938: Figure 1 is taken from that book[1]. The transmitter forms the upper part of this diagram. Light from an incandescent lamp 1 is focused on the modulator prisms 4 and 5 by means of mirror 2 and condenser lens 3: the lamp (4.8V, 4W) is run from a rechargeable battery, good for approximately five operating hours. After passing the modulator, the light is focused to a parallel beam by means of the 80 mm lens 7. The beam is six yards wide at a mile and thirty yards at five miles, as already mentioned. The functioning of the modulator remains a bit obscure after reading the manual but luckily Gifford Hull gives a much better description of it and we will follow his words: Fig. 2 is taken from his article. The light from the lamp-house strikes the hypotenuse side of a right-angle prism. The other angles of the prism are not quite 45 degrees, so that at the point of first reflection the mean angle of incidence is approximately the critical angle for glass and air media, and partial reflection and partial refraction take place. The area at which this first reflection takes place is a small rectangle measuring $3 \times 1\frac{1}{2}$ mm, the surrounding glass being blackened. The armature consists of a flat metal strip, pivoted at its centre, its ends being located closely between the pole pieces of the armature coils, which are so phased that one pushes and the other pulls.

A small, right-angle prism is carried on the armature, near its centre, and it is so positioned that one of its sides rests in contact with the small rectangle of the main prism. As the armature moves in accordance with the voice currents, so the pressure of the small moving prism against the larger prism changes in accordance with the voice currents. It will be appreciated that since the small prism is mounted close to the axis of rotation of the armature, its travel is small, but its pressure is great. It is necessary, then, when considering the analysis of the action of the device, to bear in mind that it is the pressure of the small prism on the large one that alters — not so much the air gap between the two.

If these two glass surfaces were truly optically flat and in perfect contact, there would be no change of medium at this point and no internal reflection would take place. Hence, no light would pass through the main prism. But as soon as the contact between the prisms becomes imperfect, a change of light media will occur, and internal reflection will result. In practice, the contact is never perfect, for all pressures of the prism, and most of the light is reflected. But the varying pressure brings about a varying degree of contact, which, in its turn, varies the amount of light reflected through the main prism. This, coupled with the fact that the angle of incidence is nearly the critical angle, makes the modulator a relatively efficient device.

A device is incorporated to control the quiescent, no-signal, pressure of contact. The operator is supposed to adjust this to give maximum sensitivity and minimum distortion. Gifford Hull also provided Fig.3 in his article which shows the response curve of the modulator.

The photographs show a built-in telescope that is used for setting-up the optical link, Fig.1. showing the optical rays within the telescope, which is also used for monitoring the modulator action. Part of the light that is not totally reflected in prism 4 is passed on to the eyepiece of the telescope via prisms 5 and 16 and lens 8. Looking into the telescope a green lighted rectangle is seen — the intensity of which changes with the modulation.

Part of the light emitted by lens 7 is reflected into the telescope by means of the tetrahedral prism 9. The filament of the lamp is thus seen above the just mentioned green rectangle, and is used for pointing the transmitter at the opposite station. To attenuate the image of the filament, two red filters[15] of different transmission can be selected at will, one for day

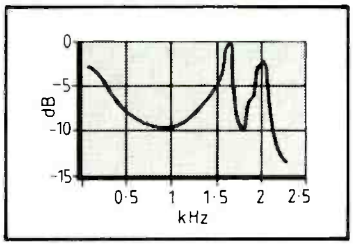


Fig.3. **Response curve of the modulator.**

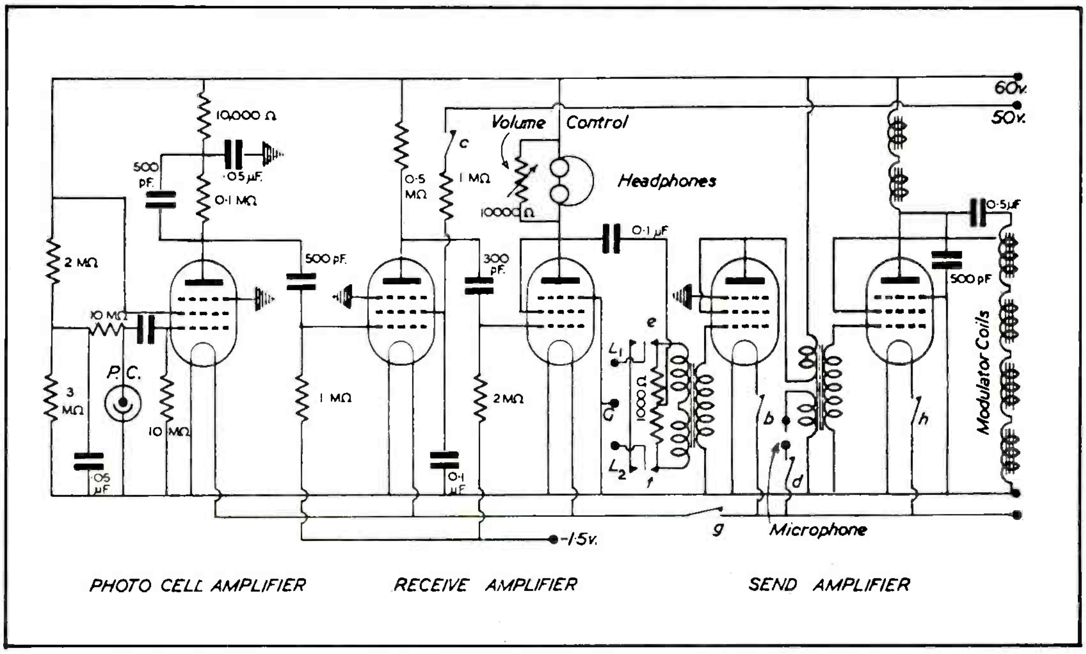


Fig.4. **Circuit diagram of the amplifiers.**

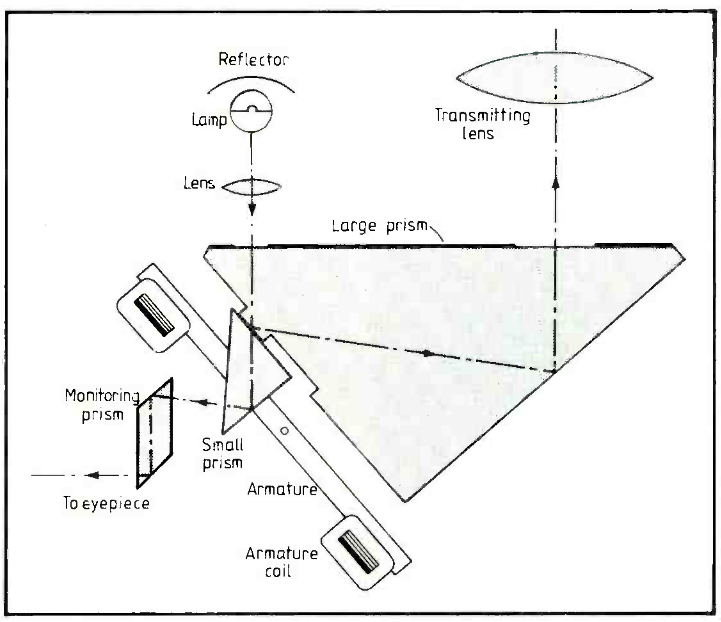


Fig.2. **Diagram showing method of modulating the light beam.**

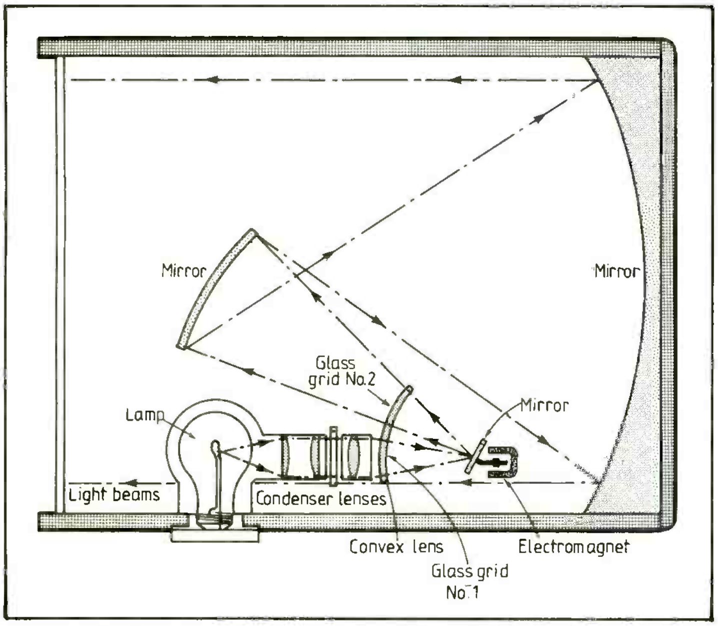
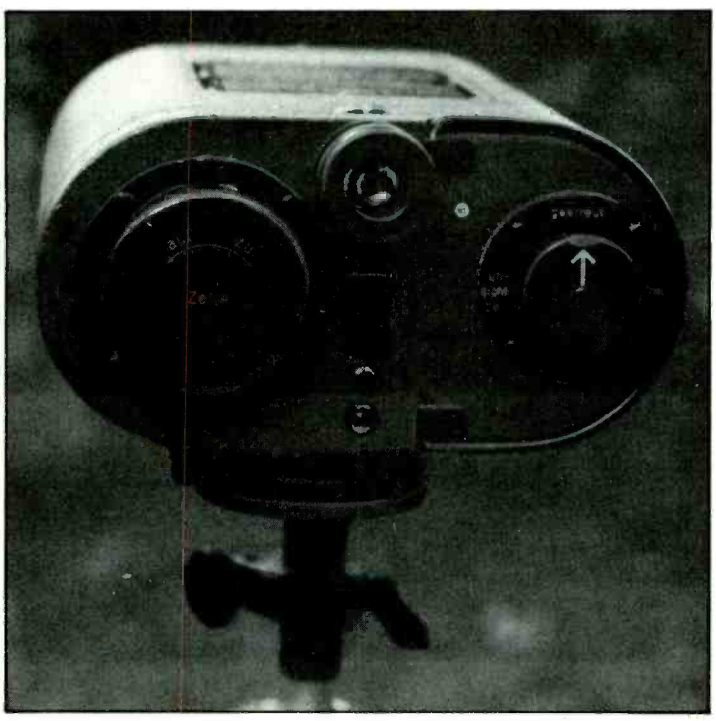


Fig.5. **Ray paths in the transmitter of the 250/130 mm light telephone.**



At the left the detachable cover for the photo-conductive cell. At the right the selector for the optical filters in the transmitter beam. *Unsichtbar* means infra-red filter; *Gestreut* is a possibility not mentioned in the text, which spreads the light over a wider angle to ease sighting; *Frei* produces white light without a filter; the fourth position *Rot* cannot be seen in the picture: it selects red light.

and the other for night operation.

Since the sighting telescope and transmitter have been set in the factory with their axes parallel, it follows that the transmitter beam will fall on the distant object whose image is covered by the lamp filament image. Provided that a view of the distant station can be had, it is an easy matter with this device to set up the equipment.

Receiver

The modulated light signal from the distant station enters the instrument via the 80 mm lens 10 and it is focused on the photo cell 11. Only a very small area, about 1 mm, of this thallium sulphide cell is exposed to the light. This is done because the image of the distant transmitter formed on it by the lens 10 is also very small, and increasing the cell area beyond what is needed to receive the whole image results in loss of sensitivity. This follows since the fractional change in cell resistance on illumination is diminished by the effect of the unilluminated parts of the cell[3]. The "Thalofide" type cell is inferior to a caesium cell, which has a better high-frequency response; however, its sensitivity to red and infra-red light is better than that of caesium cell. The cell can easily be changed by removing the cover shown in the photograph at the left.

Electronics of Lichtsprecher 80.

The circuit diagram of Fig.4., given by Gifford Hull, is better than the one in the German manual. The three amplifiers are housed in a separate box, shown in the photograph. Valves are of the standard type used by the German army during WW II — high-gain, directly heated pentodes, type RV2P800, mounted upside down in a tubular holder, being supported at both ends. The photo-cell amplifier is conventional; the cell receives a positive voltage by means of a high-resistance potentiometer from the h.t. line. The anode circuit has a resistance/capacity network that attenuates at about 4000 Hz, the purpose being presumably to minimize photo-cell hiss. This amplifier uses two valves in cascade, resistance-capacity coupled, and the last valve is triode connected to secure a low impedance for the phones. The output is also taken to the telephone bridge input circuit, the operation of which will be discussed later.

The sending amplifier normally uses but one valve, triode connected, fed by the microphone, and the anode is parallel fed by an l.f. choke, the anode load being the armature coils of the modulator. The send-receive switch normally switches on the appropriate amplifier; duplex operating is therefore not possible. But for the purpose of working into a telephone line, the switch is turned to "Telephone" and this places the bridge circuit in the sender amplifier input — and the receiver amplifier output. The bridge is balanced, to prevent singing of the circuit.

Provision is also made for keying the lamp filament by means of a push button at the end of a cord, connected to the terminals *Blinktaster* in the photograph. This provides facility for Morse transmission, but reception has to be visual. Under these conditions, greáter distances are possible. The valve filaments are supplied from a separate rechargeable battery, sufficient for 20 operating hours: the −1.5V, +50V and +60V come from an anode battery, good for 100 hours operation.

Mechanical construction

With a device of this sort, mechanical rigidity is of prime importance. The tripod is strongly constructed and whilst the head is fixed to it by a single universal fixture, it is very rigid. The head itself is made of aluminium and optical technique has been employed by Carl Zeiss throughout the apparatus. The lamp-house, whilst being detachable, is firmly held in position and the modulator is mounted on a slotted platform, so that initially it may be located correctly with respect to the lamp and the transmitting lens. The modulator prism is housed in a heavy machined brass holder, located within the permanent magnet of the armature system. The photo-cell clips into its holder very simply, but perfect positioning is ensured by the holder, since it is necessary that the incoming light is focused dead on the centre of the cell by the 80 mm receiving lens. The whole apparatus has a mass of 54 pounds.

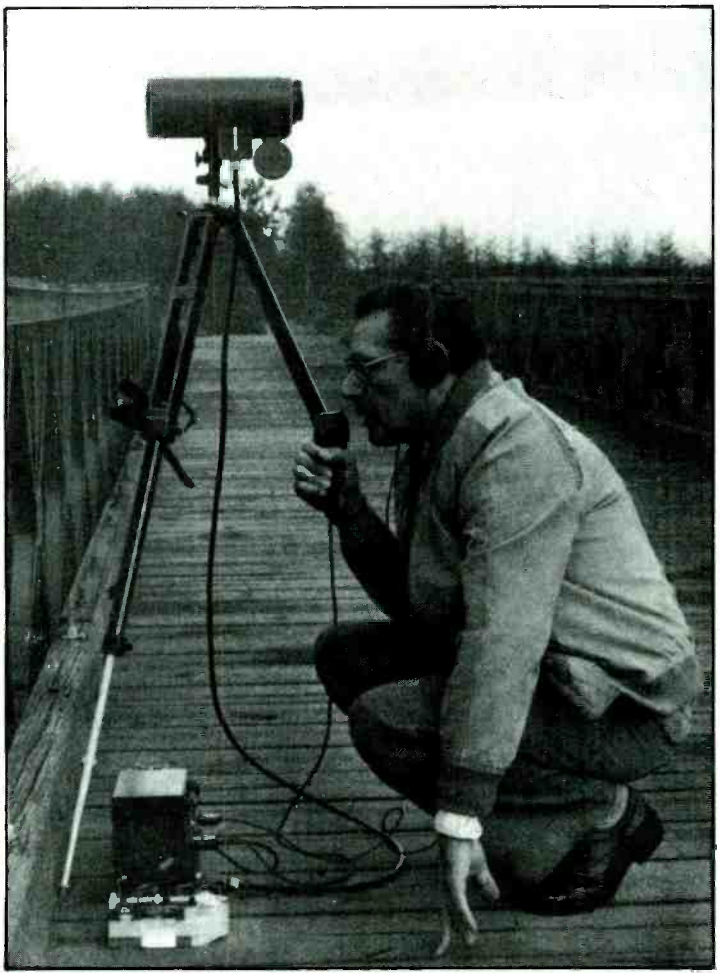
Restoration of Lichtsprecher 80

Several specimens of Lichtsprechgerät80, or simply Lichtsprecher 80, as the apparatus was also called, found their way to collectors of wartime communication equipment and were lovingly restored to original shape, some by Arthur Bauer of Diemen (near Amsterdam) and Cas Caspers of Veldhoven (near Eindhoven). After some preliminary experiments, the equipment was given a field test on a cold winter day in December 1983. Cas Caspers had selected a path of two kilometers between two little-used bridges over the Beatrix Canal near Eindhoven. Although alignment is critical due to the narrow beam width, communication was quickly established. Mr Caspers' son Remco operated a third unit. From the behaviour of the link it became clear that spanning a larger distance should pose no problems.

To find such a longer, unobstructed path is a different matter. The author was lucky to be invited for the experiment. He noticed that the audio was rather limited in frequency range and both linear and non-linear distortion were evident. Nevertheless, speech was easily readable. The non-linear distortion was also manifest from the fact that the light from the distant transmitter was fluctuating visibly under modulation. If the modulation were linear (symmetrical) this should not be possible.

Mr Caspers was standing with his unit on an old Bailey bridge, one of the few "temporary" leftovers from WW II. Occasionally a motorcar passed the bridge and shook it so heavily that the Lichtsprecher had to be set up anew.

During the summer of 1983 Caspers had already tried his instruments over a shorter distance. From time to time he noticed a strange musical note in his headphones, which he finally traced to insects in the light beam, their wings obviously causing intensity variations in the light striking the receiver. It needs no comment that the author found it a fascinating experience to see and hear these almost fifty-year-old devices in action again.



Bridge to bridge. Caspers communicating over 2 kilometers.

Lichtsprecher 250/130

As mentioned in the introduction the Germans developed during WW II an improved version of Lichtsprechgerät 80, which was designated Lichtsprecher 250/130. It has a receiver of 130 mm diameter and a transmitter aperture of 250 mm. The light modulator was of entirely different construction from that described above for Lichtsprecher 80. The principle follows from Fig.5[4]. The light from the lamp traverses a grid and after reflection from a speech-controlled mirror falls on a second grid, an image of the first grid being formed on the second one. It will be seen that the amount of radiation passing the second grid depends on the position of the mirror, so that, by controlling the mirror movement by the microphone current, the radiation beam is modulated[3]. A novel feature of Lichtsprecher 250/130 was a sunlight attachment for utilizing the rays of the sun as a light source instead of the electric lamp. Unfortunately no particulars on this intriguing feature were given in the literature available to the author. The photo-cell was of the lead sulphide type instead of thallium sulphide, providing a better frequency response. This improved photo-condictive cell was also used in some of the later Lichtsprecher 80 models. The operational features of the 250/130 mm model were about the same as those of the 80 mm equipment, but the range was greater, as to be expected from the larger optics. Tests indicated that the equipment was capable of transmission up to 20 miles, subject to weather conditions. But adjustment becomes more critical as the distance is increased and, because the sighting controls do not have vernier settings, the equipment may not have been used over the maximum distances for which it is theoretically capable[4].

Box containing the electronic part. Opening the lid reveals the four amplifier valves.

Acknowledgement

The author is grateful to Messrs Arthur Bauer, PAoAOB and Cas Caspers, PAoCSC for their help in the preparation of this article. They provided the literature and made their equipment available for photography by the author. Their invitation to take part in the field trial of Lichtsprecher 80 is also gratefully acknowledged.

References

1. Manual for "Das Lichtsprechgerät (80 mm)", number D 877/2, issued on 8 September 1938 at Berlin.
2. D. Gifford Hull, Capt.: "The German Army "Speech-on-Light" Signalling Apparatus". *Electronic Engineering*, October, 1943.
3. Bernard Lovell: Electronics. The Pilot Press Ltd., London, 1947.
4. "Improved German Photophone". The origin of this article could not be traced.

CIRCLE 4 FOR FURTHER DETAILS.

COMPACT disc DIGITAL AUDIO

Compact disc players

by J.R. Watkinson

Part 1: details of compact disc player circuitry

One of the design constraints of the compact disc and its format was that it should allow the construction of players to be straightforward, since they were to be mass produced.

The essential components of a typical CD player are shown in Fig.1. The most natural division here is into the control and servo system and the data path. The control system provides the interface between the user and the servo mechanisms and performs the logical interlocking required for safety and the correct sequence of operation. The servo systems include any power operated loading drawer and chucking mechanism, the spindle drive servo, and the focus and tracking servos which have been described in earlier parts.

Power loading is usually implemented on players where the disc is placed in a drawer. Once the drawer has been pulled into the machine, the disc is lowered onto the drive spindle, and clamped at the centre; a process known as chucking. In the simpler top-loading machines, the disc is placed on the spindle by hand, and the clamp is attached to the lid so that it is operated when the latter is closed.

The lid or drawer mechanisms have a safety switch which prevents the laser operating if the machine is open. This ensures that there can be no conceivable hazard to the consumer. Actually, there is very little hazard in a CD pickup; the laser beam is focused a few millimetres away from the objective lens and beyond the focal point the beam diverges and intensity falls with an inverse-square law. It would be almost impossible to place ones eye near the focal point when the pickup is in a player, but this should not be taken as licence for such an attempt.

The data path consists of the data separator, timebase correction and the de-interleaving and error correction process, followed by the error concealment mechanism. This results in a sample stream which is fed to the convertor. The data separator is responsible for converting the e.f.m. channel code into a separate data stream and a clock. The interference read-out process produces modulation of the reflected light, and the photosensor output will contain the modulation due to the disc superimposed on the average level of reflected light. The first stage of the process is to remove the average level to leave the modulation signal only. The care taken to ensure a d.c.-free channel code means that this can be done with a simple coupling capacitor. The resultant waveform conveys information purely in the times at which the average level or centre line of the waveform is crossed.

The signal is converted to a binary form by slicing, which is essentially comparing the signal with a reference. Again, as the code is d.c.-free, integrating the binary output of the slicer will produce a slice level which is self adjusting. This mechanism is shown in Fig.2.

The binary signal is then fed to a p.l.o., which phase compares its own output with every incoming transition. The maximum run length of 11T ensures that the phase comparison can be made often enough to minimize phase errors between the p.l.o. and the signal. The p.l.o. runs typically at 2T rate, and can be used to determine the number of T cycles between transitions. This information identifies the channel code patterns which can be decoded to the original data. It is necessary to synchronize the data separator at the beginning of each block so that it is possible to discriminate the boundaries between 17T symbols.

Synchronization is achieved by the use of two sequential 11T run lengths, a pattern which is not in the data code book and can be uniquely identified. The 17T symbols are stripped of the 3T packing bits, which have served their purpose of d.c. control and prevention of code violations, and the 14T symbols are converted to eight-bit data in a look-up table, which can be a rom or a p.l.a. The code was computer optimized to minimize the complexity of a p.l.a. decoder. L.s.i. chips have been developed to perform the data separation function; for example the Philips SAA7010, or the Sony CX7933. The separated data output from both of these consists of subcode information, audio samples and

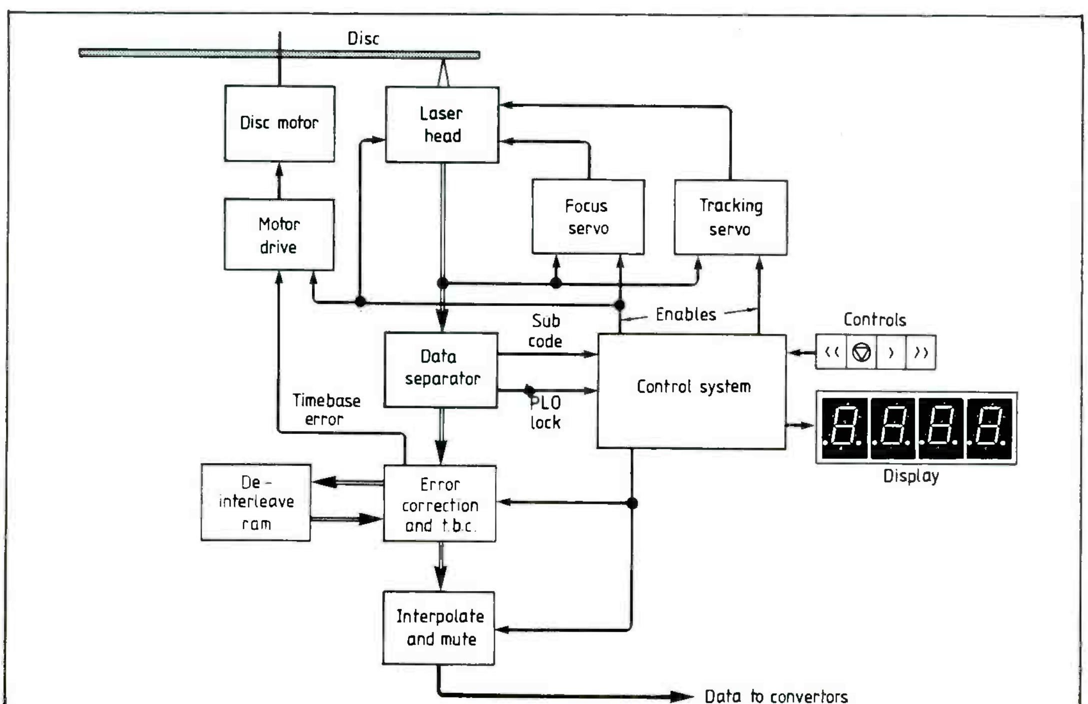


Fig.1. **Block diagram of C.D. player showing the Data Path (thick line) and control/ Servo systems. See text for details.**

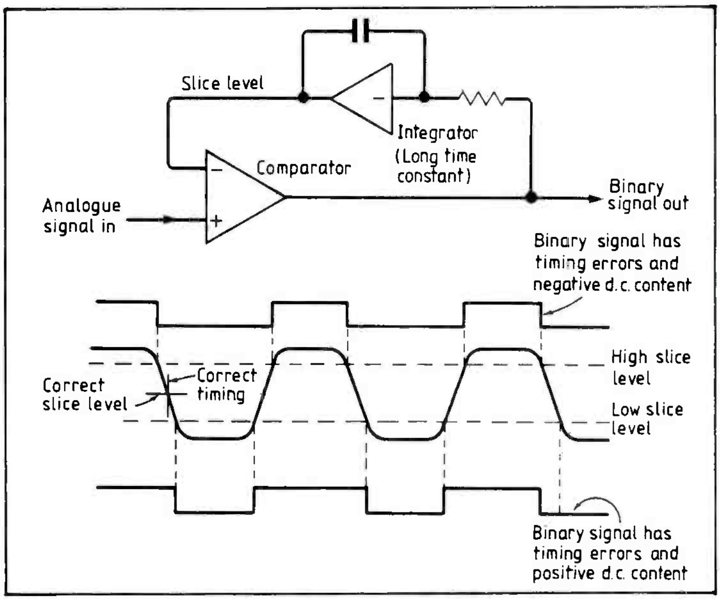


Fig.2. **Self-slicing a d.c.-free channel code. Since the channel code signal from the disc is bank limited, it has finite rise times and slicing at the wrong level as shown here results in timing errors, which cause the data separator to be less reliable. As the channel code is d.c. free, the binary signal when correctly sliced should integrate to zero. An incorrect slice level gives the binary output d.c. content and, as shown here, this can be fed back to modify the slice level automatically.**

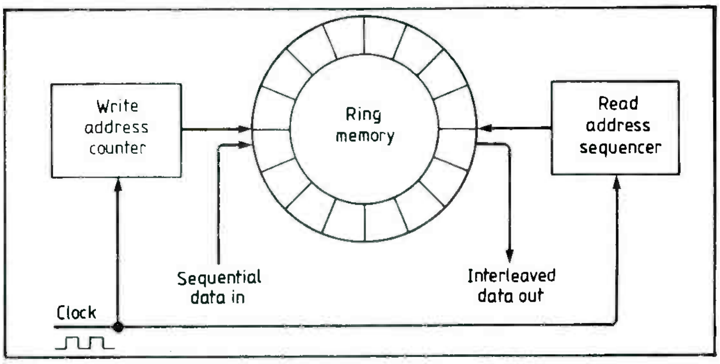


Fig.3. **De-interleave is achieved by the use of a ring memory which is addressed linearlty on one side and by a sequencer at the other side. Timebase correction may also be performed by the same unit.**

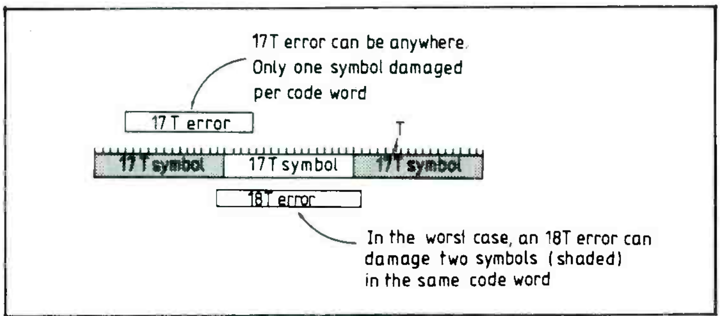


Fig.4. **The odd-even symbol interleave ensures that a 17T error causes no more than one symbol in error in each of two code words, wherever the error is. The worst case for an 18T error is that two symbols are damaged in one code word. Thus errors in excess of 17T must be regarded as burst errors.**

redundancy. The data stream will contain speed variations due to disc runout and chucking tolerances, and these have to be removed by a timebase corrector.

The timebase corrector is a memory addressed by counters which are arranged to overflow, giving a ring structure as in Fig.3. Writing into the memory is done using clocks from the data separator, whose frequency rises and falls with runout. Reading from the memory is performed with a crystal controlled clock, which effectively removes any speed variations in the sample stream, making wow and flutter unmeasurable. The timebase corrector will only operate correctly if the read and write addresses are maintained on average 180° apart in the ring memory. This implies that the long term data rate off the disc must equal the crystal clock rate. Disc speed must be controlled to ensure that this is so.

There are two contrasting ways in which this can be done. The data separator clock counts samples off the disc. By phase comparing this clock with a crystal reference, the phase error can be used to drive the spindle motor. This system is used in Sony's CDP-101, where the principle is implemented using the motors. The data separator signal replaces the signal which originally would have come from the turntable toothed wheel frequency generator.

The alternative approach is to analyse the address relationship of the timebase corrector. If the disc is turning too fast the write address will move towards the read address, if the disc runs too slow the write address moves away from the read address. Subtraction produces an error signal which can be fed to the motor. The t.b.c. ram in Philips players, which also serves as the de-interleave memory, is a 2K byte SSB2016, and this is controlled by the SAA7020, which outputs the motor control signal.

In these systems, the actual speed of the motor is unimportant. The important factor is that the data rate is correct, and the system will drive the disc at whatever speed is necessary to achieve that end. As the disc cutter produces constant density along the track by reducing the disc speed as the track radius increases, the player will automatically duplicate that speed reduction. The actual linear velocity of the track will be between 1.2 and 1.4m/s although this will be constant for a given disc.

These speed control systems only operate when the data separator has phase locked, and this cannot take place until the disc speed is almost correct. A separate mechanism is necessary to bring the disc to roughly the right speed. One way of doing this is to make use of the run length limits of the channel code. Since transitions closer then 3T and further apart than 11T are not present, it is possible to estimate the disc speed by analysing run length. The period between transitions will thus be from 694 to 2.55 µs. During disc runup the periods between transitions are measured. If the longest period found exceeds 2.55 µs, the disc must be turning too slowly. If the shortest period found is less than 694 µs, the disc must be turning too fast. A correction signal can be produced to drive the disc motor. Once the data separator achieves p.l.o. lock, the coarse speed control becomes redundant.

The method relies on the regular occurrence of maximum and minimum run lengths in the readback signal whatever the recorded data may be. This is one reason for the inversion of the C1 and C2 redundancy data (see CD format article), because it injects

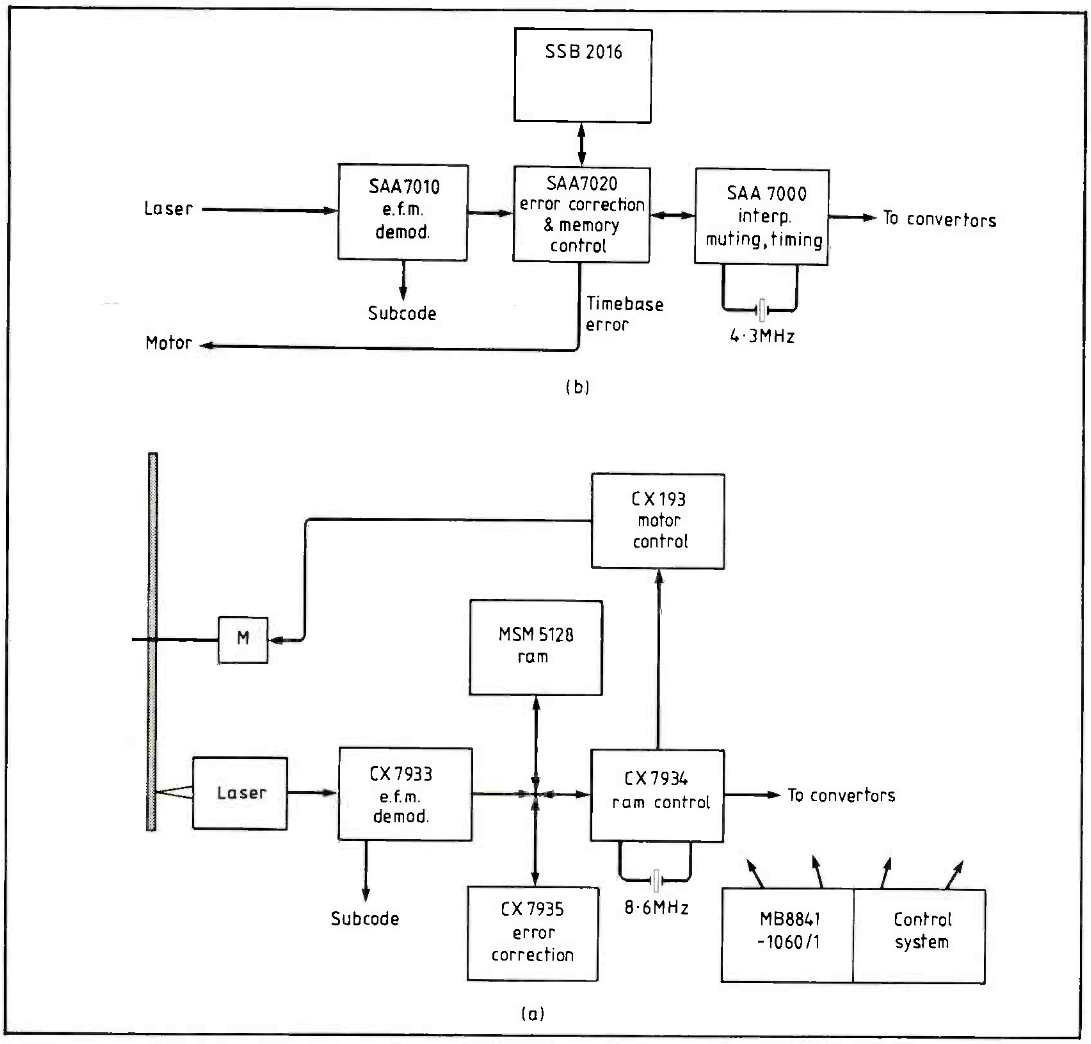


Fig.5. **Shows the l.s.i. chip arrangement of Sony's first generation CD player, contrasted with the Philips equivalent.**

some ones into the data when the programme material is zeros due to muting. This will be the situation during the lead-in at the start of the disc — the very place where lock has to be achieved. Owing to the use of constant linear velocity, the track speed will be incorrect if the pickup is suddenly made to jump to a different radius using the manual search controls. This may force the data separator out of lock, and the player will mute briefly until correct track speed has been restored allowing the p.l.o. to lock again. This can be demonstrated with most consumer players.

Following data separation and timebase correction the error correction and de-interleave processes take place. Because of the cross-interleave system, there are two opportunities for correction, firstly using the C1 redundancy prior to de-interleaving, and secondly using the C2 redundancy after de-interleaving.

Interleaving is designed to distribute the effects of a large burst error among many different code words so that errors in each are reduced. However, the process can be impaired if a small random error due perhaps to an imperfection in manufacture occurs close to a burst error caused by surface contamination.

The function of the C1 redundancy is to correct single symbol errors, so that the power of de-interleaving to handle bursts is restored, and to generate error flags for the C2 system when a gross error is encountered.

The e.f.m. coding system, using discrete symbols, guarantees that a small random error never corrupts more than two symbols. The final odd-even interleave of the CD format guarantees that a two-symbol random error will always appear as single symbol errors in two different C1 code words after the odd-even de-interleave, shown in Fig.4. Random errors are thus always correctable, and the C2 correction system always has maximum burst correcting ability. From this it follows that the maximum length of a random error is defined as 17T (3.9 μs or about 5 μs of data track). Errors of greater size are, by definition, burst errors.

The de-interleave process is achieved by writing sequentially into a ram and reading out using a sequencer. The ram can perform the t.b.c. function at the same time. The size of the ram follows from the format.

The maximum delay is 108 blocks of 28 bytes, the minimum delay is negligible, thus the average delay is 54 blocks. Since a block contains 28 bytes, it follows that a memory capacity of $54 \times 28 = 1512$ bytes is necessary.

When a little extra is allowed for timebase error, odd-even de-interleaves and error flags transmitted from C1 to C2, the convenient capacity of 2048 bytes is reached.

The C2 decoder is designed to locate and correct a single-symbol error, or to correct two symbols whose locations are known. The former case occurs very infrequently, because it implies that the C1 decoder has miscorrected. However, the C1 decoder works before de-interleave, and there is no control over the burst error size it sees.

There is a small but finite probability that random data in a large burst can produce a syndrome which convinces C1 that a single symbol error has occurred. This causes a miscorrection, and no error flag will enter the de-interleaving memory. Following de-interleave, the error is reduced to symbol size and C2 can correct miscorrections. The overall miscorrection probability of the cross-interleave system is thus quite minute. Where C1 has identified bursts, error flags will be read out of the de-interleave memory, and will be used as pointers to the C2 decoder which will correct up to two symbols. Should more flags than two arrive in one C2 codeword, the entire codeword is flagged bad by C2, and interpolation is necessary. The final odd-even de-interleave (shown in Fig.7(b) of the . . . issue) sufficiently to allow error concealment.

If the rate of bad C2 codewords is excessive, the correction system is overwhelmed, and the output must be muted. Unfortunately digital audio cannot be muted by simply switching the sample stream to zero: this introduces a click. It is necessary to fade down by multiplying samples by descending coefficients, usually in the form of half a cycle of a cosine wave. This gradual fadeout requires some advance notice in order to operate. This is

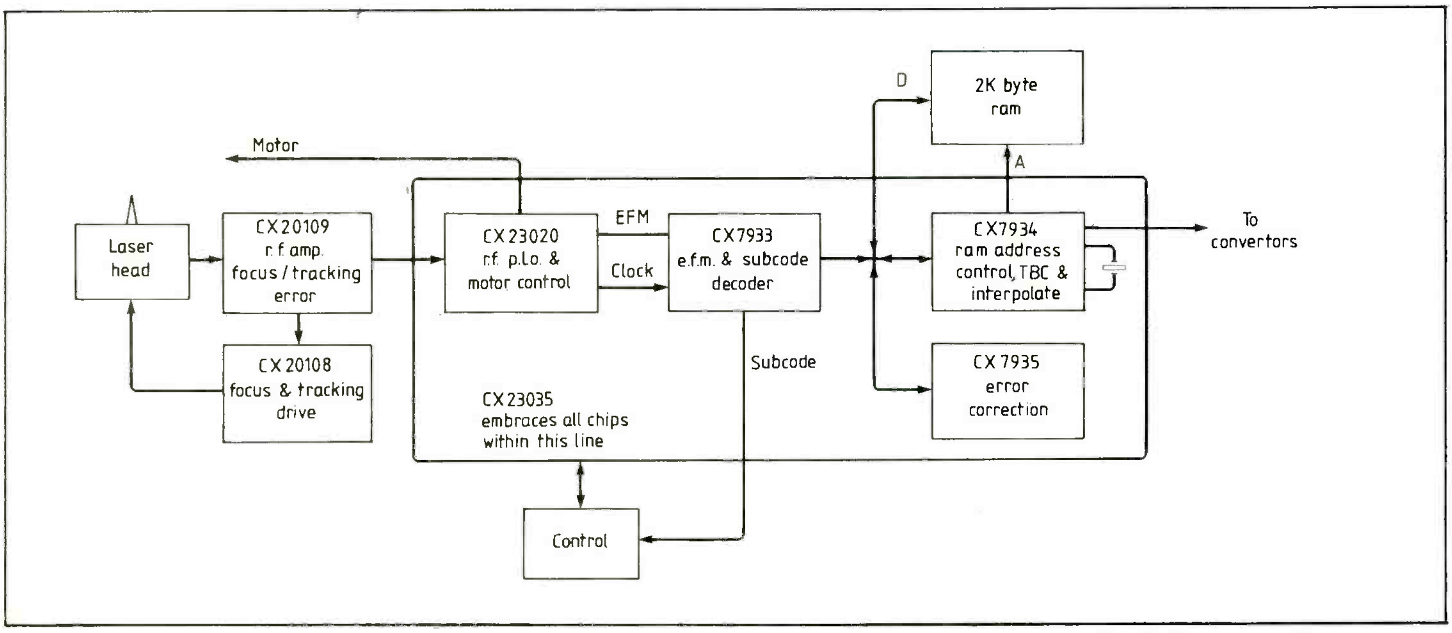


Fig.6. **Illustrates the latest mega-chip CX-23035 which is intended for car dashboard and Walkman-type CD players. This replaces the separate l.s.i.cs as shown.**

achieved by feeding the interpolator output through a further delay before the muting multiplier. The mute signal bypasses the delay, and allows the mute to commence in advance of the uncorrectable data. The output samples will thus be correct, interpolated or muted, and can be fed to the convertor system.

The control system of a CD player is invariably microprocessor based, and as such does not differ greatly in hardware terms from any other microprocessor controlled device. As the subject of microprocessors is extensively documented, this description will restrict itself to the features unique unto a CD player.

Operator controls will simply interface to processor input ports, and the various servo systems will be enabled or overridden by output ports. Software connects the two. The necessary controls are 'play' and 'eject', with the addition of at least 'pause' and some buttons which allow rapid skipping through the programme material.

Although machines vary in detail, the flowchart of Fig.7 shows the logic flow of a simple CD player, from start being pressed to sound emerging. At the beginning of the flow, the emphasis is on bringing into operation the various servos. Towards the end, the disc is read to locate the beginning of the first section of the programme. This relies upon the subcode data, which is sufficiently complex to warrant a subsequent complete article. For now, it is sufficient to state that subcode data can be used by the control system to discover what is on the disc and where, in order to locate sections of programme. The most basic implementation is to use the so-called P flag (Pause), which is an easily detected subcode bit which becomes true between programme sections. The player can jump tracks forward from the lead-in tracks, until the P flag is first seen. Programme material is thus about to start.

When track following, the tracking error feedback loop is closed, but for track crossing, in order to locate a piece of music the loop is opened, and a microprocessor signal forces the laser head to move. The tracking error becomes an approximate sinusoid as tracks are crossed. The cycles of the tracking error can be counted as feedback to determine when the correct number of tracks have been crossed. The mirror signal when the readout spot is half a track away from the target can be used to brake pickup motion and re-enable the track following feedback.

The control system of a CD player for professional/broadcast use will be more complex because of the requirement for accurate cueing. Professional machines will make extensive use of subcode for rapid access, and in addition are fitted with a hand operated rotor which simulates turning a vinyl disc by hand. In this mode the CD plays the same length of track constantly by performing an inward single track jump one per revolution. Turning the rotor moves the jump point to allow a cue point to be located. The machine will commence play at the cue point when a start button is pressed, or using a microswitch on the audio fader. An interlock is usually fitted to prevent the rather staccato cueing sound being broadcast. Even compact discs have to be protected from fluff.

Another variation of the CD player is the so-called Karaoke system, which is essentially a CD Juke Box (see picture). The literal translation of Karaoke is "empty orchestra" which means that recordings of well known songs are made without the singer, and one can sing along oneself. This is a popular pastime in Japan and Karaoke CD Players are starting to appear in clubs and bars.

The second part of this article examines the converters used in CD players, and explains the controversial subjects of oversampling and channel phasing.

Below: Sony CD Karaoke.

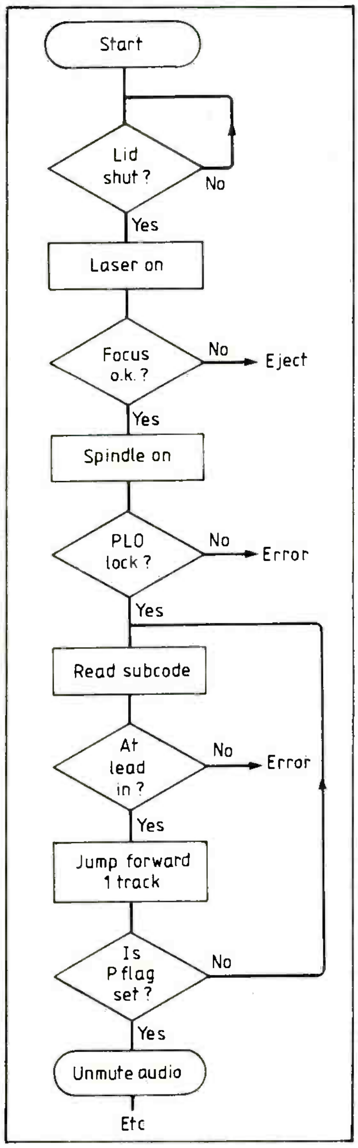


Fig.7. **Simple flowchart for control system focusses, starts disc, and reads subcode to locate first item of programme material.**

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PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
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PCF84	0.65
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PCF201	1.80
PCF800	0.40
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STV280/40	11.95
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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
TT15	34.95
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
UF41	1.15
UF42	1.15
UF80	1.75
UF85	1.20
UF89	2.50
UL41	4.50
UL44	3.50

UL84	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V240C/2K	225.00
V241C/1K	195.00
V2464A/2K	315.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
VR105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	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
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ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1B3GT	1.95
1B22	10.00
1B24	14.95
1B35A	29.50
1BC2A	2.50
1C1	2.50
1C5GT	2.50
1D5	2.50
1FD1	2.50
1G3GT	2.50
1K3GT	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1T4	0.70
1U5	1.00
1X2B	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
2C21	1.00
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C51	0.75
2C53	32.00
2CY5	1.50
2D21	1.50
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	24.95
2K25 Raytheon	75.00
2K26	95.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95

3AT2	3.35
3B2	3.00
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3D22	19.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4687A	9.50
4.125A	60.00
4-250A	65.00
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B	49.00
4CX250BM EIMAC	75.00
4CX250K EIMAC	95.00
4CX125C	125.00
EIMAC	
4CX350A	95.00
4D26	75.00
4GS7	2.25
4GV7	2.25
4J52	75.00
4JC6A	2.95
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5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
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5ANB	1.20
5AR4	2.00
5AU4	1.50
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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
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5R4GY	3.50
5T4	5.95
5U4G	2.50
5U4GB	2.50
5V4G	1.25
5Y3GT	1.95
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AF4A	2.50
6AF9	4.15
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
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6AK5	1.50
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6AM4	3.25
6AM5	6.00
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6AN5	2.65
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6AQ5	1.75
6AQ8	0.85
6AR5	5.95
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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
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6BZ7	2.95
6C4	1.10
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6C8G	1.50
6C11	2.50
6C18	2.50
6CA4	4.95
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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	1.35
6H6GT	1.95
6HF8	0.95
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
6K8Y/G	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	1.20
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
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6SS7	1.95
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6U8	1.15
6U8A	1.50
6V6GT	1.50
6X2N	1.00
6X4	1.50
6X5GT	1.00
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7A6	4.50
7A7	2.00
7AD7	1.75
7B6	3.50
7B7	2.50
7C5	3.50
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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
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10LD12	0.65
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12A6	3.95
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12AU6	1.50
12AU7	0.65
12AV6	1.95
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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
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
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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
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50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
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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
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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
705A	8.00
708A	8.00
715C	45.00
725A	275.00
803	14.95
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807	1.95
810	45.00
811A	12.95
813	23.50
813USA	45.00
829B	14.50

833A	95.00
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872A	27.50
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931A	13.95
954	1.00
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958A	1.00
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1625	3.00
1626	3.00
2050W	4.50
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3545	4.00
404A	10.95
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4313C	4.00
4328D	9.00
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5829WA	6.50
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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
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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	9.95
6157	2.50
6158	3.20
6201	6.45
6205	6.95
6211	2.50
6267	2.25
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	2.35
7193	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	11.00
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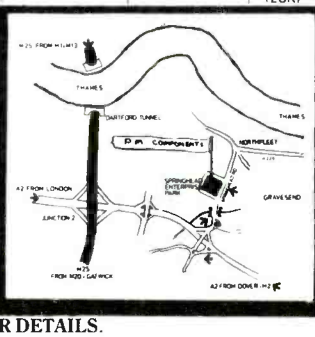
8012	15.00



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CIRCLE 77 FOR FURTHER DETAILS.

Call cost calculator

by S.A. Cameron

Building and using this Z80-based design, which can save its cost in a matter of months.

At switch-on, an introductory message moves through the display. The user touches Reset and the display changes to indicate a direct-dialled local call — the commonest call type and the setting to which the system reverts whenever Reset is pressed. The codes used were explained in Fig.1. last month.

To select a different call-type, press any select key: Dist, for example, alters the distance.

When an operator-controlled normal charge call is selected, pressing the Mode key engages the Special Service selection mode. The current special service is displayed. It changes if Dist or Rate is pressed. Pressing either Mode or Start/Stop returns the display to the current call type.

Total accumulated cost: if Reset is held down for two seconds, the display shows the last distance called and the total cost.

To reset or change the cost, press Mode: one digit will flash, a different one in rotation with each press. Pressing Dist or Rate will increment or decrement that digit.

Costing a call

Once the required call type is selected, the unit is ready to cost the call.

When the call is answered, press the Start/Stop key. The display now shows the elapsed time (on the left) and the cost (on the right) of the call. Press Start/Stop again when the call has finished.

If a further call is to be made, press Reset, reselect the call type if necessary and repeat the sequence.

To display the information used in costing the call, press Dist to obtain the number of seconds per unit, Rate for the cost

per unit and Mode for the Special Service cost. The time and cost display returns automatically after two seconds.

When the current charge unit is nearing its end a warning is given in the display and the buzzer sounds. If the unit time is greater than 40 seconds, the lowest bar of the fifth digit lights up when 20

seconds remain. With ten seconds left, the centre bar lights instead. At 5 seconds the top bar

lights. When it disappears the cost display increases to mark the start of the new charge unit.

If the unit time is less than 40s, the three bars appear at half, three-quarters and seven eighths of the way into each unit.

The call cost is added to the total only if the timer has been started and stopped and the reset button pressed. Any other operation, such as pressing Reset during a call, will not add to the total.

Construction

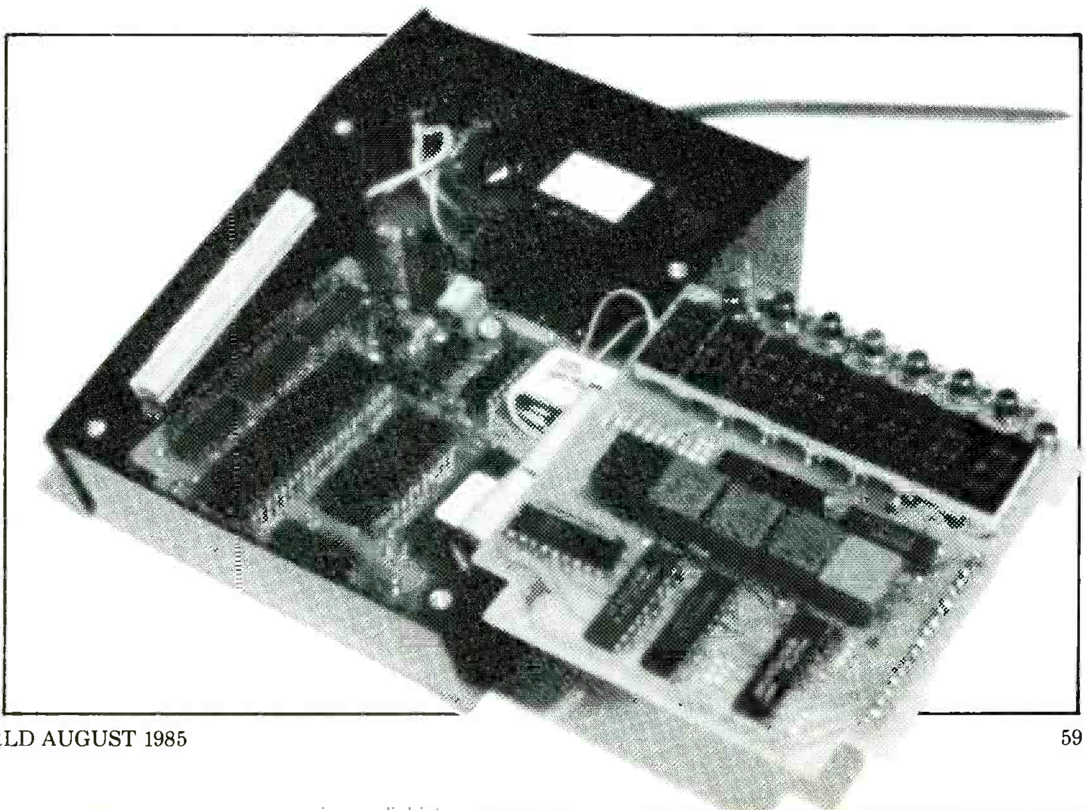
The illuminated mains switch and the fuse-holder should be fitted first. The mains lead should pass into the box through a grommet and the mains wiring to the main board should include 100mm of slack to allow easy dismantling.

Next construct the power supply and test it to ensure that it produces 5V.

When fitting the remaining components, take care to insert i.cs the correct way round. Sockets should be provided for the ram and eprom and may also be used for the display devices to raise them to the level of the front panel cut-out.

Before inserting the c.p.u., ram and eprom, power up and make sure that the address and data lines are isolated from each other and that the supply has not

A variety of factors can affect the cost of a telephone call and this design takes account of all of them.



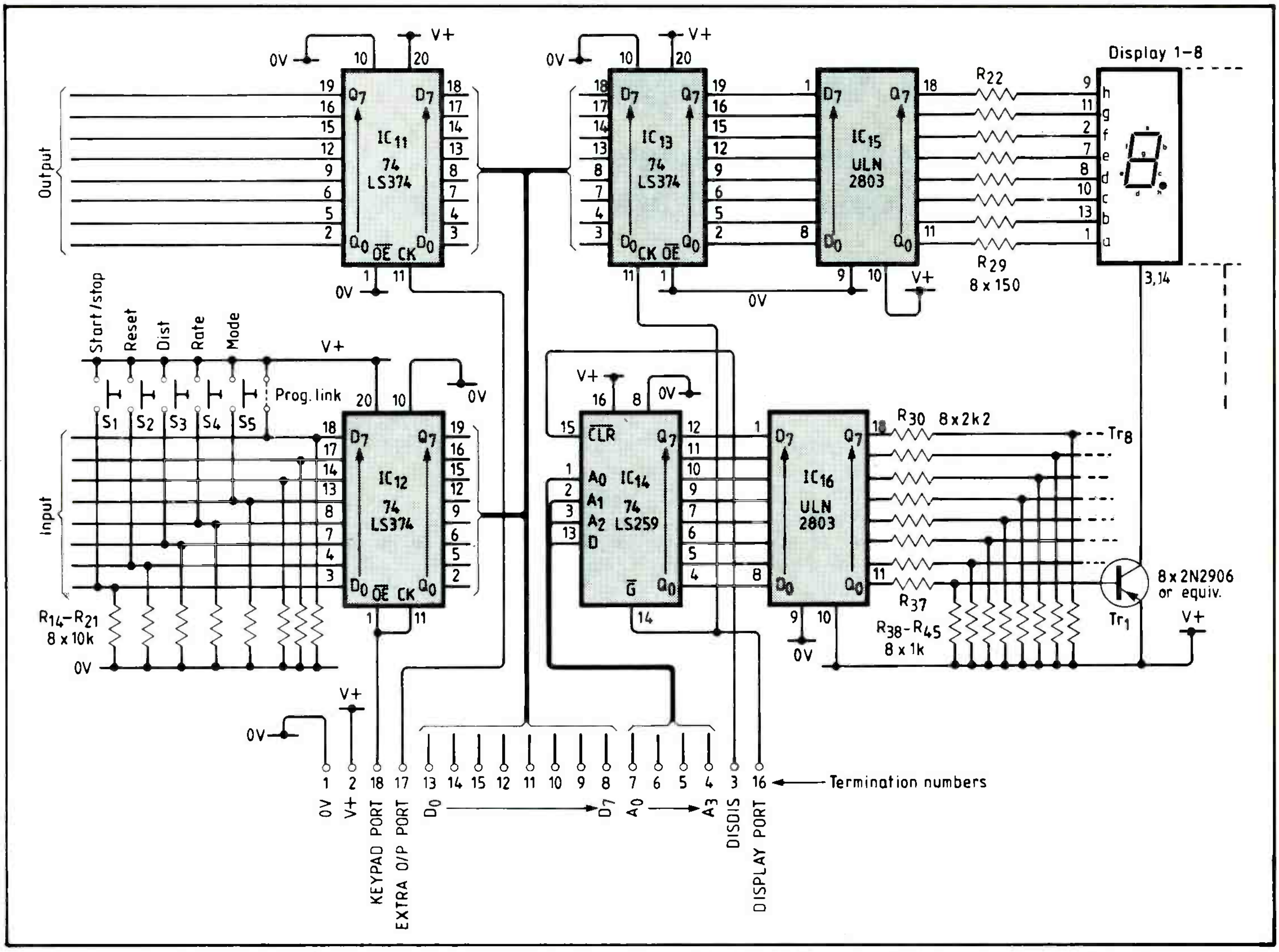
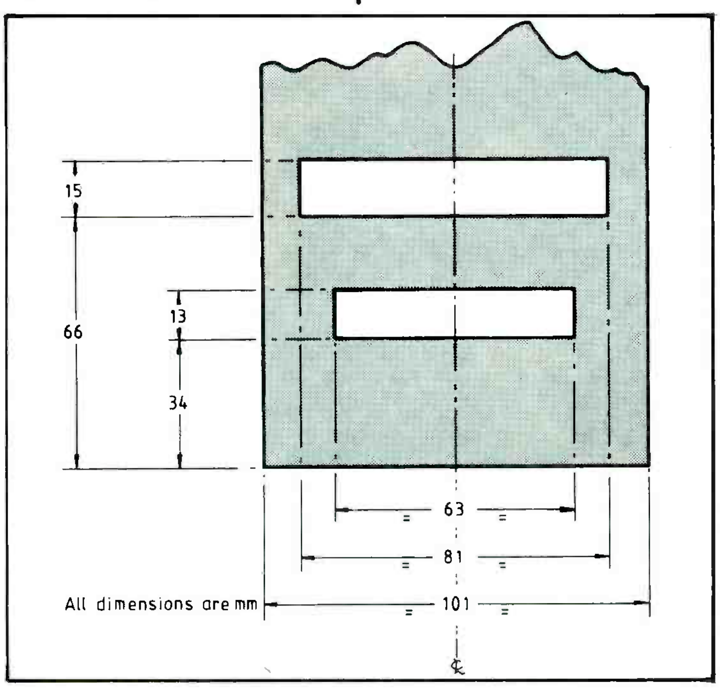


Fig. 1. **Display board. Details of the processor board were given in last month's article.**

Fig. 2. **Front panel cut-outs.**



been shorted. The oscillator can be tested with a d.c. voltmeter, which should display a reading somewhere between 1V and 4V.

Connect the ribbon cable to the component side of the main board and the track side of the display board. Two pins may be inserted for the reprogramming handbag link. An additional switch could be mounted on the box to make reprogramming easier.

The instrument is now ready for testing. At switch-on, a scrolling message should appear in the display. To obtain a readable scroll speed, adjust R_8. Press Reset and the display should show the initial call type, the piezo buzzer sounding with the flashing dots.

Now press Start/Stop. The timer will start, but it is unlikely to be accurate. Compare the display with a watch and adjust R_8 until the two agree. The scrolling rate should still be acceptable. If you have access to test equipment, adjust for a 1kHz signal at the $\overline{INT}$ pin of the Z80. The battery may now be inserted and checked to ensure that the back-up supply is present when mains power is off.

When installing the p.c.b. you can use self-adhesive strips to hold down the main board and to secure the piezo buzzer to the ribbon cable side of the box. It is important to fit an insulating cover to the fuse-holder and to protect other exposed mains connections with heat-shrink or insulating tape.

The display board will be supported by the p.c.b.-mounting strips: bend the box to slip it in. Lastly, screw the top panel on.

Key-pad expansion

The simple keyboard of the standard instrument can be extended with no change in the existing software.

The software always samples the input port as though it were being scanned by eight output lines, but in our basic system it interprets it as just the numbers 1 to 5. If scanning is implemented it will automatically interpret the extra keys.

The location Scmask is used so that any of the output ports Q_0 to Q_7 can be used for other purposes without being toggled. For example, if Q_{0-2} and Q_4 are being used then Scmask=00010111 binary.

Location Prthold holds the output port bits high or low. So for the above example, to hold the unused bits low Prthold must be zero. To hold them high, Prthold must be $E8_{16}$.

There is a maximum of five input lines for the key-pad but eight output scan lines can be used, giving 40 keys allocated numbers from 1 to 40. The present software will accept any of these key numbers but will act only on the first five.

The user may provide additional routines in ram to interpret the extra key-numbers held in the Kynum byte $27ED_{16}$. The keypad can still be used with this expansion, which allows a full alphanumeric keyboard to be attached. Auto-repeat works for all 40 keys.

Component sources

A kit of parts including the box but excluding p.c.bs and eprom is obtainable at the special price of £38.25 (add £1 for inland postage; v.a.t. is payable on the total) from T. Powell (Electronic Components), 16 Paddington Green, London W2 1LG.

Software in eprom can be supplied by the author at £8.50 including postage. The listing is available separately. The address to write to is 7 Donnington Court, Worthy Road, Winchester, Hampshire SO23 7BJ.

A set of two printed circuit boards, silk-screened and double-sided with plated-through holes is available from Combe Martin Electronics, King Street, Combe Martin, Devon EX34 0AD. The price is £23 inclusive for customers inland or abroad.

To be concluded with a description of the reprogramming procedure and the data storage format.

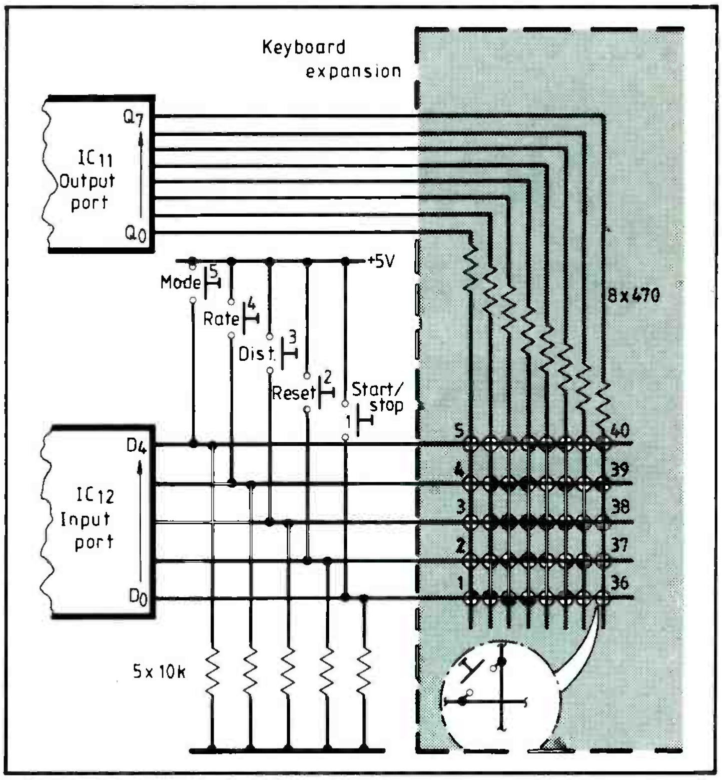


Fig.3. **Key-pad expansion. A keyboard of up to 40 keys can be used if required.**

BOOKS

Projects for the Car and Garage by Graham Bishop. Revised edition, Macmillan Educational, 115 pages, soft covers, £4.95. Over 30 attractive construction projects for the car owner, including electronic ignition systems, anti-theft devices, lighting, instruments, audio and test gear. All are described in enough practical detail even for the beginner.

A Practical Introduction to the New Logic Symbols by Ian Kampel. Butterworths, 164 pages, hard covers, £11.50. You saw Ian Kampel's articles in *Wireless World* (March, April and May 1985): now read on.

The Primer of High-performance In-circuit Testing, European edition, published by Factron-Schlumberger, 96 pages, soft covers. Available from Factron Ltd., Ferndown Industrial Estate, Wimborne, Dorset BH21 7PP. An introduction to automatic testing, how it works and what it can do, with special reference to Factron equipment. Written simply enough for the complete beginner and liberally illustrated with diagrams and cartoons. There is a useful glossary.

Television by Eugene Trundle. Questions and Answers series, Newnes Technical Books, 117 pages, soft covers, £2.95. Transmission and reception techniques made plain. The last chapter covers some recent developments, including MAC transmission, digital processors and memory features.

Microelectronics Systems 3 Checkbook by Ron Vears. Butterworths, 269 pages, soft covers, £5.95. Densely-packed but well laid out compendium of microprocessor wisdom covering the Business and Technician Education Council's level 3 syllabus; designed as a support for a fuller textbook. Concentrates on the 6502, Z80 and 6800 processors. Includes some 70 tested programs, more than 140 worked problems and 140 further problems.

Using Wordwise Plus by Paul Beverley. Norwich Computer Services, 94 A4-size pages, soft covers, ring-bound, £6.50. At-the-keyboard guide to the latest version of the BBC Micro's best-selling word-processor. Deals efficiently with such teasers as how to underline a centred heading without having the underlining stretch into the left-hand margin. Later chapters cover problems with printers, segment programming and coping with errors. At the end are details of some simple applications, including off-beat ideas such as making Christmas cards and embroidery patterns. The book can be obtained by post for £7 inclusive from T.E.R. Roberts, Lamorna, The Street, Bunwell, Norfolk NR16 1NA. A disc (40 or 80-track) containing most of the example programs and the larger data files is available at £5. By the same author and at the same prices, **The Wordwise Applications Guide** applies the same treatment to the original 8K Wordwise.

Epson Printer User's Handbook by staff of Weber Systems Inc. Century Communications, 303 pages, soft covers, £9.95. Unless your computer speaks Microsoft Basic, the manual supplied with the popular Epson FX and RX printers can be hard going. This book spells out how to get at the fancy print modes, dot graphics, user-defined characters and more. A useful chapter explains the use of Epsons with some widely-used software packages, including dBaseII and Wordstar. There is a short preface for U.K. readers with a special note on the BBC Micro.

Macro 11 Programming by C.C. Zammit. Adam Hilger, 119 pages, soft covers. An introduction to the DEC Macro 11 assembler for student or professional use. Covers the use of Macro 11 on the DEC Professional Personal computer, the Micro PDP11 and the previous PDP11 minicomputer series, supplementing the reference manuals provided by DEC.

Teach Yourself Assembler 6502 by Paul Overaa. Best of PCW series, Century Communications, 220 pages, soft covers, £7.95. Developed from the author's series in *Personal Computer World*. Later chapters cover techniques for representing numbers, data structures, sorting, searching and solving problems. A companion volume by the same author and at the same price deals with the Z80.

Forth Techniques by Richard Olney and Michael Benson. Personal Computer News Language Library, Pan Books, 253 pages, soft covers, £6.95. For the reader who already possesses a working knowledge of Forth, this book describes techniques for controlling hardware, handling files and processing strings and numbers. The final chapter explains how to build a compiler to produce turtle graphics.

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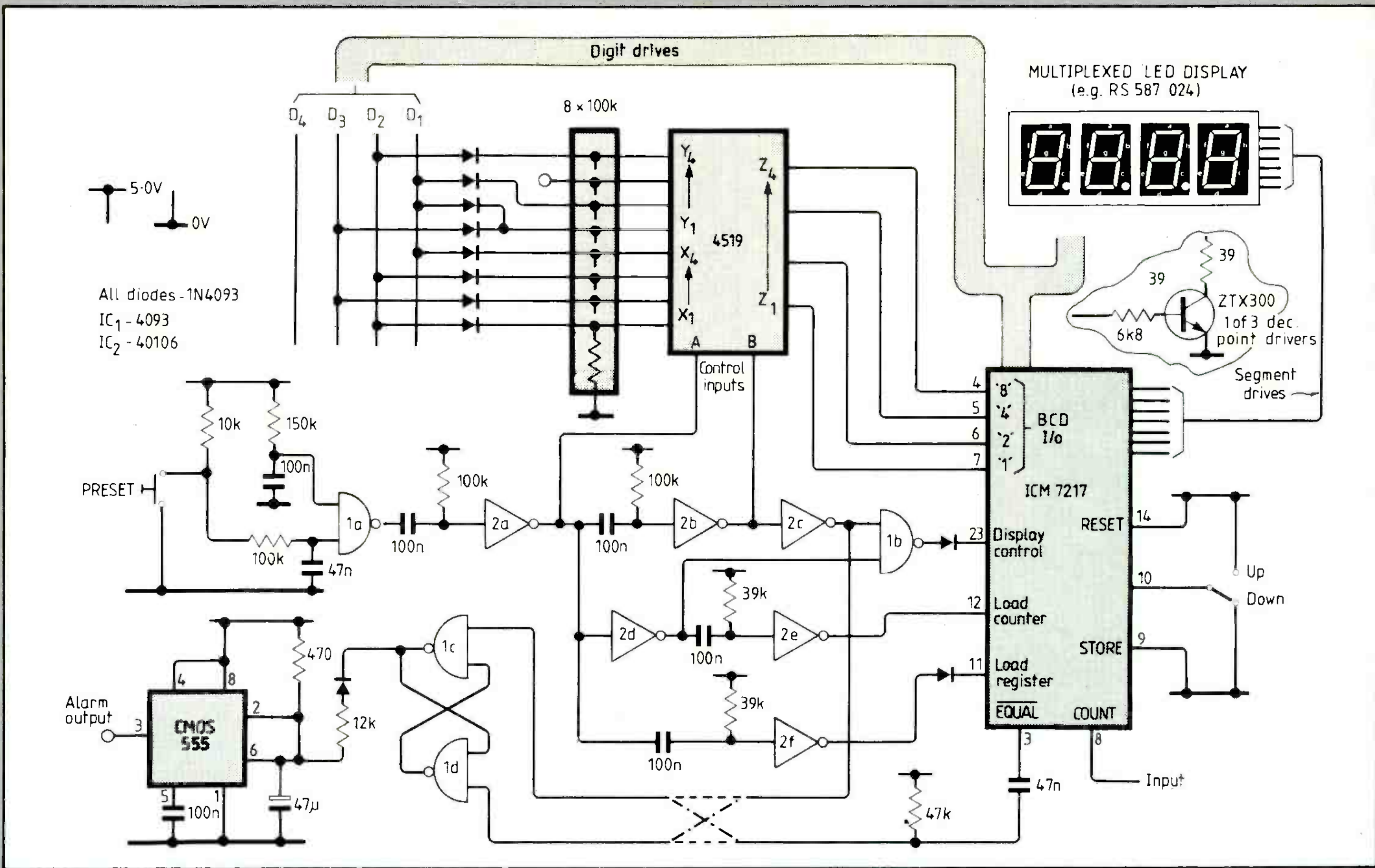
CIRCLE 76 FOR FURTHER DETAILS.

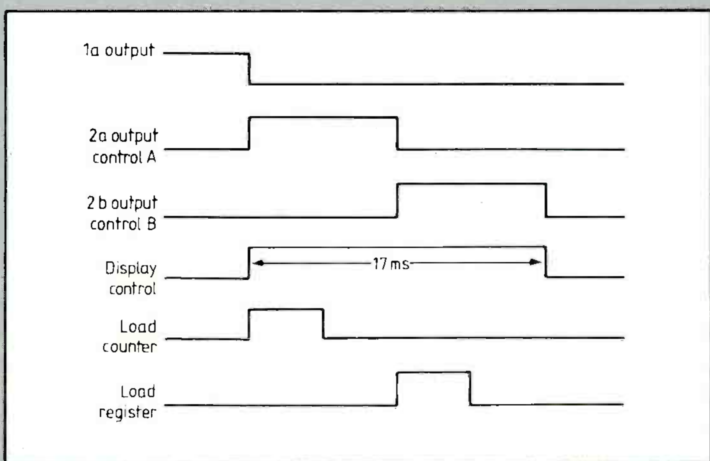


Presettable counter with alarm

Exploiting features of the GE-Intersil ICM7217 four-digit counter provides a presettable up/down counter with high or low alarm. Preset and alarm values are programmed in b.c.d by connecting diodes between the digit drives and 4519 quad two-input multiplexer.

Programmed as shown, the preset and alarm values are 0258 and 0183 respectively. These values are loaded into the 7217 following a negative pulse from IC_{1a}, which occurs when both inputs of IC_{1a} go high, i.e. shortly after switch-on or on releasing the preset push button, see timing diagram. For reliability, the display is blanked during loading to increase levels on the digit-drive lines.

I designed this circuit for use as a remote display and high-level alarm in a depth measurement system which, upon interrogation, produces a number of pulses proportional to the distance between the top of a container and the level of material in it.



To convert pulses to level, the counter is first preset to the maximum container level and then used to count down. Alarm latch $IC_{1c,d}$ is set during the presetting operation, allowing the 555 timing capacitor to charge. If the measured level is greater than the alarm value set then the alarm is not reset by the $\overline{EQUAL}$ pulse and the timer output goes high after a delay. Reversing alarm latch set and reset lines provides a low-level alarm.

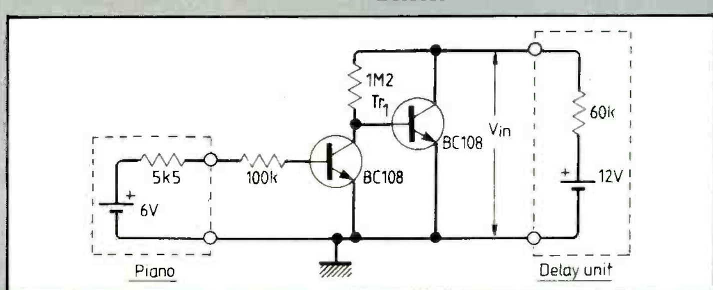
D.W. Cooper
Rochester
Kent

Electronic piano interface

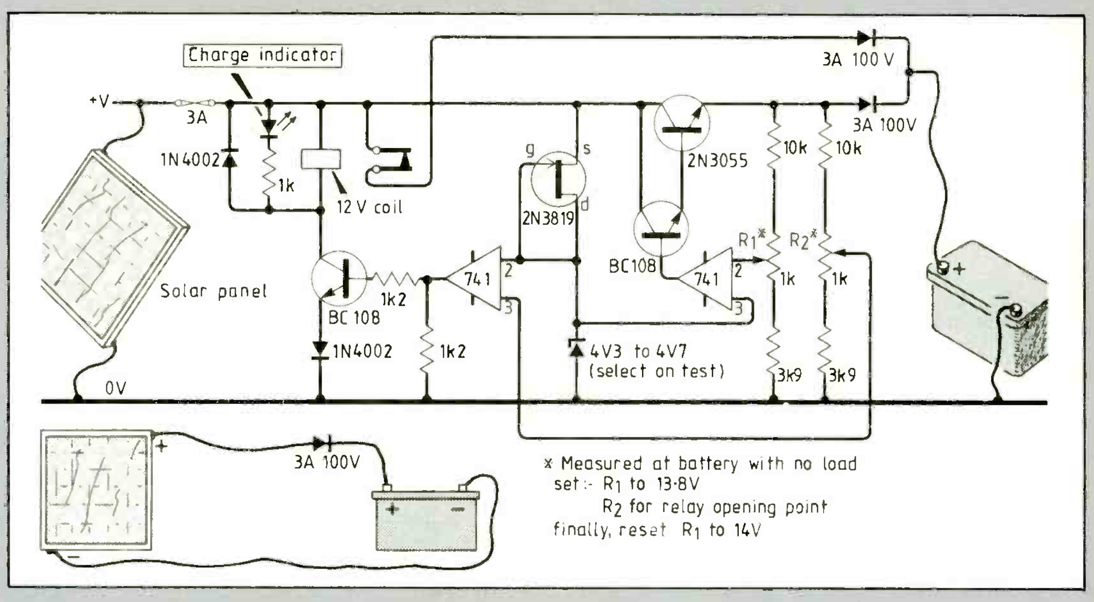
This circuit allows the sync. output of a Roland Piano Plus to control the foot switch of an analogue delay unit without using an auxiliary power supply. Many electronic pianos have a sync. output so the idea should find other uses.

Normally the sync. output, used to indicate pressing of a key, is low and the delay effect inhibited. When any key is pressed, the sync. output goes high and the interface effectively opens the foot switch to allow the delay effect to operate. The delay effect turns off when V_{in} is less than about 5V; Tr_1 is biased to normally hold this level.

J.C. Gardiner
Bristol



Solar-panel regulator



Most solar electric panels give about 19V off load. This allows for a drop of 0.6V across a blocking diode when charging a 12V lead-acid battery; the diode stops battery current from flowing through the panel in darkness.

This arrangement is fine as long as the battery never becomes fully charged — a 12V battery can quickly overcharge to 16 or 17V if the charge voltage is not regulated.

Voltage drop caused by a regulating transistor, usually around 1.2V, is too high to allow most solar panels to work efficiently. In this circuit, power from the panel is delivered to the battery through a relay and blocking diode. When battery voltage reaches 13.8V, the relay contacts open and the 2N3055 transistor trickle charges the battery to a maximum of 14V.

These voltages can be set slightly lower, although most lead-acid batteries gas freely at 13.6V. This gassing is greatly reduced at a slightly higher voltage. The relay contacts close as soon as battery voltage falls below 13.8V.

Battery power is not used to drive the circuit. The fet acts as a constant current source.

Nicholas Butt
Sudbury
Suffolk

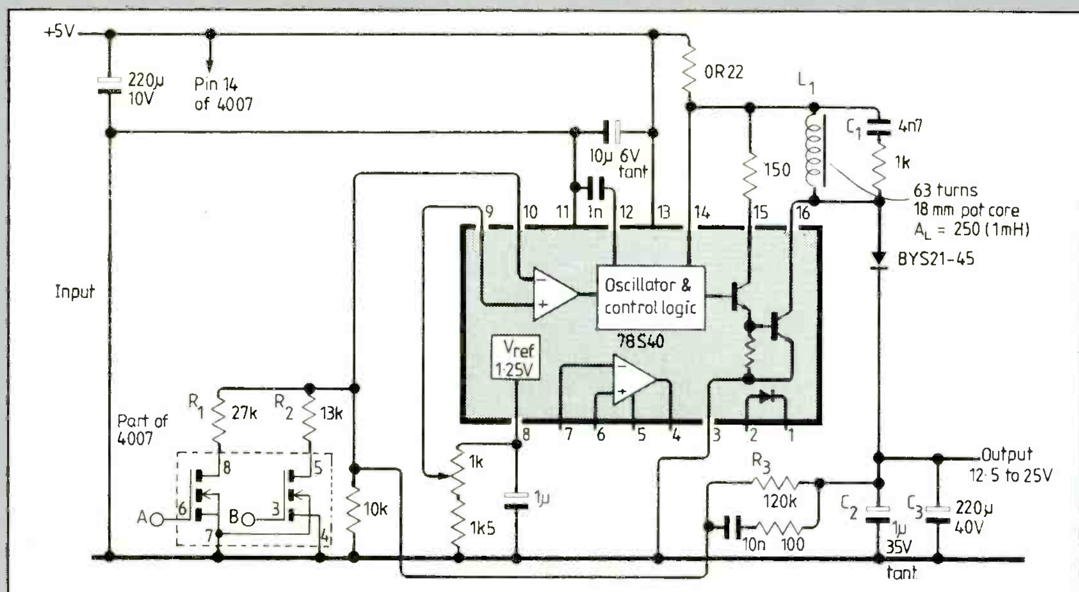
Programmer power supply

This power supply for an eprom programmer provides all standard programming voltages (12.5, 21 and 25V), and is intended as an add-on to computers where the only supply available is 5V. Output is switchable using t.t.l. level signals.

The output delivers 75mA at 25V for an input of 4.5 to 5.0V, at around 85% efficiency. A single potentiometer adjusts the output voltages, whose ratios are determined by the feedback resistors. The Shottky rectifier diode gives significantly better performance than the on-chip rectifier, which wastes 10% of the output current in leakage to the substrate.

A similar circuit may be used for a switchable 5/6 Volt supply for 'intelligent' eprom programming. Another application might be as a charger for up to 20 AA size NiCd cells in series.

J.R. Hunt
Doncaster



Control inputs A	Control inputs B	Output volts
0	0	12·5
0	1	21
1	0	16·5
1	1	25

Changes for 5/6V output

R_1	39k	C_2	10µ 16V Tant
R_2	Not fitted	C_3	470µ 10V
R_3	39k	L_1	63 turns 14mm pot core A_L = 100 (400µH)
C_1	2n2		

Eight analogue inputs for Z80/8085

The ADC0809 analogue-to-digital converter from National Semiconductor is an eight-bit device with one converter and eight multiplexed analogue inputs. Internal latching and control logic is included and being cmos, the device only consumes about 15mW. Further, it runs from a single 5V supply.

Use of precision resistors, zener diodes and LM741 allows inputs between −5 and +5V but limits input to the converter to between about 0-5V.

For conversion, the converter requires a pulse generator; this circuit uses an LM311 to provide clock pulses at about 600kHz. To make the converter output suitable for microprocessor arithmetic operations, the most significant data bit should be inverted to give binary numbers in two's complement mode. This can be done either by a three-state inverter or in software.

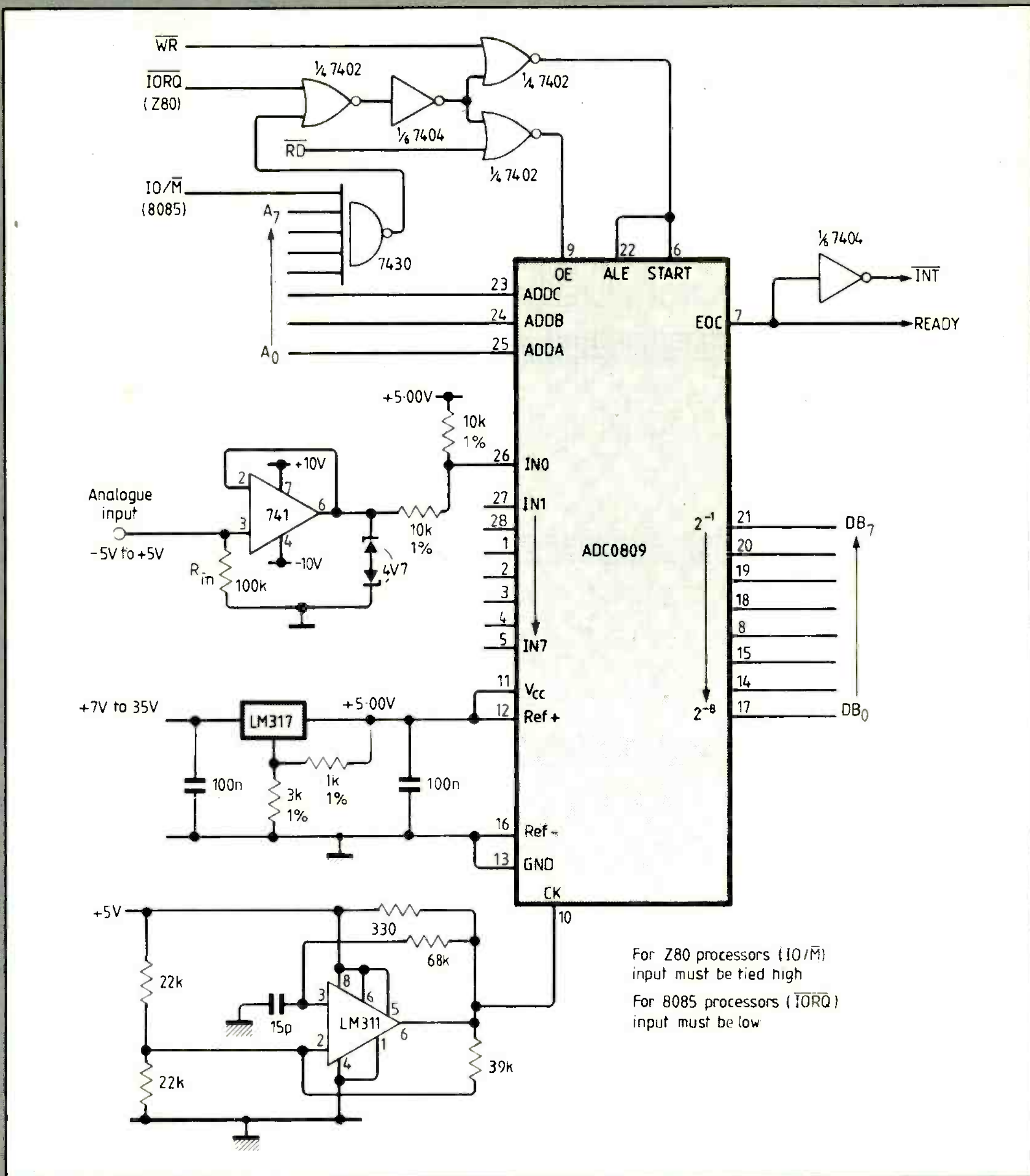
The converter has six control inputs and one control output. Three of the inputs are connected to address lines A_{0-2}. The other three are controlled through microprocessor read and write outputs and the decoded peripheral address (i.e. the address of the converter).

Considering the address decoding logic, addresses used for the converter are $F8_{16}$ to FF_{16}. To start conversion, an instruction for input channel selection and conversion start is needed. In assembly language, OUT 0F8H selects the first input and starts conversion.

To remove the prepared data from the converter, its output must be enabled after 100μs, which can be done using IN 0F8H. The converter control input can be wired to the computer interrupt input to inform the processor that conversion is ended and the result is ready.

Since conversion time is approximately 100μs, the control output can be ignored for 100μs after conversion.

M.R. Mirabedini
Tehran
Iran

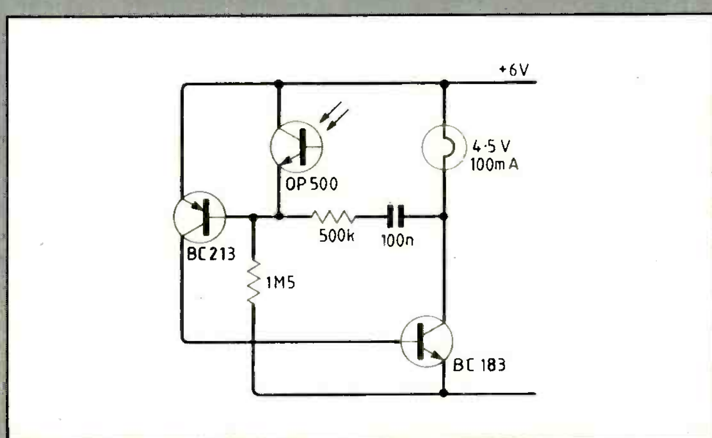


Analogue in		Converter out
To 741	To converter	
+5V	+5V	11111111
0V	+2.5V	10000000
−5V	0V	00000000

Buoy flasher

A regenerative oscillator flashes the lamp in this circuit designed for a marine marker buoy. During daylight hours, the phototransistor clamps the BC213 transistor to stop oscillation so power drain is very low; only transistor leakage has to be catered for. Flash period is changed by altering the RC network.

Andy Bartram
Exeter
Devon



Public-key cryptosystems

It is now ten years since Whitfield Diffie and Martin Hellman of Stanford University, (and independently Ralph Merkle) conceived a new family of secure "public-key" cryptographic systems which promised to simplify greatly the problem of effective key management for multi-point communications networks. To emphasize the advantages of public key encryption they published a long and detailed tutorial paper on the techniques of cryptography and cryptanalysis ("Privacy and authentication: an introduction to cryptography" *Proc. IEEE* vol. 67, no 3, March 1979, reported in "Electronic cryptography" *Wireless World*, September 1980). It is widely believed that this detailed revelation of the "black arts" greatly disturbed the American cryptographic agency (National Security Agency) and lead to a tighter control in the USA on academic publication. Diffie and Hellman outlined public key systems in which each user would have two keys, one for encryption which could be published in a directory but also a decryption key that would be kept private; once a message had been encrypted only the recipient would be able to decode it as nobody else would possess the unique decryption key. A practical implementation of one particular public key system, RSA, was outlined in 1977 by Rivest, Shamir and Adleman of the Massachusetts Institute of Technology. Although several of the original "knapsack" algorithms have been shown to contain hidden weaknesses that could make them much less than "computationally secure", the RSA algorithm appears to have survived the most determined efforts of the cryptanalysts. RSA, like other public-key systems, depends on the fact that multiplying is relatively easy with a computer but factoring is extremely difficult. For example whereas two 100-bit factors can be multiplied electronically in a fraction of a second, the reverse process of factoring them could take hundreds of thousands of years of computer time.

RSA has already found practical use for high-grade diplomatic, military and banking applications, although J.A. Gordon of Cybermation has recently shown (*Electronic Letters*, April 25, 1985) that it is possible to "forge" some RSA key certificates and thus defeat one of the prime claims for public key systems, the assurance that a message has come from a specific sender. However J.A. Gordon shows that there exists a simple remedy to this problem, so retaining the advantages of the RSA cryptosystem.

A practical problem, however, of all public key cryptosystems is that encipherment requires more computational power than private key systems, such as those using the Data Encryption Standard with its mixed substitution/transposition modulo addition of the key. This tends to limit the maximum practical rate of encipherment with practical v.s.l.i. devices.

In the UK, Martin Kochanski of Business Simulations Ltd is reportedly about to market a Fujitsu c-mos array of 16 v.l.s.i. chips for RSA that can encrypt at some 5Kbit/s using 512-bit keys about seven times the rate of previous commercially available public-key cryptosystems.

This is still much slower than the private key systems, which require two identical keys for sender and receiver, including D.E.S. and British Telecom's B-Crypt which can encrypt telephony and data at rates up to about 2.5Mbit/s. The 64-bit keys of D.E.S. however involve not only the serious problems of key management, particularly severe for multiple-terminal networks, but are not regarded as secure against determined computer attack.

While D.E.S. and B-Crypt would be considered secure for the vast majority of commercial applications, large banking networks using them are faced with enormous problems of key management and seek also the assurance of 'authenticity'. However even unconditionally or computationally secure crypto-systems can be circumvented if in some way an outside agency can obtain access to the message files, etc. The Americans recently disclosed that electronic typewriters in their Moscow embassy has been 'bugged' over a long period. It is recognized that even single-channel monitoring of the timings of a 'golf-ball' typewriter permits the recovery of text written on the machine.

As David Cornwall ('John Le Carré) has written: "The honest-to-God steam spy is probably in greater demand than ever. Because of the enormous expense and extravagence of technological methods, the number of linked computers and mathematication you need for codebreaking and the vast amount of junk you process, it's obvious that if you can buy a cipher clerk on the other side you have saved yourself millions... but Intelligence finally is only as useful as the idiots who use it." The alleged Walker spy ring in the USA, specializing in communications, appears to bear this out.

Spreading police radio?

The long drawn out controversy about how to prevent unauthorized interception of police and other emergency mobile-radio networks has taken a new turn in the USA with the FCC opening the way to use of frequency-hopping spread-spectrum techniques in the "industrial, scientific and medical" frequency bands including 902 to 928MHz, 2.4 to 2.48GHz and 5.725 to 5.875GHz.

Frequency-hopping has so far been confined largely to military and government communications networks and it is by no means certain that it will be widely adopted for civilian services. FCC have already authorized American radio amateurs to begin using spread-spectrum techniques above 420MHz in 1986.

A rival, lower-cost technique for secure communications, digital encryption of speech, has already been chosen by the FBI and was used at the Los Angeles Olympics. Speech encryption of some police messages is already used by some police forces. Frequency-hopping is likely to be given a cool reception by cost-conscious police departments.

Frequency-hopping radios made by Transcrypt International offer 500 or 1000 radio channels spaced 10kHz apart with dwell times of about 80ms, selected by pseudorandom codes.

Software on tv

J. Billingsley and R.J. Billingsley of Portsmouth Polytechnic have reported (*Electronics Letters*, May 9, 1985) the development of an improved method of transmitting software and digital data by optical techniques on broadcast television transmissions, at rates of the order of ten times that of the simple flashing spot system developed by Thames Television and Channel 4.

The Plymouth Polytechnic method, suitable for data rates of multiples of 500 baud, uses a simple low-cost receiver interface and, unlike 7Mbit/s teletext signals, can be recorded on a domestic video tape recorder for subsequent decoding.

The new method permits the transmission of a complete byte to be transmitted in each television field. It is suggested that, for example, numbers of software programs could be transmitted simultaneously for educational use, possibly recorded overnight. Up to 24 light spots or more can be displayed on the screen without risk of crosstalk, individual programs being selected by positioning a phototransistor detector over the appropriate spot. More than a megabyte of software could be transmitted in a 20-minute session, with receiving equipment of much lower cost and complexity than with "telesoftware" transmission by teletext, it is claimed.

Leukaemia and radiation

Following closely after the Polish report of an enhanced statistical risk of certain cancers among military personnel exposed to microwave radiation has come a report from the New Zealand Department of Community Health ("Leukaemia in Electrical Workers in New Zealand", *The Lancet*, April 6, 1985) that supports earlier investigations into this occupational hazard. The New Zealand investigation has concentrated on breaking down the electrical industry into eight main categories and finds (on the basis of 546 male leukaemia patients and 2184 matched controls) significant excess of cases in only two of the eight categories: (1) electronic equipment assemblers and (2) radio and television repairers. The New Zealand study thus tends to support the view that the leukaemia risks previously identified among electrical workers are rather more likely to arise from exposure to metal fumes and substances used in electrical components or assembly such as polychlorinated biphenyls (widely used until the 1970s as in high-voltage transformers and capacitors) than from exposure to non-ionizing radiation from electromagnetic fields. The New Zealand study however recognizes that the second hypothesis is supported by another study based on children living near power transmission equipment.

The same issue of *The Lancet*, however, also reports an American study by Samuel Milham of the Washington state Department of Social and Health Studies of 1691 deaths of radio amateurs resident in California and Washington states during the period 1971-83. These included 24 deaths ascribed to leukaemias compared with an expected 12.6, with the increase almost entirely limited to myeloid leukaemias. S. Milham believes that occupational exposure alone does not explain the leukaemia excess among amateur radio operators and concludes that his findings "offer some further support for the hypothesis that electromagnetic fields are carcinogenic".

Amateur

Falling off in the number of newcomers being attracted to amateur radio and the proportion of people failing to renew licences in several countries is being ascribed to the combination of a number of factors including:
(1) improved world-wide telecommunications that have taken the thrill out of talking to distant stations.
(2) the increasing cost and complexity of modern communications equipment, the disappearance of low-cost specialized components, which have made home construction and even home maintenance difficult and relatively rare.
(3) youngsters have switched from radio communication to personal computers — and drop out of electronic hobbies when the computers lose their attraction.
(4) amateurs have become too absorbed in QSL-card collecting, "squares" and contest operating rather than meaningful communication with overseas enthusiasts.
(5) the ever-present and major problem of electromagnetic compatibility, with amateur transmitters blamed for causing radio frequency interference to the vast range of electronic consumer appliances in the home.
(6) the difficulties experienced by licensing authorities in attempting to enforce the regulations — for more than ten years abuse of the South London 144MHz repeater has reflected badly on the hobby, in the UK.
(7) the easy availability of c.b. licences has built up further resentment at having to learn morse before permission is granted for h.f. operation.
(8) the cost and slowness of the process of obtaining licences in the UK compared to some other countries where licence examinations can be taken at almost any time, with licences issued to successful candidates virtually the same day.
(9) the secrecy that surrounds the City & Guilds licence examinations in which the "pass" mark appears to be adjusted each time to fail approximately one-third of candidates.

Despite this depressing list it should be stressed that the hobby is still held in very high esteem both by newcomers and the vast majority of those already licensed. None of the main problems, however, appears to have any easy solution.

While some believe that in order to appeal to younger newcomers it is necessary to stress new technology in the form of packet data, spread-spectrum, Oscar satellites and microwaves, others believe that the fundamental attraction lies in the use of relatively simple equipment for speech and manual morse communication. As a newly-licensed amateur wrote recently "with just a handful of components, a morse key, and a wire antenna strung up into a tree, it is possible to converse with fellow human beings miles away. This is, by any reckoning, an extraordinary and wonderful thing — too often forgotten by the many who buy all their 'gear', plug it in, switch on and talk."

Kraus's antennas

Over the years many major contributions to antenna theory and practice have come from professional engineers whose interest in radio was initially sparked by amateur radio. Outstanding among these has been Professor John D. Kraus, W8JK of Ohio State University who in 1937 built and described the first family of bidirectional close-spaced flat-top driven arrays based on the theories of Dr George Brown of RCA. This was a few months before Walter Van Roberts, W3CH0 of RCA described the first undirectional close-spaced Yagi beam array similarly based on Brown's *Proc.IRE* paper of January 1937.

Kraus, however, went on to originate the theory and practice of folded doublets, multiwire dipoles and, in 1940, the corner reflector which in a compact structure offers high gain, broad bandwidth and remains easier to construct than the parabolic reflector antenna. In 1946, Kraus attended a lecture on the then new travelling wave tube and immediately felt that the long helix of a TWT might form the basis of a new antenna structure, though the lecturer denied this, saying "I've tried it and it doesn't work." To Kraus — as he describes in "Antennas since Hertz and Marconi" (*IEEE Trans*, vol.AP-33, no.2, February 1985) — "the finality of his answer set me thinking. If the helix were larger in diameter than in a t.w.t., I felt it would have to radiate in some way but how I did not know. I was determined to find out, and that evening in the basement of my home I wound a seven-turn helical coil of wire one wave-length in circumference for operation at 12cm. I was thrilled to find that it produced a sharp beam of circularly polarized radiation off its open end. In the days and years that followed, I embarked on an extensive set of measurements and published a series of articles, with my students Claude Williamson, Otto Glasser and Thomas Tice collaborating on some of them. We showed that in its beam mode, a helical coil is a supergain antenna with almost constant resistive input and very wide bandwidth... non-critical to an unprecedented degree... easy to use in arrays because of almost negligible mutual impedance."

Later Kraus became director of the Ohio State University's famous large radiotelescopes including a 96-helix 250MHz array in 1953 and the 110-metre "Big Ear" array on which work began in 1956.

John Kraus was first licensed as W8JK in 1926 and as recently as 1982 contributed to *QST* an update on his original W8JK close-spaced rotary 14MHz antenna of 1937 which was supported by a gondola-like structure of bamboo.

In brief

The Spalding and District Amateur Radio Society has published an enlarged second edition of its useful "Digest of horizontal wire aerials" compiled by Dennis Hoult, G400, containing some 91 different designs of simple transmitting aerials and 14 antenna tuning units (46pp, £3 post paid from D. Hoult, Chespool House, Gosberton Risegate, Spalding, Lincs PE11 4EU)... Restricted talk-through time during the morning and even rush-hour periods has been introduced on the Grampian Repeater Group's 144MHz repeater located about 15 miles south west of Aberdeen... North Staffordshire Amateur Radio Society is participating in the Stoke-on-Trent Festival Exhibition on September 22 (details David E. Morgan, G6MLI telephone (0782) 332657... Cathy Clark, G1GQJ has taken over the position of honorary secretary of the Radio Amateur Invalid and Blind Club from Frances Woolley, G3LWY.

PAT HAWKER, G3VA

LOGIC SYMBOLS

The chief problem with logic diagrams, it seems to me, has always been that the diagram is expected to serve two different purposes. For some, it must be a compact functional explanation of the circuit, but for others it must be a mechanical or hardware description, and so compromises in notation have always been necessary. The new system has eliminated the need for compromise by serving neither purpose.

McKenny W. Egerton, jr.
Owings Mills
Maryland
USA

REAL A.M.

D.M. Lauder is right to point out the problems of the poor strong-signal performance of many present-day radio receivers in making 'the case for real a.m.' (*E & WW* May, 1985). But he goes too far in condemning all pre-amplifiers.

We have tested untuned commercial pre-amplifiers with gains approaching 15 dB designed to be inserted between aerial and radio and we share Mr Lauder's concern at their effects. So when we designed the a.m. buffer amplifier for the heated rear-window car aerial (*E & WW* Feb., 1985) we aimed simply to compensate for the reduced effective height of the heater compared with a standard 1m whip and for the longer cable from the rear of the vehicle. The a.m. signal voltage from the heater aerial at the receiver input is never more than 1 dB stronger than that from the whip.

Then we tested the performance, entertaining the locals as we reversed the vehicle close to the base of a 10 kW a.m. transmitter mast. We certainly measured intermods — but they were never worse when on the heater than on the whip. They arose in the receiver, not in the buffer amplifier.

In the Barnet area, the field strengths of the Brookman's Park and Capital Radio transmissions which intermodulate in Mr Lauder's receiver are both approximately 0.5 V/m. However, these exceptionally strong signals generate a 459 kHz component of only 60 microvolts at the output of the heater aerial unit, which ought to be effectively rejected by even the poorest radio.

We sympathize with Mr Lauder's enthusiasm for real a.m.; our contribution is to reduce the gassiness caused by correding whip. Coat-hangers don't give real a.m., however good the radio!

David Last
Brian Easter
University College of North Wales
Bangor

BRITISH INVENTION

The photograph accompanying the April article by R.E. Young sums-up much of British industry. Two men working on the then leading edge of technology. The approach road unmade, uncut grass and weeds, rubbish dumped by the gate-or maybe it is raw material waiting to be used. I bet there wasn't even a bench to put their tools or working drawings on-that is if they had any. Genius and creativity there may be, but look at the working conditions, lack of investment and careless management. And if anybody thinks things have improved since that photograph was taken I suggest they take a look out of any commuter train on their way to work.

I keep wondering about the genius who positioned the central gate right in front of a largish tree-and what those two men did when it rained — or maybe those days were perpetually sunny.

John Hunt
UNDP
Tehran
Iran

VALVE DISC PREAMPLIFIER

I would like to comment in Richard Brice's design for a valve disc pre-amplifier (*WW*, June, 1985)

It is a pity that space was not available for Mr Brice to elucidate on why passive equalization tends to sound 'better' than negative feedback equalization. There is a school of thought that says the ear is not sensitive to small changes in phase relationships and I think that here is a case for the opposition. A signal which is subjected to passive equalization does not have to pass through the network and is therefore not subjected to phase shift at high frequencies.

Anyone who has tried to record and reproduce a 1kHz square wave on a tape recorder will know that what goes in does not come out even though all the harmonics up to the 13th or 15th are in fact there. The fact is that the harmonics appear at the output in the wrong order and cannot faithfully reconstruct the waveform even though it may actually sound very similar.

I was once the proud owner of a Ferrograph Five tape recorder which employed passive equalization on replay and I was able to record and reproduce a very respectable squarewave at 1kHz at 3.75 i.p.s.

I have tried passive equalization with cassettes, too, and it seems to me that, provided all the harmonics are reproduced in the right order according to Fourier's analysis the input waveform will be faithfully reproduced at the output. This fact may also interest your contributor David Stonebanks, in his quest to record data.

My conclusions are that the ear is sensitive to phase shift; the difficulty lies in describing the subtle, but audible, differences.

Michael J. Lewis
Hadlow
Kent

ENERGY TRANSFER

With reference to the energy-transfer controversy, I agree with Mr Catt that the velocity of electrons in conductors is too low for the role of the primary transporter of energy along transmission lines, but I cannot agree with his contention that the energy transport takes place in the space between the conductors, in the form of "energy slabs". It is a fact that the electromagnetic fields (or more precisely, the physical phenomena that have given rise to the concept of the electromagnetic field) are most intense in the immediate vicinity of the conductors, which strongly suggests that the primary transporter is concentrated in the conductors. Accordingly, I would like to put forward the following explanation of the transfer mechanism.

Conductors of electricity are substances which contain free electrons. Although to a first approximation these electrons may be visualised as a more or less stable "electron gas" or "fluid", it is a well established fact that each free electron has only a limited lifetime, and there is a continuous process of electron-hole generation and recombination. The process is accompanied by the absorption and emission of quanta of energy (photons), which travel from atom to atom at the velocity of light, but in theoretical studies of electrical conductivity this elusive "photon gas" is not considered in any detail, and the emphasis is on the tracks and lifetimes of the much more tangible electrons and holes.

My suggestion is that it is in fact the photon gas that constitutes the primary transporter, since in addition to having the correct velocity of propagation, it can also explain the "two superimposed slabs of energy" concept which Catt used to account for the fact that when a transmission line is charged from a d.c. source and then discharged into Z_0, the resulting pulse is twice as long as could be expected on the basis of existing theory (*Wireless World*, December 1980, Page 80). But the slabs would not be concentrated in the space between the conductors. They would be most intense in the conductors, or in the outer layers of the conductors, and would be mere mathematical devices representing the inntegrated effect of the individual photons.

I must add that when the theory of electron-hole generation and recombination was developed in connection with semiconductor processes, it was found that the rate of recombination was much faster than could be expected on the basis of chance encounters between electrons and holes — a difficulty which led to much work before a more satisfactory picture emerged. This suggests that the photon gas mechanism too might be rather complicated; it might even involve photon-photon interactions of the interference pattern type that has defied all attempts at commonsense explanations. But there can be little coubt that if the primary transporter of energy along transmission lines is concentrated in the conductors, as is almost certainly the case, then the most likely canndidate for that role is the photon.

Assuming that the above explanation is substantially correct, another question would arise — what would be the physical nature of the electromagnetic fields which according to classical theory are supposed to be closely associated with conduction phenomena? The answer seems to be that there would not be any physically real "fields" in the sense of regions of space where "pure energy" is stored without the active involvement and participation of physically real particles. A "field" would be nothing more than a purely imaginary device for predicting how individual particles or aggregates of particles would behave in the proximity of other particles and aggregates, and how particle distribution patterns evolve.

G Berzins
Camberley
Surrey

Once upon a time there lived a chap called Fleming who gave his first name to creamed rice. He was a handy sort of fella. A little later a nutter called MacHarg took both the right and left hands of Fleming and tied together his index fingers so that they could interact, and his middle fingers so that they could interact also. He then discarded Fleming's lesser fingers, two on each hand, but left the thumbs attached.

A well known magician hitched a funnel on to one thumb and poured milk into the funnel: he then milked the other thumb into a pan, so providing something to cook the rice with as food for thought, if not a lot.

At least the experiment demonstrated that between action and reaction there lies interaction which occurs in the middle of the playground, a necessity if anything is actually to happen such as a transfer of energy between dynamo and motor, deus and machina. The four horsemen involved in the interaction may be worthy of note.

However, if one wishes to involve c, it may be a good plan to first determine what c actually is: I suggest that interaction is faster than c, but that action and reaction might occur at c. (Thank you again Roy Hodges.)

As noted in my letter of February 1983, this will require a massless sensor for energy, not only to disprove it, but also to prove it. Doubtless the pages of *WW* will continue to resonate with arguments on the subject until such a wondrous device is invented, so to be ensured of interminable life! (Thank you, too, Providence.)

When the said wondrous device is invented, we shall also be able to determine whether the interaction between a photon and an orbiting electron is concrete (as with a rack and pinion) or abstract (as with induction). It seems to matter if c is to discover its real identity.

After all, if energy can move faster than our senses or anything else can react, then apparent action at a distance at last becomes conceivable.

That was quite a Catt you let out of the bag, Mr Hodges!

James A. McHarg
Wooler
Northumberland

It is precisely because Ivor Catt does not distinguish between resistance and impedance that his theories fail. For a step function a transmission line behaves like a resistor. Initially, current and voltage are in phase but that is the only resemblance. Resistance has the exclusive property of turning electrical energy into heat: all energy arriving at a resistor is turned into heat. A loss free transmission line, by definition, transmits the energy. To understand transmission lines properly it is essential to take proper account of the vectors involved: a TEM wave in a transmission line has the electrical and magnetic field vectors are at right angles to the direction of propagation. They are also at right angles to each other. If the line is lossy one or both of these conditions does not hold, if the line is correctly terminated by a resistance, but what am I saying? The dimension of length is not needed to describe a resistor, perhaps the average quarter watt is really just another of these transmission lines like Catt's capacitor, another Dogg's dinner of confusing waves.

Ivor Catt may believe that modern physics is seriously divided over electrical theory but he has produced no evidence of this. He has shown a truly amazing lack of knowledge of what current theory is about (does anybody really believe that perfect capacitors are physically realisable?) His latest letter (May, 1985) is another fine example. Of course the currents in the two conductors cancel, it would be the same with two batteries in series and two resistors in place of transmission lines. This property of current summing to zero is widely used in three phase power transmission: in some applications the three phases have no common return, amazing, isn't it?

It is indeed hard luck on Mr Potter that in the same issue (April, 1985) as his letter, there was a very good article about badly matched antennas (How long is a piece of wire? — J.J. Wiseman) I'm sorry to (try to) disillusion him but unterminated lines do radiate, perhaps not very much at 50 Hz, but things can get quite exciting if you are trying to transmit power much above 1000 km and you don't account for transmission line effects at a million volts! Yes, waveguides radiate if left open, the efficiency depends on the degree of match, which is generally quite good for waveguides and rather poor for wall sockets! To assume the impedance of free space is some sort of universal all pervading resistance of 377 ohms is to make the same mistake as Ivor Catt and to display the same degree of ignorance.

Dermod O'Reilly
Antwerp
Belgium

RELATIVITY

It is a pity that R. Priestly's friends Tom, Dick, and Harry had their taproom discussion of the lightning strikes interrupted by that domino game (June letters), since if they had continued they might have asked and answered the question that Einstein missed. The question is obvious to anyone who actually gets down to making measurements:- how much time did Dick on the up-train reckon elapsed between the strike at the front of the train and that at the back? The answer can be determined easily enough[1]; it is the time Dick reckons light takes to travel between the two scorch marks on the train multiplied by v/c, where v is the speed of the train, and c the speed of light.

For scorch marks 200 metres apart and a train speed of 120 km/h this works out at 7.4×10^{-14}s, so that since the light from both strikes reached him at the same time, Dick reckoned that he was 2.2×10^{-5}m closer to the rear scorch mark, several thousand nanometres as Mr Priestly says.

The scorch marks on the track and on the two trains were made coincidentally in both time and space for each strike taken individually. Tom, applying a convention that works for slowly moving objects, assumes that because he reckons both strikes to be simultaneous the marks on the track are the same distance apart as those on the trains. Dick knows otherwise, since the mark at the rear of his train was made after that at the front, so that the corresponding marks on the track must be too close.

This is the essence of the Lorentz-Fitzgerald contraction, which is not a real physical contraction, but the consequence of making measurements at different points on a moving object which are simultaneous in the frame of measurement instead of in the frame in which the object is at rest. If Einstein had realised as much before dashing off to develop General Relativity an awful lot of confusion would have been avoided.

C.F. Coleman
Grove
Wantage
Oxfordshire

Reference
C.F. Coleman, *Eur. J. Phys.* 4(1983) 240-247

Given the Law of Inertia as an experimental fact, the set of all possible trajectories of freely moving particles is a 'space' as mathematics construes the word. It satisfies Newton's specification for 'absolute space' exactly. Thus, if the Law of Inertia is a fact, so also is 'absolute space'.

In view of its importance to an understanding of both classical physics and relativity and how they are related let it be said explicitly — 'absolute space' is a mandatory consequence of the Law of Inertia and is a rigid structure consisting of a fourfold infinity of straight lines created by freely moving particles which may be numbered by the methods of geometry and which, exactly as Newton prognosticated, 'in its own right and without regard to anything external remains always similar and immovable'.

Relativists already accept the Law of Inertia. When they accept its consequences they will understand why relativity succeeds and will be able to obtain such of its formulae as are valid by less fanciful arguments.

R. Berriman
Palmerston North
New Zealand

In the June letters column Mr Wellard used the pretext of drawing *Wireless World* "readers' attention to the implications of E. Eastwood's article" to launch a misguided and unequivocal attack on some of the finest minds in nineteenth and twentieth century physics.

Most of the published analysis of the Michelson-Morley apparatus give expressions for the maximum observable fringe shift assuming one arm of the apparatus is headed directly into a supposed "ether wind". A more generalized analysis corresponding to an arbitrary orientation of the apparatus will also lead to an observable fringe shift.

In 1881 when Michelson set up his interferometer and rotated it through 360° there was no significant shift of the fringe pattern. Undoubtedly surprised and disappointed he had to conclude: "The result of the hypothesis of a stationary ether is thus shown to be incorrect".

A modernized version of the Michelson-Morley experiment used two lasers in a test of the basis of special relativity[1]. No change of beat frequency was detectable within the accuracy of the measurement (about ± 3 kHz). This was less than 1/1000 of the change that one would calculate from an ether wind hypothesis and represents the most sensitive test yet made of the isotropy of space with respect to the speed of light signals.

Incidentally, Mr Wellard's statement that a theory can be false is incorrect. A theory is in any case relevant to a highly selected group of data — usually with the recalcitrant ones ignored — and the theory can at best be said to be adequate or inadequate as a means of intercorrelating the members of the group.

Turning to gravitational red shift, Einstein's first statement on the phenomenon was: "An atom absorbs or emits light of a frequency which is dependent on the potential of the gravitational field in which it is situated". The gravitational red shift has been observed in a terrestial experiment by Pound and Rebka[2] who made use of the Earth's gravitational field. This fact, together with further empirical corroboration from the deflection of light by a gravitational field and Einstein's explanation of the residual motion of the perihelion of Mercury, supports the General Theory of Relativity as a sound description of the Universe.

P.H. Spratt
Carlton Colville
Suffolk

1. T.S. Jaseja, A. Javan, J. Murray and C.H. Townes, *Phys. Rev.*, 133, A1221 (1964).
2. R.V. Pound and G.A. Rebka, *Phys. Rev. Letters*, 4,337 (1960).

Having followed Dr Murray's most interesting and stimulating articles and the relevant correspondnece, there still seems to be some confusion over Einstein's trains. In *WW* May 1984, Dr Murray quotes Einstein as defining simultaneity by imagining an observer (M) on a railway embankment mid-way between the points of origin of two flashes (A and B). Then, "if the observer perceives the two flashes at the same time, they are simultaneous". Since each flash may be thought of as arising at a unique point in space, should not Einstein have specified that the track, embankment and observer must be stationary in space for his definition to have any validity? In the ensuing argument, when Einstein introduces his moving observer (M'), we have M and M' coincident "just when the flashes occur, (as judged from the embankment)". This could mean that there was coincidence either when M saw the flashes or when they actually occurred. I am not clear which interpretation Dr Murray used. If it was the latter, it seems inevitable that M' would see the flash from B first because, by the time the light signals reached him, he would no longer be at the mid point. In that evemt, Einstein's discussion of the different perceptions of simultaneity (by M and M') seems meaningless. Perhaps Dr Murray would care to comment.

May I raise another aspect of e.m. propagation. Almost invariably, discussion of e.m. propagation velocity is confined to velocity along the direction of propagation. What about the velocity at an angle to this direction? If one could remove gravity and air resistance and then fire a machine gun from a moving train at right angles to its direction of motion, the bullets would retain the lateral component of velocity due to the train and would appear to the gunner to "propagate" away from him in a line at right angles to his motion. If, however, they somehow disobeyed Newtonian principles and did not retain the train's component of velocity, the trajectory would appear to the gunner to lag at some angle with respect to the normal to his direction of motion. What about a beam of light? If light propagates independently of source motion, would it not exhibit a lagging trajectory?

If, as has been predicted from the measured anisotropy of the 3°K microwave radiation field, the earth (solar system) is moving through the cosmos at some 400 km/sec, should not a light beam propagated from a fixed point on earth and at right angles to this motion exhibit a quite perceptible deflection? The deflection expected would be by an angle of approximately 4.6 minutes of arc which represents a displacement of the beam by about 1.3 metres at one kilometre. If this really happens, would it not by now have been noticed during such activities as surveying, optical ranging, metrology etc.? If it does not, should we conclude that, laterally at least, light does behave in accordance with Newtonian principles? In this event, a reasonable assumption might be that it should behave similarly along the direction of propagation. I cannot think of any relativistic arguments which make this an improper question or which would preclude the observation of a deflection if one occurred. Perhaps some of your readers can!

M.G.T. Hewlett
Midhurst
West Sussex

COMPUTER-AIDED PROFITEERING

Since I became involved with computers as a hobby, in a limited way, I have become very frustrated and disillusioned with the whole political and commercial dirty work of the computer industry. The basic concept of computers and digital electronics has been exploited to the disadvantage of the consumer, in order to gain commercial advantage.

I refer to such things as, for example, non-standard RS232, non-standard d.o.s., non-compatible equipment, etc. Also, it appears that many manufacturers go to the extent of holding back information so they can sell as many information books as possible. From various sources we keep getting little bits of so-called new information on what can be done with a machine which has been on sale for years: for example, poke numbers. Surely, when a machine is produced, all the information can be provided for the user, in one book, at the time of sale. After all, the manufacturer must know all about the machine — he built it!

In connection with the above, I would like someone to tell me (a) if any disk drive, printer or other peripheral can be modified to be *fully* compatable with any (home) computer, and if not why not; and (b) if any (home) computer can be modified to be compatible with any other (home) computer.

A.D. Tregale
Australia

by Tom Ivall

Radar in retrospect

Report on IEE seminar marking fifty years of radar development

"The myth that we entered the war as the sole possessor of radar has of course long since been exploded. The Germans had been developing radar since 1934 and entered the war with the Freya early warning system on 2.5 metres, a wide deployment of Wurzburgs on 50 centimetres, a naval radar on 80 centimetres, and an airborne radar on 60 centimetres. Until our development of centimetric radars the German systems were superior to ours."

This was Sir Robert Cockburn, a former director of the Royal Aircraft Establishment, on Britain's radar in the 1939-45 world war. He was presenting a paper at the IEE's celebratory seminar on fifty years of Radio Detection and Ranging, "The history of radar development to 1945", held in London, 10-12 June.

It was not only Sir Robert's comments that made it abundantly clear, to anyone in doubt, that other countries besides the UK made important contributions to the development of radar. Papers given by American, Dutch, German, Italian, Japanese and Swiss authors, with accounts by British authors of French and Russian work, gave a pretty full picture of what was essentially an international achievement.

Paradoxically, though, a large part of this combined achievement wasn't co-operative but competitive — under the fierce stimulus of war. The UK's leading work in airborne microwave radar, for example, only became available to Germany and its allies when British aircraft were shot down and their radar sets were salvaged and studied.

The notion put about some decades ago that Britain "invented" radar would certainly not have been swallowed by anyone with even a general knowledge of radio science and engineering, let alone the radar specialists.

The basic principle — reflection of electromagnetic waves from objects — had been known to the whole scientific world for over half a century. After all, as early as 1865 Clerk Maxwell had recorded his belief that light was an electromagnetic-wave phenomenon — implying the possibility of reflection — and Hertz had rapidly shown that reflection was indeed a reality soon after he had demonstrated the existence of e-m waves in 1888.

From then on, physicists and experimenters in several countries observed the phenomenon of radio wave echos, and a few speculated on possible uses of this effect. The chronological table in this report, starting from a hundred years ago, lists some of the early discoveries, experiments and proposals that led to the development of radar as a mature technology. In general it is a story of gradual progression from metre-waves to centimetre-waves, as magnetrons became more stable and powerful, and of widening application from ground stations to ship and aircraft installations. Dates are largely drawn from the IEE's seminar but should not be taken as necessarily exhaustive, authoritative or completely representative.

The table does show, however, at least half a dozen industrialized nations contributing to radar in various ways. Mr S. Swords of Trinity College, Dublin, in an excellent survey of the beginnings of radar, listed the following nine countries as having provided significant technological effort: (in alphabetical order) America, Britain, France, Germany, Holland, Hungary, Italy, Japan and Russia.

Forgetting the crude, jingoistic propaganda of the past, there is no question, though, that Britain played a very important part in the whole story, particularly under the pressure of war. To judge from the seminar, the UK appears to have made two major contributions. One was the rapid and highly effective development, production and deployment of centimetric airborne radar, following the invention of the resonant cavity magnetron by Randall and Boot at Birmingham University in 1939. The other was the early warning chain of 19 ground metre-wave radar stations built round the coast of Britain — the so-called CH (Chain Home) stations — from Orkney to the Isle of Wight. This chain was built secretly at a cost of about £10M (now roughly equivalent to £200M), was totally integrated with the RAF's system of fighter aircraft control, and was fully operational to meet the onslaught of enemy bombers by the start of the 1939-45 war.

When the Tizard Commission went to the USA in 1940 — to exchange Britain's military tech-

Chronology of early R&D leading to radar

1885 Edison (USA) patents system for collision avoidance at sea.

1888 Hertz (Germany) observes reflection of e-m waves.

1900 Tesla (Serbia) suggests radio detection of icebergs.

1904 Hulsmeyer (Germany) patents and demonstrates spark-transmitter apparatus for detecting presence of ships — the Telemobiloscope.

1916 Marconi (Italy) and Franklin (UK) note reflection of 2-m waves from metal objects.

1921 Hull (USA) publishes description of early form of magnetron.

1922 Marconi suggests use of s.w. reflections to detect and find bearing of ships.
Taylor and Young (USA) observe 60-MHz reflections from river steamer.

1925 Appleton and Barnett (UK) discover new layer in ionosphere (F) by h.f. echo sounding.

1927 Okabe (Japan) invents split-anode Magnetron.

1928 David (France) suggests use of h.f. beam for detecting aircraft.

1930 Hyland (USA) observes 60 MHz reflections from aircraft.
Franklin (UK) proposes use of centimetre waves to obtain "wireless pictures".

1931 Butement and Pollard (UK) demonstrate reflection of pulsed 50-cm waves from objects at about 100m range, using rotating beam.

1933 Philips company (Netherlands) produces 1-GHz split-anode magnetrons.
Korovin (USSR) starts research on radio detection of aircraft.
Kuhnold (Germany) starts research on reflection technology at 2 GHz.

1934 David (France) tests 75-MHz c.w. detection of aircraft.
Kuhnold (Germany) demonstrates 630-MHz echos from a battleship.
USSR tests c.w. 64-MHz early warning radar with range of over 70 km.
Netherlands armed forces group observes reflections at 240 MHz.

1935 Tiberio (Italy) formulates theoretically the "radar equation".
Germany installs 100-MHz radar on ships.
Watson-Watt (UK) presents memorandum "Detection and location of aircraft by radio methods" to government.
Wilkins (UK) tests c.w. aircraft detection using BBC's Daventry h.f. station.
Gutton (France) installs 16-cm scanning radar on *Normandie* liner.

1936 Okabe (Japan) demonstrates c.w. Doppler radar.
Vallauri (Italy) starts research group on "radio detector telemetro".
Page (USA) produces 80-MHz pulse radar for aircraft detection.

1937 Gutton (France) develops split-anode magnetron of 10W mean power at 16cm.

1939 Randall and Boot (UK) construct resonant cavity magnetron.

1940 USA establishes civilian Radiation Laboratory to develop military microwave radar.

1943 USSR establishes permanent military Council for Radar.

nology secrets for production capacity — the US Army and Navy were so impressed by these two achievements that action followed immeditely. According to Dr E.G. Bowen, who related his part in this exchange, urgent steps were taken to put US radar systems into operational use, and orders for the manufacture of both US systems and copies of British radar systems went out to industry. "It persuaded the top [American] brass that radar was a tool of prime operational importance in modern warfare," commented Dr Bowen.

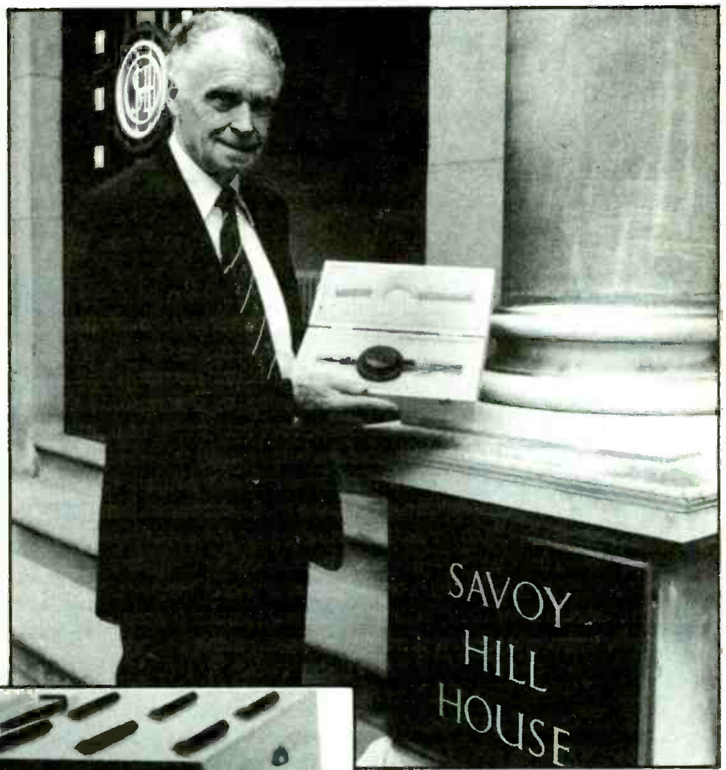
All this can be seen to have started from Watson-Watt's authoritative and now famous memorandum to the UK government in 1935, "Detection and location of aircraft by radio methods." It was certainly this document which provided the IEE with an arbitrary — though justifiable — date for celebrating fifty years of radar development in 1985. And Dr C. Susskind of the University of California, in his provocatively-titled paper "Who invented radar?", seemed to support the choice. After saying somewhat mellifluously that the development of radar followed upon "the confluence of several prerequisites brought to maturation in the 1930s" he expressed the view that Watson-Watt's memorandum stood out as the most influential of all radar publications because it was "the first to lead to the development of a system for gathering and collating radar data and acting upon them."

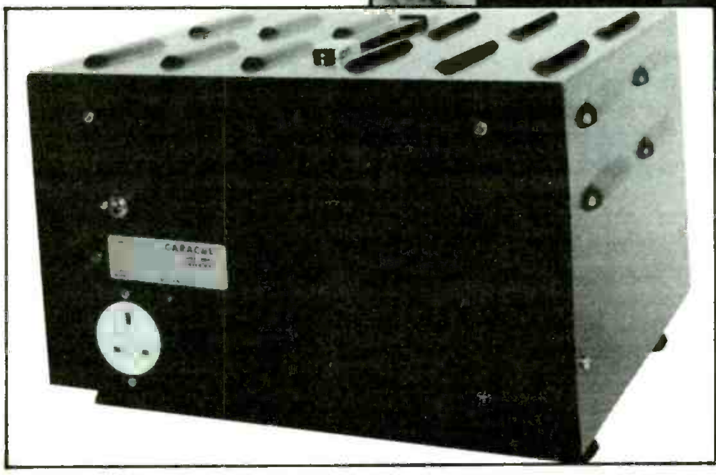
The other maritime nations that are often compared with Britain in terms of geographical area and population are Italy and Japan. As can be seen from the table, both of these countries contributed to radar development, though somewhat late in the course of events.

Italy's involvement, according to a paper by Captain R. Palandri and Professor M. Calamia, dated from 1933. In that year Guglielmo Marconi — while handing over a microwave link between Rome and Castelgandolfo — impressed the significance of radar on the Italian military authorities. (He had been, after all, a member of the Fascist party since 1923.) Then in 1935 Marconi gave demonstrations of reflection phenomena and this resulted in a report being sent to the Italian minister of defence by Professor U. Tiberio.

Soon afterwards a research group was formed at the Royal Institute for Electrotechnics and Communications. Professor Tiberio joined this group in 1936 and devised experiments to test the validity of the "radar equation" he had formulated. From 1936 to 1943 various radar systems were developed, including a frequency modulated c.w. equipment working on 200 MHz and a 70-cm pulse radar with a double horn antenna, newly developed transmitter triodes and 'acorn' receiver triodes. Manufacture of radar sets started in 1941 but met with difficulties due to the war and was finally halted when hostilities moved onto Italian territory in 1943.

Japan's contribution to radar was outlined by Dr S. Nakajima of the Japan Radio Company and by Mr Sword's survey. Dr Nakajima spoke of microwave research work by his company and the Japanese Navy's Technical Research Institute from 1932 onwards, but said nobody had practical applications in mind at that time. Research on magnetrons started in 1933, including experiments with 18 different types of anodes. Continuous power outputs of 500W were obtained from water-cooled magnetrons and wavelengths of 0.7, 2, 3, 10 and 15cm were generated.





Dr E.G. Bowen with the cavity magnetron he took to the USA as part of the Tizard Commission in 1940. The raised cylinder in the middle indicates the periphery of the resonator system; this is surrounded by circular cooling fins. On the left are the cathode and heater leads (the oxide-coated cathode being connected to one side of the heater). On the right is the output side arm.

Dr Nakajima said that in 1953 he had visited the London Science Museum and examined the Birmingham University resonant cavity magnetron on view there. He could not see any difference between it and the Japanese-developed magnetrons of the late 1930s.

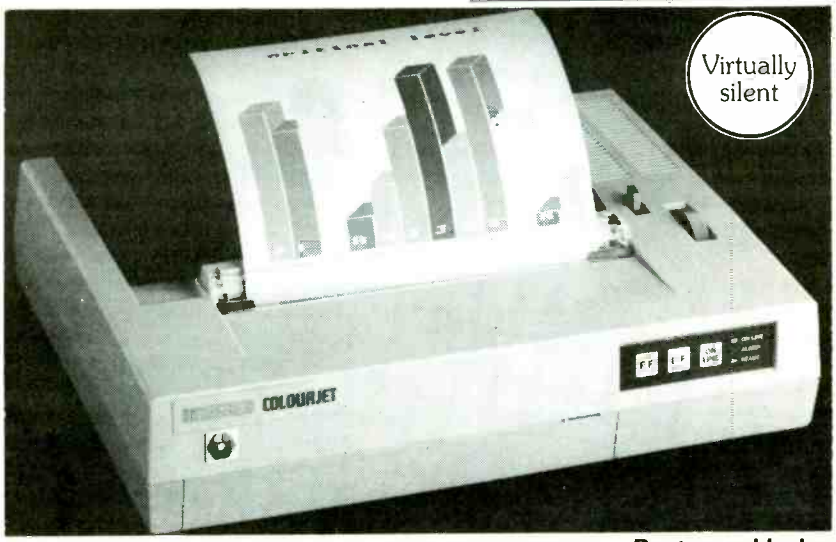
In 1936 Professor Okabe, possibly influenced by Professor Yagi (of dipole fame), demonstrated detection of aircraft by a c.w. Doppler system. The following year, experiments in conjunction with the Japanese Navy achieved detection ranges of up to 5 km in Tokyo Bay. For defence of the Japanese mainland against air attack the Navy set up c.w. radar stations on ships and land operating on 1.5m, 2m and 6m. The 6m sets could detect aircraft in formation at a range of 450 km and single aircraft at 250km. Mobile ground radar for aircraft detection went into production.

Airborne radar development did not start seriously until 1942, after a captured British airborne pulse radar had been sent to Japan from Germany in 1941. But v.h.f. aircraft radar sets were produced, working on wavelengths around 2 metres. A copy of the German Wurzburg gun-laying radar was put into production in 1943 but never went into service.

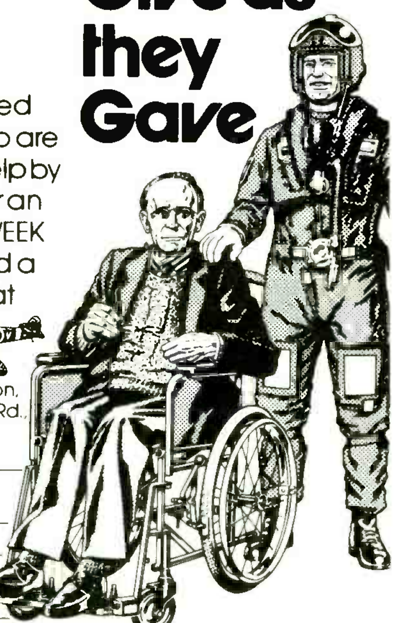
In general, commented Dr Nakajima, Japan was not very prominent in radar development before 1945 because the country's research capability was in no way comparable with those of the USA and UK: for example, only A-type displays were used. He complained that he had had an R & D of 800 people working on radar and magnetrons at the time Japan entered the war, but this was cut down to a half in the ensuing years. Japanese scientists and engineers were not fully utilized in the Army and Navy Research programmes.

Most of the people attending the IEE seminar appeared to be sexa-, septua-or octo-genarians. Indeed one very lively account of radar development at the Lorenz company came from the nonagenarian Dr G. Muller — but only his recorded voice, as he had preferred to remain at home in Berlin for his 90th birthday party. Hardly anyone present seemed to be under the age of fifty.

It was a pity the young apparently showed no interest in what was undoubtedly an exciting and adventurous period of electronics history.



Virtually silent
COLOURJET



Sine-wave inverters

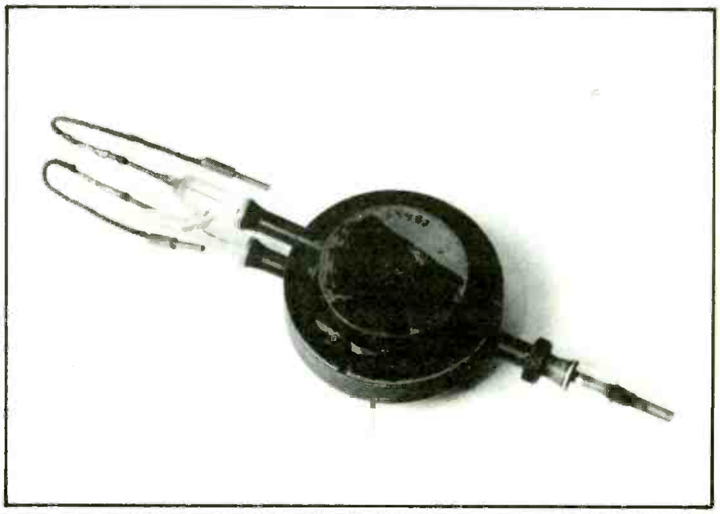
Solid-state a.c. power supplies can provide 200 to 1000VA at 50 or 60Hz continuous power at any mains voltage derived from 12 or 24V batteries. Pulse-width modulation is employed in the new range of inverters from Caracal. This results in high efficiency across the whole load range and a low standby current. In addition they are smaller and lighter than former inverter designs.

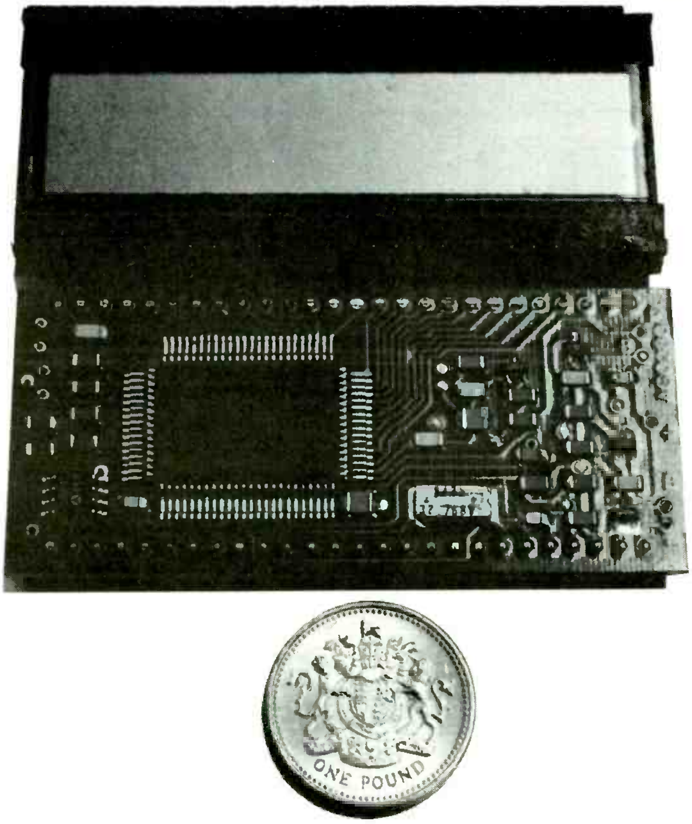
The output waveform is claimed to contain only 3% t.h.d. and the output voltage is held to within 2% for any combination of loading and variation of the d.c. input. Frequency is held to less than 0.3Hz.

Battery protection is provided by a low-voltage warning light followed by an automatic cut-out to prevent full discharge of the battery.

Protection against overload, output short-circuits and reversed input are all provided. The inverters come in rugged welded-steel cases.

Caracal Power Products Ltd., 42 Shortmead Street, Biggleswade, Beds. EWW203





Low-cost toroid transformers

Research into materials and into manufacturing techniques has enabled Drake to reduce the price of toroidal transformers. The most significant change has been in the use of polyester tape wrappings instead of the usual varnish impregnation. Drake admit that this method of outer insulation cannot compare with vacuum varnish-impregnated Terylene tape (which they also supply) but say that it is totally suitable for many general-purpose, power and audio applications. This PW range of transformers offers ratings from 50 to 900VA. Copper foil earth screens between the primary and secondary windings can be provided when safety considerations so require.

Drake Transformers Ltd., Kennel Lane, Billericay, Essex CM11 2Sp. EWW205

Multi-assembler on a chip

A 16K eprom and a floppy disk for use with the BBC Micro provide facilities for assembling machine-code instructions for a wide, increasing, range of processors. Meta is an assembly language editor on a rom and works very like the popular BBC wordprocessor Wordwise. This means that all the Wordwise facilities are included; cursor movement around the text, search and replace, loading and saving files or marked parts of files etc. Plain English error messages are provided if any errors are detected during assembly and the editor is automatically invoked at the point where the error occurs.

Complex expressions are allowed by the assembler including brackets to eight levels. Mathematical accuracy is to 32 bits. There are many facilities for macros and EQU pseudo op. codes and a library of macros is provided. Source code is assembled in two passes and the system is claimed to be particularly fast at doing this.

At present seven families of processor are provided for: 65XX, including 65C02; 68 and 63XX; 6809; 8080/8085; Z8; Z80. Shortly to be added are 68000, 8088/8086, Z8000 and Micro Nova. These are provided as a free upgrade to the system disc and as Freepost is used, they are really free! The assembly language file may be saved onto disc. The assembled code may also be sent to disc files, sent to sideways ram, user or printer ports or transmitted through the RS423 port. Meta has a comprehensive manual and a machine-code game which illustrates the use of the system. All for £69.95 with discounts to educational establishments. Crash Barrier, Freepost, Flitwick, Bedford MK45 1YP. EWW208

Single-chip controllers

These controllers can be built to meet any specific control requirement. They are based on a Hitachi chip mounted on a p.c.b. and incorporating a liquid-crystal display. They can be used to control time, temperature, pressure etc. Using surface-mounting production, they are smaller and inherently more reliable than conventional circuit boards.

Race Electronics, who designed the board, can programme the device to tailor its functions to meet the needs of a wide range of industrial and electronic control appliances. Typical uses are likely to be in white goods where it can replace the more expensive and cumbersome electro-mechanical controls. It can be used as a direct replacement or be incorporated into new designs to take advantage of its compactness. One successful application has been in its use in a meat probe temperature sensor for a range of ovens.

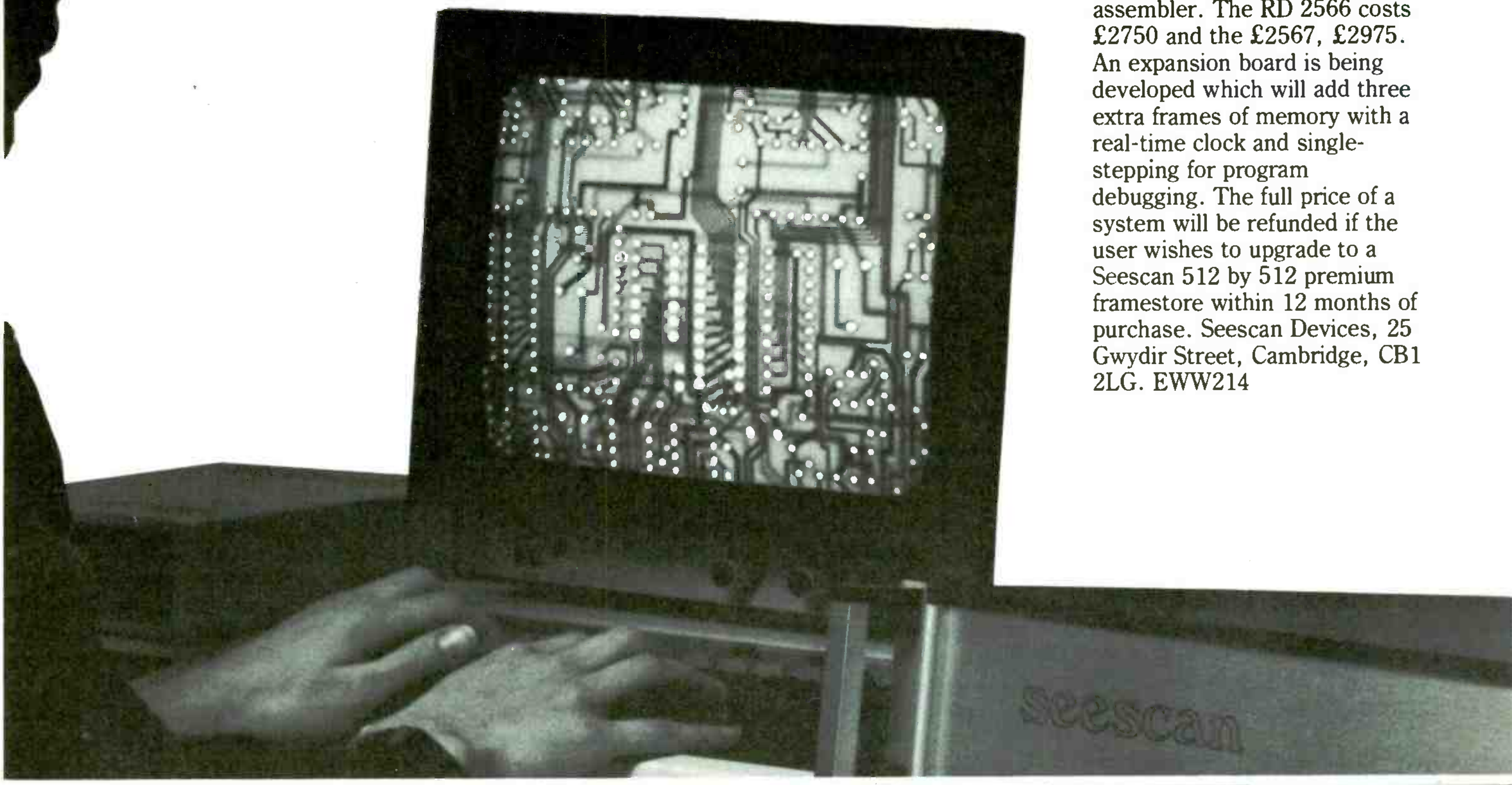
Race Electronics Ltd., Lanelay Road, Talbot Green, Pontyclun, Mid Glamorgan CF7 8YY. EWW207

Video imager from Cambridge

Research Fellows from Cambridge University have formed a company to market their expertise in image processing. The result is the Seescan RD2566 and 2567 systems. They are self-contained microprocessor-based systems with applications including a wide range of uses in scientific, industrial and educational areas. They provide a useful introduction to such systems and can be upgraded. Each incorporates a 256 by 256, 6-bit (7-bit on the RD2567) frame store with a on-board Z80 running at 6MHz (or optionally, 8MHz).

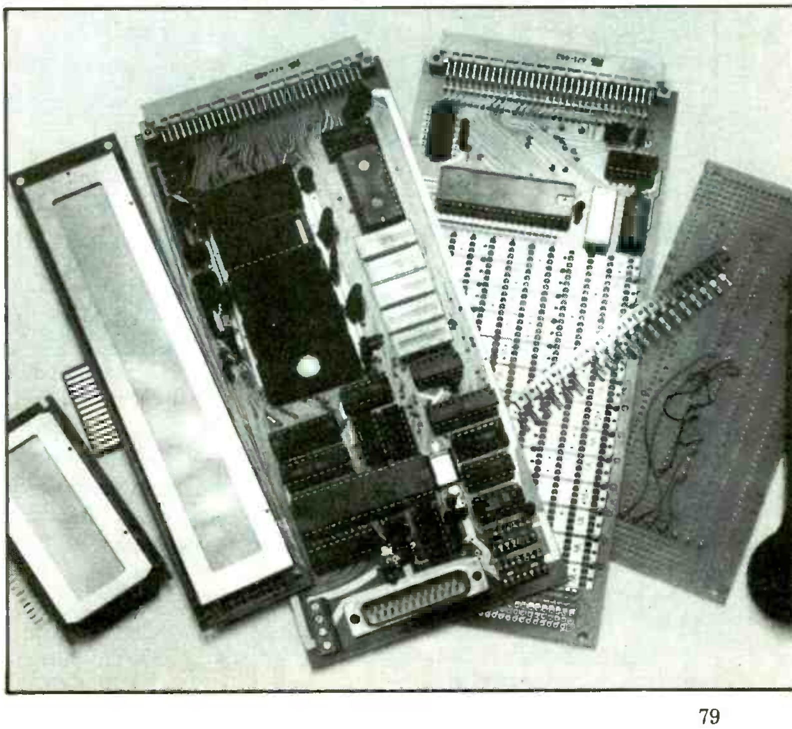
The systems have RS232 and BBC 1Mhz bus interfaces for use with terminals. These allow for graphics facilities and a software development package for the rapid development of programs which will customize their system. The graphics facilities include user-defineable overlays and look-up tables which can be used to enhance the contrast and for gamma correction. Both systems have an 8-bit video output enabling the display of 256 shades of grey.

The software supplied with the system include a Z80 monitor and a Z80 assembler. The monitor is accessed through the interface ports by an RS232 or BBC micro. It includes full screen memory editing facilities, copy and fill commands as well as an in-line assembler. The RD 2566 costs £2750 and the £2567, £2975. An expansion board is being developed which will add three extra frames of memory with a real-time clock and single-stepping for program debugging. The full price of a system will be refunded if the user wishes to upgrade to a Seescan 512 by 512 premium framestore within 12 months of purchase. Seescan Devices, 25 Gwydir Street, Cambridge, CB1 2LG. EWW214



Development boards

The 85000 series is a family of boards for the development engineer, college and/or electronics enthusiast. The Processor board contains a fully buffered 8085 Microcomputer with a potential on-board memory capacity of 96Kbytes. Peripherals are connected through 64-way connectors. Among the peripherals already produced are a communications board based around an Intel 8256 muart, and a display board which can drive members of the Epson EA series of liquid crystal alphanumeric displays. With this combination most of the looked-for functions of a micro-computer are provided. It is also possible to add any required interface on the blank development areas of the peripheral boards. Three voltage planes and an earth are provided and additions can be easily incorporated using the Vero Speedwire system. The processor board also has facilities for configuring different systems. Many different types of memory chip can be acommodated. The control signals are redirected by shorting jacks and the memory size and addressing range is selected by five 8-way dil switches. Each of the boards is claimed to be of high quality at a low price, though a price is not quoted, with p.t.h. They may be used for rapid development of a system. Further details from Automation and Control Technology, Crofton Road, Marsh Barton, Exeter EX2 1QW. EWW213



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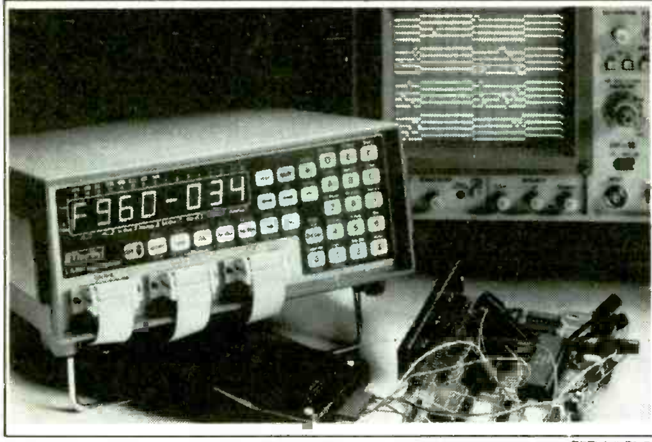

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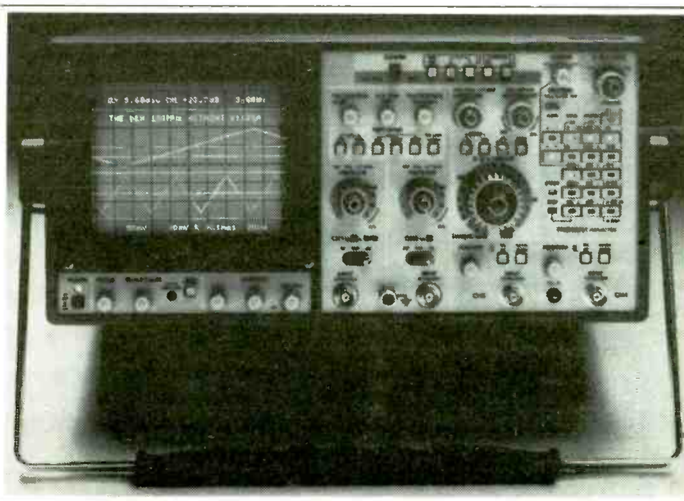
Thurlby-Reltech Instruments, 46 High Street, Solihull, W.Midlands, B91 3TB



CIRCLE 40 FOR FURTHER DETAILS.

CIRCLE 19 FOR FURTHER DETAILS.

CIRCLE 79 FOR FURTHER DETAILS.

CIRCLE 55 FOR FURTHER DETAILS.

Sight for Nimbus

A new version of Digithursts' MicroSight image analysis system has been produced for the Research Machine's Nimbus computer. It can capture images up to 512 by 512 pixels with 256 grey levels. Using standard graphics, the image can be displayed at 256 by 256 resolution with 16 grey levels on the Nimbus screen.

The system uses an 80186 c.p.u. running at 8MHz, 320K of memory and twin floppy disc drives. Hard discs, memory expansion up to 1MByte and networking are available as options.

Image measurement software makes counting objects possible and sizing particles or measuring areas. This is of practical use in pharmaceutical research, metallurgy, microbiology and agriculture.

Images captured by the system can be dumped to a printer, stored on a disc and may be manipulated and edited through graphics programs for use in art, design, advertising, display and computer-aided learning.

The Nimbus vision system includes the computer, video camera and interface, mouse and software at a starting price of £2950. Digithurst Ltd., Leaden Hill, Orwell, Royston, Herts SG8 5QH. EWW204

Satellite software

Two discs have been produced for the BBC Micro for satellite tracking. The first is an orbital prediction suite that allows the prediction of positions of satellites in circular or elliptical orbit. The second is specifically related to Uosat-2 telemetry and allows the user to decode, process and display data received from Uosat. A third disc is to be produced that will enable the graphical display of the data from disc 2 so that correlations may be extrapolated. The package is being produced by Scarborough 6th Form College and York University to coincide with the launch of a nationally coordinated package of hardware, software, information and texts on *Satellites in Education* by the Micros in Education Project and the University of Surrey. Marketed by Amsat-UK, 94 Herongate Road, London NE12 5EQ. EWW212

Music on the Beeb

When we wrote about the Music 500 and the Music System, we were not completely happy with those methods of getting music out of the BBC Micro. Now two more products have become available and we are happy to recommend either or both.

Murom is a music rom. Music is entered by selecting note, octave, envelope and note length in pre-determined columns; one for each of the four channels. Each note or time beat is on a numbered line which makes it easy to copy, insert or delete notes. Octave, envelope and note length are programmed into the function keys and are selected by a combination of shift, control and function. The notes are entered by name and a shifted note provides a sharp; there are no flats but as A# is the same as B♭ (in modern equal temperaments) this is not a problem. There is no provision for entering key signatures so all sharps must be entered as accidentals. It is possible to transpose music after it has been entered. The notes sound as they are entered and it is possible to scroll backwards and forwards through the entered music playing individual voices or all of them together. Also provided at the touch of a key is an envelope which is very easy to use and envelopes so created may be used in the music editor or saved seperately.

To enter longer compositions it is necessary to reserve the space needed in memory in advance and it is possible to have sufficient space for over 2000 notes or chords. There are a number of pre-programmed envelopes which may be invoked by 'star' commands. And there is also a selection of sounds; ZAP, PING etc. which may be called from within other programs. As long as Murom is present in the computer it is also possible to include music in programs and examples of interrupt-driven music are included on the demonstration cassette. These allow music to be played while the computer is free to do other things. Murom comes from the BBC user group, Beebugsoft, PO Box 50, St. Albans, Herts. EWW209

The other product connected with music is a combination of book and software produced by Acorn. *Creative Sound on the BBC Microcomputer* by David Ellis and Chris Jordan is an introduction to sound synthesisers in general as well as being a guide to the facilities on the BBC. As Chris Jordan designed the SOUND and ENVELOPE commands for BBC Basic, he has 'inside knowledge' of their workings and knows how to get the best out of them. He and his co-author do this very effectively through a number of demonstration programs listed in the book and available on the cassette or disc that accompanies it.

In the section on computer composing there is a program to play Mozart's Musical Dice game in which bars are selected according to the throw of two dice and the application of two tables which formulate the selected waltz tune. As there are 380 000 million combinations of the bars, it follows that every time the program is run a German waltz by Mozart is created that no-one, not even Mozart has heard before! Unfortunately, because the bars have to follow on from each other each composition sounds very similar to the last one and the authors even cast doubt on whether it was composed by Mozart at all. It is however an interesting example of a program written two hundred years before there was a computer to run it on. There are other examples of music composed by the computer at random.

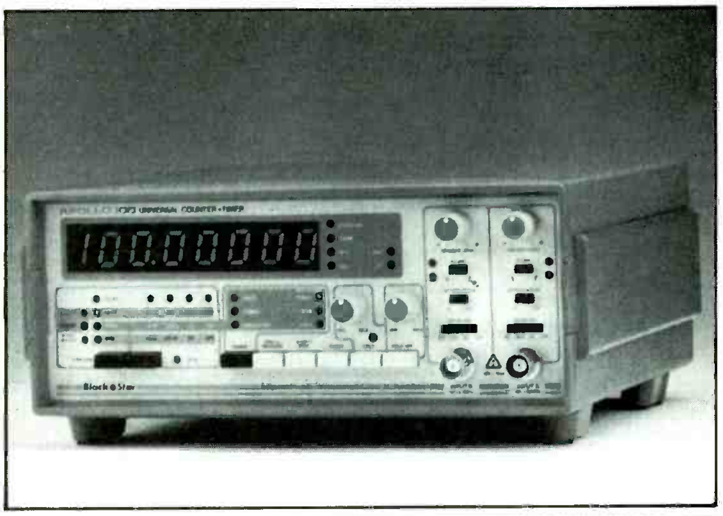
One section introduces a Music Composition Language (MCL), Similar to, though "somewhat humbler" than the language used to enter music on the Fairlight Music Computer. This allows envelopes and notes, duration etc. to be entered as data statements which are then compiled into a compact internal code and translated into sound commands in 'real time'. Key signatures are provided for. Again, there are some excellent examples listed and provided on the cassette or disc. The final section is on the use of the computer in the music classroom and includes programs that generate different pitches, intervals, key signatures, scales and modes, and rhythms for study and aural training.

It is possible to buy the book along for £9.95, but we would strongly recommend getting the cassette or disc as well as there are over 40 programs, some of which are quite lengthy and it would be a great chore to enter all of them. Cassette + book, £17.95; Disc + book, £19.95. Acornsoft Ltd., Vector Marketing, London Road, Wellingborough, Northants NN8 2RL. EWW210

Universal counter-timer

There is an addition to the range of low-cost instruments manufactured by Black Star. Apollo 100 is a compact mains-operated 100MHz counter-timer with a 8-digit led display for the measurement of frequency, period and period average, frequency ratio and time interval. Stop-watch, r.p.m. and totalise modes are also provided.

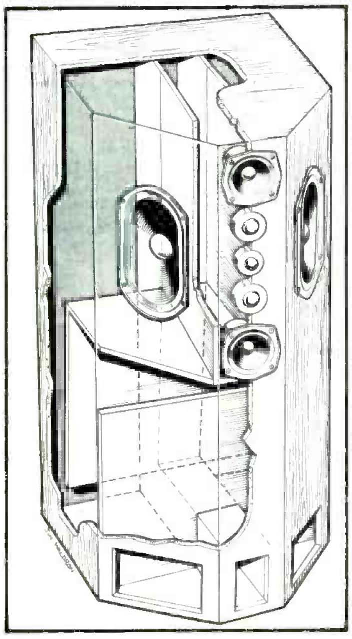
Full signal-conditioning controls are provided for both inputs, including attenuation, edge selection, trigger level and a low-pass filter. Other controls include single measure, start/stop and reset, display hold and trigger hold-off. The 10MHz timebase from a crystal-controlled oscillator provides a temperature stability of 2.5p.p.m. and this may be improved to 0.5p.p.m. by the optional inclusion of an oven-controlled crystal. A rear socket allows access to the internal oscillator or use of an external reference source. Price: £285. Black Star Ltd., 4 Stephenson Road, St. Ives, Huntingdon, Cambs PE17 4WJ. EWW215



New transmission lines

Following the demise of IMF, Transducer Developments, who manufactured the drive units for IMF, have decided to market its own range of transmission-line loudspeakers. They have enlisted John Wright, the original designer of IMF loudspeakers to design a new range.

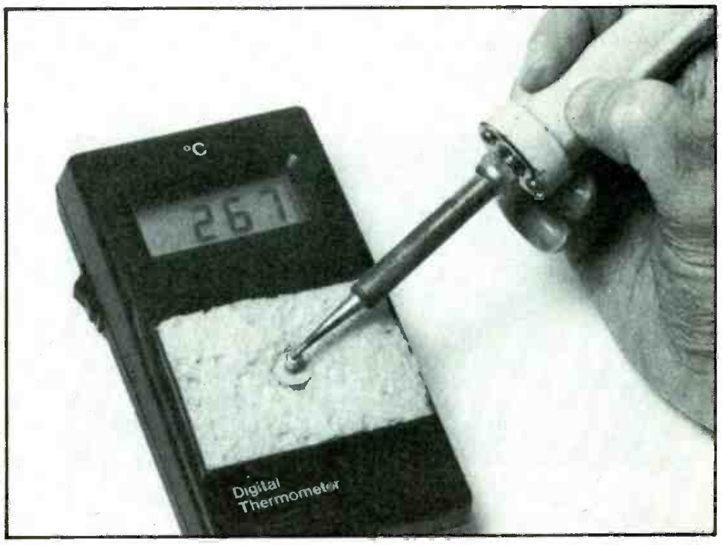
The transmission-line principle, which extends the bass response a further octave than conventional speakers, is claimed to be particularly applicable to digitally originated material, where the signal is flat down to 20Hz. The new design is wedge-shaped for maximum dispersion and employs a double transmission line. The mid-range is exhausted into a tapered open line to avoid colouration from the box. The tweeters and super-tweeter are metal dome, ferro-fluid cooled. The design optimises the

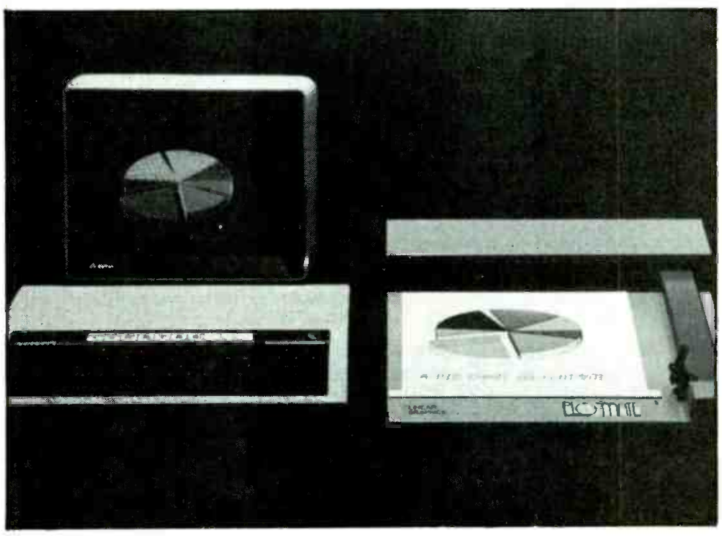


transmission-line system in the light of new materials and manufacturing prodcedures. TDL Electronics, Unit 11, Hampton Lovett Industrial Estate, Droitwich, Worcets WR9 0NX. EWW206

Soldering thermometer

Where the temperature of soldering is critical it is possible to use this soldering iron thermometer which has a resolution of 1°C and an accuracy of 0.5% over a temperature range of −50 to +500°C. The type K (NiCr-NiAl) sensor is at the centre of a cleaning sponge. The instrument will run for 1000h on a PP3-size alkaline battery. £39.50 from West Sussex Instruments Ltd., 12A Coronation Buildings, Brougham Road, Worthing, W. Sussex BN11 2NW. EWW201





Low-cost plotter

An XY plotter for use with home microcomputers is provided by the Plotmate. It has a bed sufficient to accomodate an A4 sheet but can cope with larger sizes (up to A2) by using a composite command. The paper is held onto the metal plotting base by magnetic strips.

The drawing facilities include triangle and block filling: there are 15 sets of shading patterns and dotted lines. Drawings may be drawn to any orientation and may be repeated with new origins, or re-scaled.

The plotter will interface directly with the BBC Micro and recognises most of the same Basic commands used for BBC screen graphics. There is also an interface package available to allow it to be used with any micro that has an RS232 or Centronics printer port. Other software provides facilities for drawing complicated shapes, for the production of bar-graphs and pie charts and an electronics package for drawing circuit diagrams. The plotter costs £299. Linear Graphics Ltd., 28 Purdeys Way, Rochford Essex SS4 1NE. EWW202

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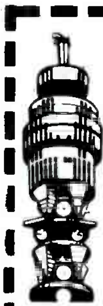

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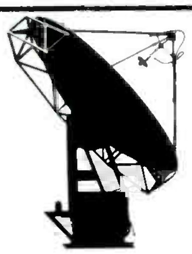

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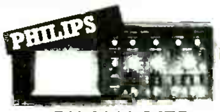

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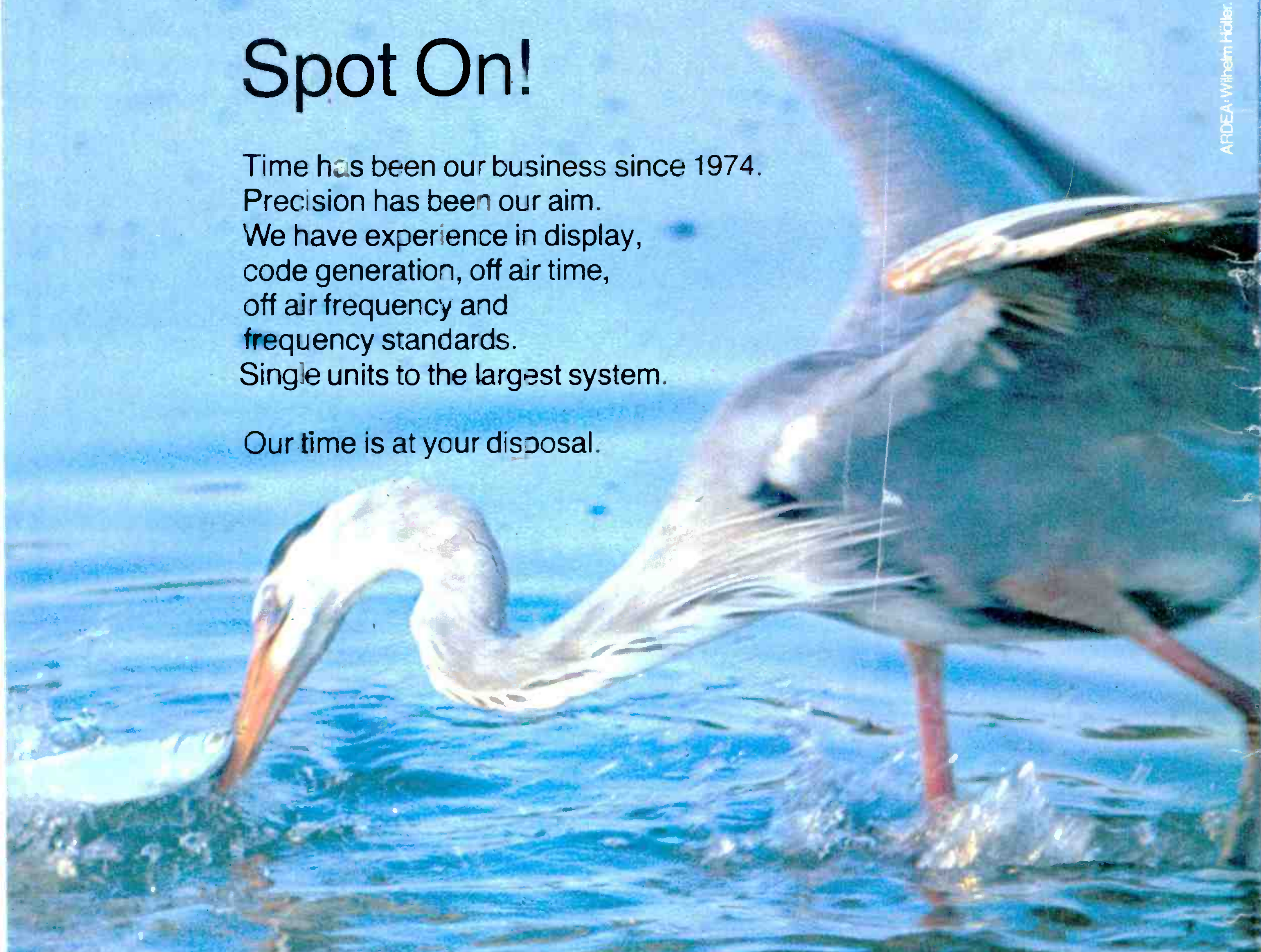

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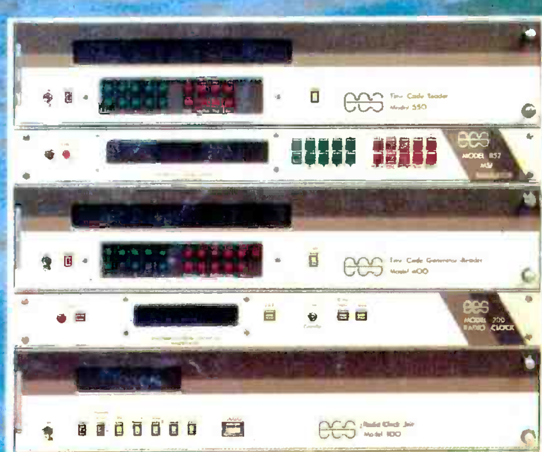

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