ELECTRONICS &

Wireless world

April 1985 85p

Choosing a crystal

Current follower

Short-wave loop aerial

Vehicle location in tunnels

Australia	A$	3.30	Italy	L	4200
Denmark	DKr.	38.00	Spain	Pts.	370.00
Germany	DM	7.00	Switzerland	SFr.	8.00
Greece	Dra.	24.00	Singapore	M$	7.00
Holland	DFl.	9.00	U.S.A.	$	4.00

FARNELL 1kW AUTORANGING POWER SUPPLIES

- Compact, lightweight and efficient switch mode power supplies
- For bench or rack mounting in manual or systems applications
- Fast remote programming speed
- Autoranging output
- Constant voltage, constant current

Operating modes:
Local or bus control
Remote programming
Remote sensing
Auto parallel
Auto series
Auto tracking

- Ten turn voltage and current controls
- Digital display of voltage, current, over voltage setting and status flags
- Bar graph indication of voltage/current capacity
- Front panel adjustable over voltage limit
- Front panel output enable switch
- Current monitoring output

GPIB option provides:
Bus control of voltage and current
Bus measurement of voltage and current
Clear LED indication of bus control, listen, talk, SRQ

The Programmable AP Series

Get all the details from the colour brochure. Send for your copy now to:

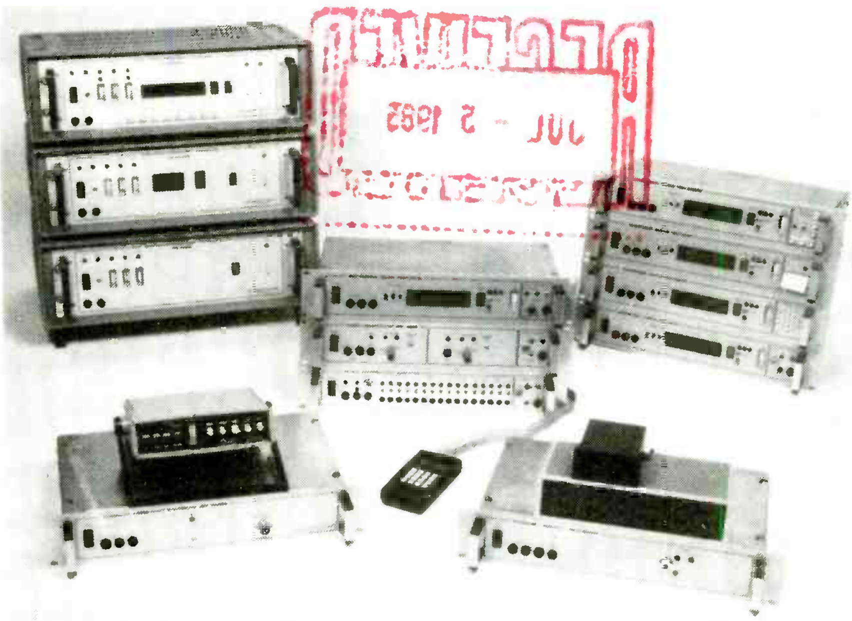
Farnell

FARNELL INSTRUMENTS LIMITED · WETHERBY · WEST YORKSHIRE LS22 4DH · ENGLAND · TEL. (0937) 61961 · TELEX 557294 FARIST G

CIRCLE 1 FOR FURTHER INFORMATION

RADIOCODE CLOCKS LTD

SPECIALISTS IN ATOMIC TIME, FREQUENCY AND SYNCHRONISATION EQUIPMENT



NEW PRODUCTS

- **MINIATURE RUBIDIUM OSCILLATOR MODULE**
  Lower power, fast warm up, optional output frequencies, programmable frequency offsets.
- **RUBIDIUM FREQUENCY STANDARD**
  High performance, compact and rugged instrument. 2U rack or ¼ ATR case options.
- **INTELLIGENT OFF-AIR FREQUENCY STANDARDS**
  Microcomputer controlled instruments, directly traceable to N.P.L., precision ovened local oscillator, comprehensive monitoring and status information, real time synchronisation.
- **LOW COST MSF FREQUENCY STANDARD**
  Instant operation, directly traceable to N.P.L., self-contained portable unit, no scheduled frequency changes, 24 hr transmission, real time synchronisation

- **Off-air frequency standards**
- **Intelligent time systems**
- **Caesium/Rubidium based clocks & oscillators**
- **Master/slave systems**
- **Time code generators/readers**
- **Record/replay systems**
- **Intelligent display systems**
- **Precision ovened oscillators**
- **Time/frequency distribution systems**

Radiocode Clocks Ltd*

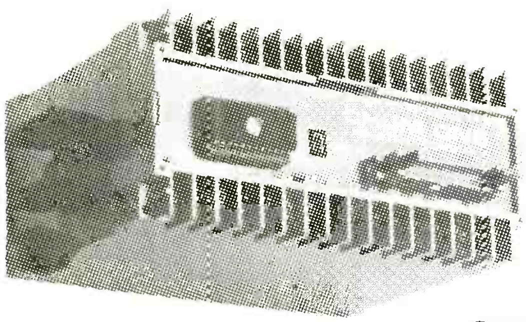
Unit 19, Parkengue,
Kernick Road Industrial Estate, Penryn,
Falmouth, Cornwall. Tel: Falmouth (0326) 76007

(*A Circuit Services Associate Co.)

CIRCLE 32 FOR FURTHER DETAILS.

CHUM ONE A

Industrial Computer



£258

- ★ Control BASIC and Z80 Assembler Language
- ★ On Board EPROM Programmer
- ★ Detachable Hand-Held Keyboard and Display
- ★ 4K Bytes of Battery Backed Memory
- ★ Up to 64 Relay Outputs
- ★ Up to 64 Opto-Coupled Inputs
- ★ 4 Analogue Inputs
- ★ 1 Analogue Output
- ★ RS232 Interface
- ★ Cassette Back-Up Memory
- ★ Real Time Clock

The Chum One A offers the complete solution to all measurement and control problems. Programs can be written, tested and modified in RAM then at a touch of a switch blown into an EPROM.

**WARWICK DESIGN GROUP, 12 ST. GEORGE'S ROAD
LEAMINGTON SPA CV31 3AY (0926) 34311**

CIRCLE 24 FOR FURTHER DETAILS.

HIDE IT!

The ICOM IC-125T's small size enables unobtrusive installation in any vehicle, a strong security factor.

This mobile transceiver from ICOM offers a great deal to dealers, suppliers and users of PMR mobiles for CBS message handling and small private installations where security is concerned. Despite its small proportions the IC-125T has 25 watt output and is synthesized.

This enables the 125T to be quickly programmed by inserting diodes in the matrix board. As no crystals are needed there is no frequency tuning, no fuss, no waiting, the customer that wants his radios yesterday can have them! Quick demonstrations on a prospective customers own frequency can be quickly arranged.

The ICOM IC-125T has, over the years proven to be an extremely reliable radio, as have the handheld sets IC-H2 and H6.

125T features include: 25W output, 5 tone Selcall option CCIR, ZVEI and NATEL with revertive call and alarm light, socket for additional equipment, programmable call tones, capacity for CTCSS etc, forward facing loudspeaker, microphone, DC lead, mobile mounting kit, black vinyl finish. Size: 50(H) x 150(W) x 180(D)mm.

For more details contact your local ICOM dealer. If you are unable to locate an ICOM dealer in your own area or country, contact Thanet Electronics Ltd. at the address below.

Thanet Electronics Ltd

Suppliers of Radio Communication Equipment to the Ministry of Defence.

143 Reculver Road, Herne Bay, Kent.
Tel:(0227) 363859/363850 ICOM

CIRCLE 23 FOR FURTHER DETAILS.

ELECTRONICS &
Wireless World

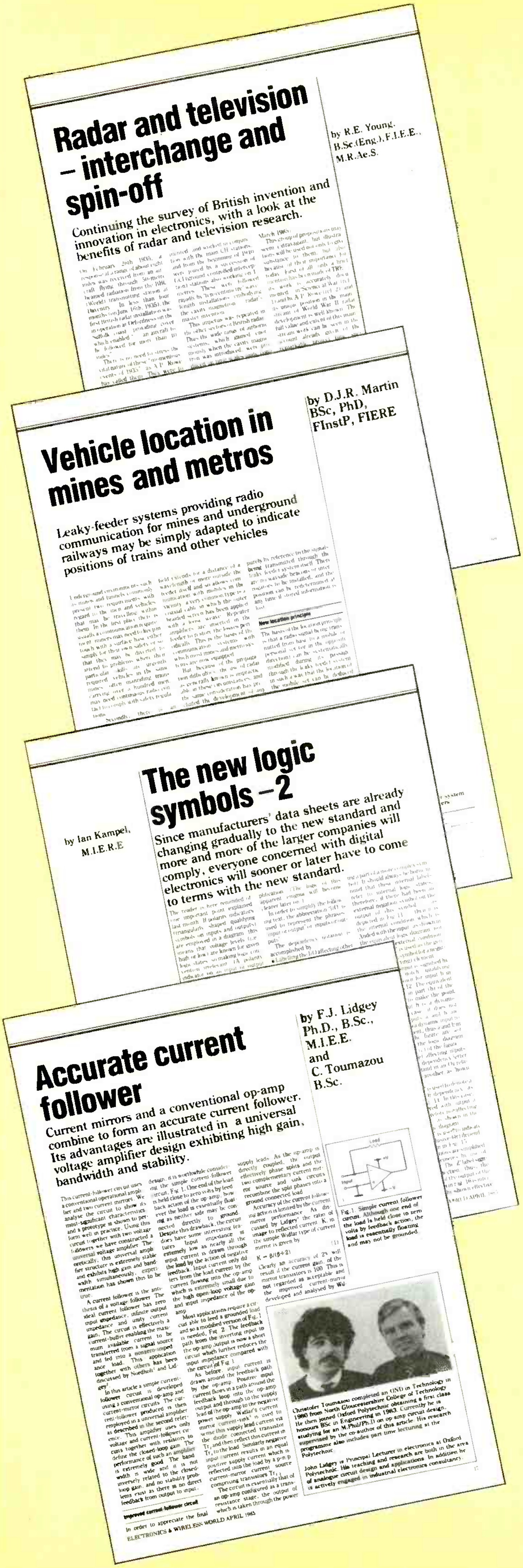
over 70 years in independent electronics publishing

April 1985

Volume 91 number 1590

FEATURES

REGULARS



Cover picture is a collection of quartz crystals, illustrating G. Huyler's piece on these often imperfectly understood devices. Photograph by courtesy of Cathodeon Crystals Limited.

NEXT MONTH

Enlarging timer by John Linsley Hood measures reflected, rather than transmitted light, cutting off the light source when exposure is complete.

Bench power supplies are the subject of our latest equipment survey, which will cover the units available on the UK market – characteristics, facilities, prices and other relevant information.

Altimeter and variometer for microlights and gliders is a true aneroid barometer, using a pressure transducer made by Motorola.

Printer buffer by Mike Catherwood takes over the job of sending text to a printer to free the microcomputer for other tasks.

Current issue price 85p, back issues (if available) £1.06, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.

By post, current issue £1.30, back issues (if available) £1.40, order and payments to EEP Sundry Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Tel.: 01-661 3378.

Editorial & Advertising offices: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Telephones: Editorial 01-661 3614. Advertising 01-661 3130.

Telex: 892084 BISPRS G (EEP)

Facsimile: 01-661 2071 (Groups II & III)

Beeline (300 baud): 01-661 8978 (Keyword EWW. Type NNNN to end).

Subscription rates: 1 years £15 UK and £19 outside UK.

Student rates: 1 year £10 UK and £12.70 outside UK.

Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3248.

Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 04444 59188. Please notify a change of address.

USA: $49.40 surface mail, $102.60 airmail. Business Press International (USA). Subscriptions Office, 205 E. 42nd Street, NY 10017.

USA mailing agents: Expediters of the Printed World Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022, 2nd class postage paid at New York.

ISSN 0043 6062.

Editor
PHILIP DARRINGTON
01-661 3128

Deputy Editor
GEOFFREY SHORTER, B.Sc.
01-661 8639

Technical Editor
MARTIN ECCLES
01-661 8638

Projects Editor
RICHARD LAMBLEY
01-661 3039 OR 8637

News Editor
DAVID SCOBIE
01-661 8632

Drawing Office Manager
ROGER GOODMAN
01-661 8690

Technical Illustrator
BETTY PALMER

Advertisement Manager
BOB NIBBS, A.C.I.I.
01-661 3130

MICHAEL DOWNING
01-661 8640

ASHLEY WALLIS
01-661 8641

Northern Sales
HARRY AIKEN
061-872 8861

Midland Sales
BASIL McGOWAN
021-356 4838

Classified Manager
BRIAN DURRANT
01-661 3106

IAN FAUX
01-661 3033

Production
BRIAN BANNISTER
(Make-up and copy)
01-661 8648

Publishing Director
DAVID MONTGOMERY
01-661 3241

International Agents and the Advertisers Index appear at the back of this issue.

Leapfrog

There are rumblings in the micro market. Some of the big names are gone and others look none too healthy. It would therefore appear that the public has realised that paying three or four hundred pounds for a machine to fill up spare room in a cupboard is not the most rewarding way of employing one's disposable income.

A quick survey among one's circle of acquaintances (non-engineering ones) reveals that around 70% of those with school-age children bought microcomputers for them about a year or eighteen months ago because "the school had one" or because the children "plagued my life out for one" or simply as a result of being informed by advertisers that the modern school child would develop ingrowing toenails without one.

The acquisition of a computer by the average household has not, in the main, resulted in an explosion of enthusiasm for information technology. Indeed, after a short period for the novelty to wear off, a barely suppressed yawn has become the more common response to computer exposure. For, having bought the computer, parents' expectations of immediate and dramatic metamorphosis of child into technocrat have been blunted by the sight of their progeny playing games involving frogs, invaders from space and monkeys climbing trees, the result of failure in most of the games being instant liquidation. After achieving proficiency at these somewhat recondite pursuits, the keen edge of enthusiasm for modern technology dulls and the computer is put away with the other expensive toys, such as skateboards.

The intention of the makers of computers, at least in the beginning, was to introduce users to computing easily and gently by means of games programs. But the notional progression from games — the programming of computers to do something useful and interesting — seems not to have happened. The introductory booklets that come with computers do try to lead one into a programming attitude of mind, but many of them are quite difficult to follow, particularly for children, and with so many games available, many owners have been led to the belief that that is what computers — at least home computers — are for.

It is possible that a rapid change of direction on the part of those developing programs for sale may halt, or even reverse, the current trend towards computer rejection. But someone is going to have to do something rather rapidly, because there may not be many affordable machines to buy quite soon.

Britain lags in chip race

Despite Mr Pattie's assurances to the Americans, mentioned in our news of last month, that Britain was leading Europe in the use of integrated circuits, The Policy Studies Institute offer a different viewpoint. They have surveyed more than 3500 factories in Britain, Germany and France and have discovered that:

- Britain is behind Germany in using microelectronics in products, but ahead of France.
- In all three countries the most commonly expressed obstacle to the use of micro-electronics is the lack of people with specialist technical expertise.
- Twice as many British manufacturers, compared with German or French, blamed the economic recession for their lack of utilisation of the devices and a similar proportion found it difficult to get finance for new projects.
- One thing that was not a British problem was opposition by trade unions which was seen as a threat by half as many British as by their continental counterparts. Over half the British firms said that they consulted their workforce before introducing new technology compared with 40% in Germany and 23% in France.
- In all three countries about three-quarters of the factories using microelectronics report that there has been no reduction in the number of people employed. Of the remaining quarter, some have had increases in employment but almost twice as many have cut staff. Where applications are used in products there has been a majority of increases in numbers employed, though there was detected an overall decrease of one or two jobs per factory. There is a possibility however that higher rates of use and more advanced applications could lead to greater effects on employment but so also could the inability to keep up with our international competitors in making use of the new technologies.
- In all three countries there has been a slowing down in the introduction of new applications, compared with two or three years ago.
- Germany has more engineers with micro expertise than Britain or France. British firms send more engineers on training courses that the French but they send more technicians. The Germans train more of both. There is a considerable shortage of trained personnel in all three countries.

In conclusion the report recommend as vital the need to train more technical people, to provide finance for education and to kindle economic expansion. The British are not too far behind to catch up.

Space cooperation with China

A Memorandum of Understanding (i.e. some degree below a formal agreement) on space collaboration has been signed between Britain and China.

This marks an advance in Britain's relations with the Chinese space authorities, who are rapidly developing their own independant satellites and launching systems. The Memorandum will enable regular exchanges of space scientists to take place, as well as paving the way for cooperation in satellite technology developments.

Mr Li Xue, first Deputy Minister of Astronautics, who signed the Memorandum with our Geoffrey Pattie, also lead a large delegation of Chinese space technologists on a tour of British space research establishments including British Aerospace and Marconi Space Systems.

- A different agreement has been signed between Marconi Electronic Devices Ltd. and the Chun Shu Rectifier plant in Beijing. MEDL have licenced the Chinese plant to establish a manufacturing plant for power thyristors and silicon rectifiers. The British company will also be providing know-how and support for the Chinese plant and will be training Chinese technologists in the UK. The first stage of the agreement is the provision of a £100k technology transfer data pack coupled with the purchase of £300k of semiconductor devices and piece parts made by MEDL at Lincoln.

1Mbit d.ram from Japan

Toshiba have announced that they have succeeded in developing a one megabit dynamic ram. Using micro-lithography they have used a 1.2micron geometry to get 2.25 million elements onto a chip of silicon 4.78 by 13.23mm. The device has an access time of 70ns and consumes 270mW during operation and 15mW in the standby mode.

The company claims that its success is due to a method of being able to reduce the area of isolation between elements while maintaining the isolation. This uses buried oxide isolation (or BOX) where grooves are etched into the silicon substrate and the grooves are then filled with an oxide film to perform the isolation. In conventional methods, the oxide can protrude onto the areas where elements are formed and this both increases the useable size of each element and the size of the isolation zone, making it difficult to achieve a geometry of less then two microns. The BOX isolation has the added advantage of forming capacitors on the side walls of the groove as well as on the surface, leading to a more efficient memory element. Toshiba have no plans yet to produce the device in quantity.

World plan for f.m.

More than 53000 stations in the band 87.5 to 108MHz are allowed for in the Agreement signed as a result of the Regional Aministration Conference for the Planning of v.h.f. Sound Broadcasting. The conference was convened by the International Telecommunications Union following the 1979 WARC decision to extend the band above 100MHz to 108MHz.

The frequency assignment plan, known as the Geneva Plan, takes in such considerations as the prevention of interference with aeronautical radionavigation stations which occupy the nearest band and the procedures for its own modification. The Plan is to become operative in mid-1987 and is planned to meet the requirements of sound broadcasting services with the f.m. band for a further 20 years.

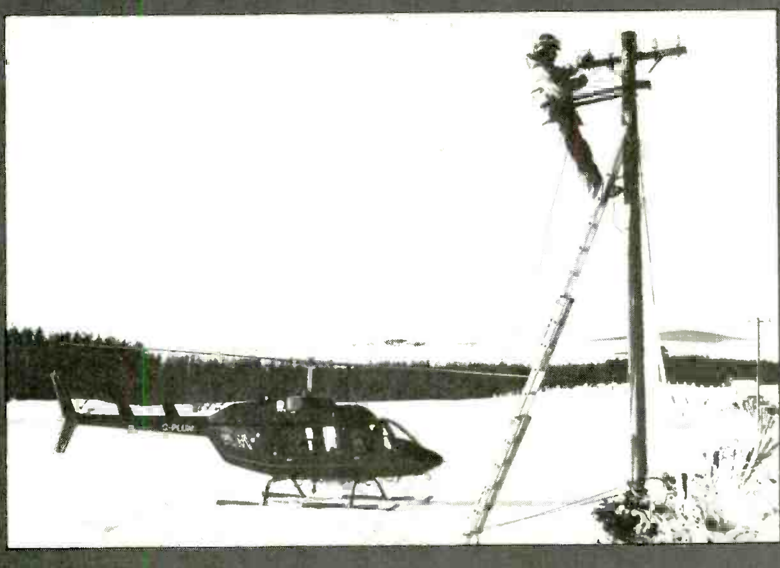
Acorn rescued

One could hardly think of a computer company more stable than Acorn with its BBC marque and its wide use in education. Yet like so many other computer companies it was suddenly plunged into a "cashflow crisis" and nearly collapsed altogether. The crisis seems to have been brought about by the pre-Christmas over-estimate of the number of Electron computers to be sold and the post-Christmas decision to reduce the price of the Electron to that of the Sinclair Spectrum, compensating those dealers who had a stock of Electrons with the difference in price.

The rescue has come from a seemingly unlikely source, Olivetti the Italian typewriter giant who have expanded into word processors and business computers and are themselves part owned by A T & T. They have bought a 49.5% share in Acorn and have the option to take a majority shareholding if they so desire. Hauser and Curry, Acorn's founders and joint managing directors are to stay on the board along with their recently appointed chief executive, Alex Reid, though it is thought that there will be a new supremo appointed by Olivetti.

The Italian company is rated second to IBM in the European IT market and tenth in the world. They produce the M24 Personal Computer which their extensive advertising claims is "significantly faster and more powerful then the IBM PC." Their investment in Acorn suggests an attack on the world educational computer market.

People in high places. Rick Boran is seen fitting a new antenna for the Cellnet telephone service to the IBA mast at Beulah Hill, South London. In the distance is the Crystal Palace mast.
Up a pole, above a wintry landscape in Suffolk, Jill Barnes, one of a small, but increasing number of female telephone engineers, is clearing a fault in an overhead line. Others gain access by helicoptor and snow-mobiles.



High-speed semi-conductor

The giant Japanese electronics company, NEC, have announced the development of a new semiconductor material which is constructed from several layers alternating between gallium arsenide (GaAs) and aluminium arsenide (AlAs). The material is produced by molecular beam epitaxial growth to enable very thin layers to be grown on the crystal's substrate. This 'super-doped' lattice structure greatly improves the conductivity of the electron supplying layers and enables the making of very high-speed devices with up to about 10 picoseconds per gate. Indeed at low temperatures, such as that of liquid Nitrogen at 77k, a switching speed of 5ps/gate is possible. Previous tests on mixed crystals of AlGaAs proved that their conductivity was reduced by the active energy of doped impurities. It is thought that this was due to imperfections in the crystal structure around the dopants and the new material completely overcomes this while retaining the very low threshold voltage variation associated with the mixed material crystals.

NEC also claim that the new material will enable the control of the physical properites of materials artificially on an atomic level and permit the development of such new devices as hetero-bipolar transistors and high-power semiconductor lasers. The material might also be used in the production of components in ultra-high-speed computers as the switching speed approaches that of Josephson devices. A prototype ring oscillator is likely to be the first practical application of the material and this will confirm its theoretical properties.

Tentative plans for Band III

Geoffrey Pattie, Minister for IT, has announced the initial decisions on the future use of Bands I and III, left vacant by the demise of 405-line tv. Much of Band III is to be used for mobile radiotelephones using trunking and providing common base station and message handling services.

Prevailing opinion, following the responses to the governments consutative document, favoured the adoption of a common signalling standard for trunked systems and the preparation of such a standard is making good progress. However there is some conflict with the new cellular radio telephones which it is felt should not have to compete with a rival system until it is better established. There is still the possibility of operating a nationwide mobile service with no, or only restricted, access to the public switched telephone network. Such a service would not conflict with cellular radio and could offer more efficient use of the band as calls are usually much shorter over radio than those interconnected with the telephone system.

So the plans will possibly include the introduction of one or two non-interconnected national networks with the further possibility of local networks which may have p.s.t.n. interconnection in the major conurbations. Further advice from the Director General of Telecommunications is being sought.

There were further responses to the Consultative document, including plans for Band I, which are still under consideration.

In brief

Advanced Micro Devices of California are to invest £144M on a new wafer fabrication plant at Greystones, Co. Wicklow, Eire. The plant will produce microprocessor, telecommunications and memory products and will create 650 jobs, over a third of them highly skilled. Construction of the plant will commence this year with production underway by the end of 1990.

Improved interlocking at British Rail

Two applications of information technology techniques have been installed in railways. The first is a solid-state interlocking (SSI) system for a new signal box at Leamington Spa. Interlocking systems have been very important in railway management as they ensure that no conflicting train movements are set up. Signals and points are locked and originally the interlocking was entirely mechanical, offering a severe restriction on the range of each installation. Later, and until now, electro-mechanical relays have been used in profusion to control electrically operated points and signals. The London Bridge signalling centre uses more than 34 thousand relays to control up to 100 trains simultaneously over 150 miles of track. The replacement of these by a solid-state system would need about 20 cabinets of equipment, reducing the space required by more than half and elimination 12 small trackside buildings. The Leamington Spa system requires only one cabinet. It is to be run in parallel with the existing relays without connection to the signals or points. Initially it is to be connected to a "dummy load", a computer which will simulate the equivalent of several years of operation. Gradually it will be tested on specific sections of the lines and will eventually take over. To the signalman and driver there will be no difference and they will continue to operate exactly as before.

With SSI the interlocking is performed centrally by microcomputers which communicate through serial data links with lineside terminals directly controlling the signalling equipment. Cross-checking duplicate and triplicate systems are used to ensure safety and availability. Built-in diagnostic facilities enable faults to be detected and rectified speedily. The system was conceived by British Rail and developed by them in conjunction with Westinghouse Brake & Signal and with GEC-General Signal.

Private science

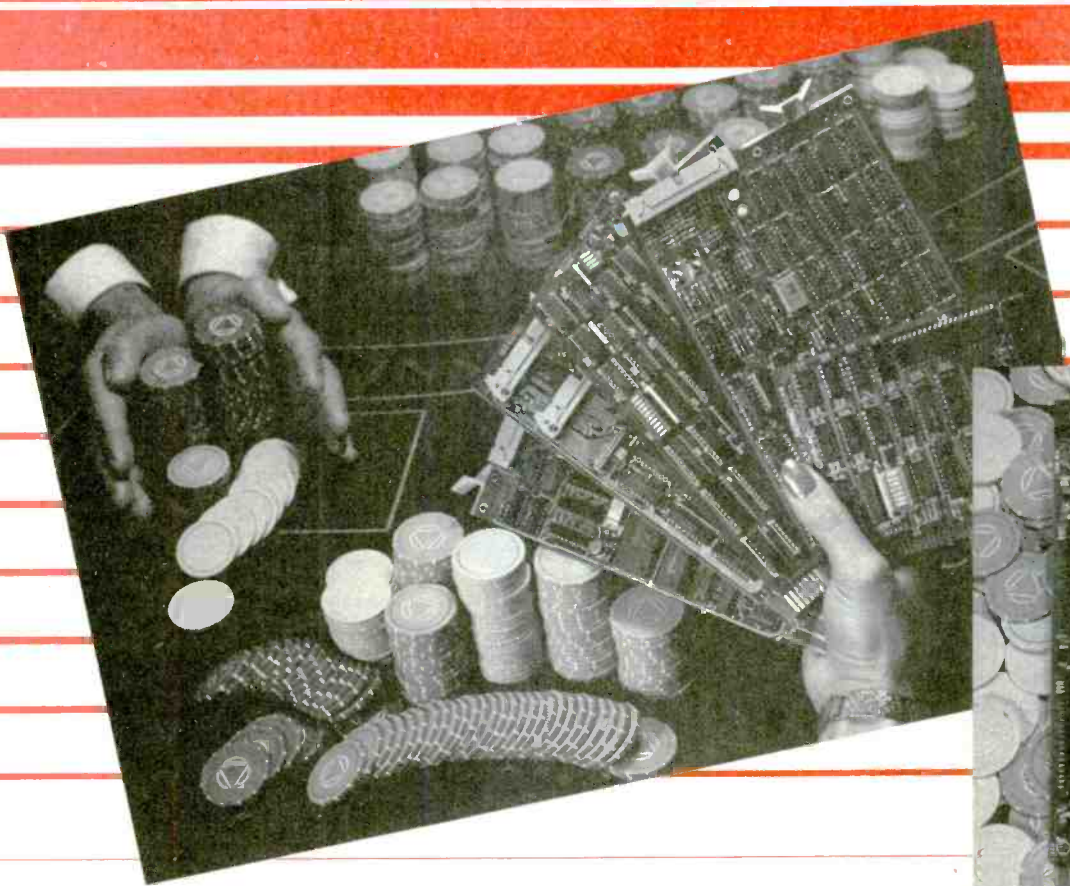
Japan is often looked to as an example of how we should succeed commercially. If we look more closely at that success however, it is possible to see that they are very good at exploiting ideas, of turning them into commercial propositions, but that they also have a very thin basis of original thought, of generating the same ideas that they are so good at exploiting.

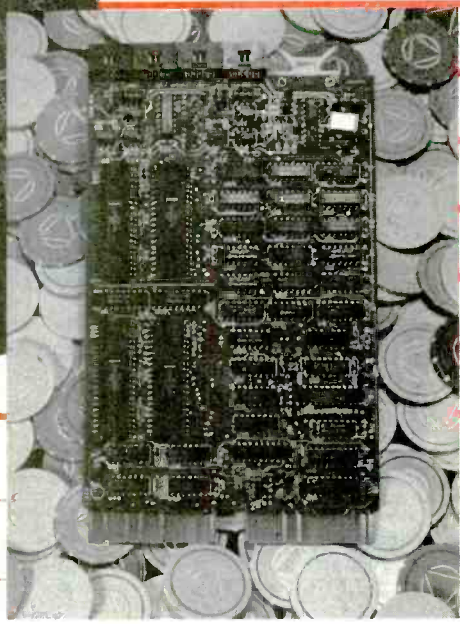
Now, the Department of Education and Science is trying to emulate the Japanese by finding private sector funding for science research. We understood that the Research Councils were set up to fund research so that it would be free from commercial pressures. The whole philosophy of the present Government is exactly the reverse of this; that public funding (of almost anything) is inherently bad and that commercial pressure is somehow the return to a 'real' world.

Great Britain has always been proud of its contribution to world scientific knowledge. Many practical and useful inventions have come from an academic study of apparently obscure phenomena but that have turned out to be commercially exploitable.

The private sector are looking for fast returns on investments. They are unlikely to be willing to finance basic research that may look as if it is going nowhere. But this is the very research which will eventually lead to closing the gaps in our knowledge and ultimately to products and services and so improve the quality of our lives.

CARD SHARP





LSI-II SERIAL I/O

Our cards take the gamble out of systems integration!

Take a look at our cards for LSI-II Q Bus, VME Bus, DEC Unibus, STD Bus, IEEE 488 Bus, VERSA Bus, Multibus, IBM PC and Digital Rainbow.

You'll find we give more value or more functions, or save you money or space in your backplane.

Our technical support is by people who really know computer buses, our sales and service engineers are factory trained to know our products.

Whether its serial I/O, analog I/O, digital I/O, comms, bubble memory, system fault analysis or bus conversion, our board level products give you more, to help you build a better system.

For the best deal in cards call us, we'll see that YOU WIN.

Model 304 four channel serial I/O port for interfacing Q Bus to asynchronous serial data channels. A direct replacement for the DLV11-J, totally software compatible. Each port may be independently configured for RS232C, RS422 or RS423, at nine jumper selectable data rates from 150 to 38.4K baud generated by an on board clock. An external clock may be provided for up to 250K baud data rate.
Four level vector interrupt structure capability for multi user environments with the possibility to configure channel four as the system consul. All this on a standard 8.9" × 5.2" card with despatch the same day you order.

AMPLICON

Amplicon Electronics Limited Richmond Road Brighton East Sussex BN2 3RL UK
CIRCLE 83 FOR FURTHER DETAILS. Tel. Brighton (0273) 608331 Telex: 877470 AMPCON G.

Electronic Brokers Test & Measure

CHECK OUR

OSCILLOSCOPES & LOGIC ANALYSERS

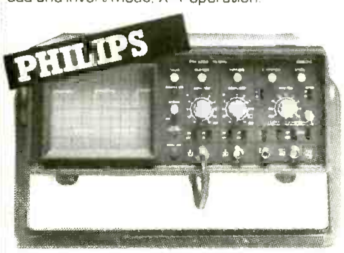
Philips PM 3267 £1295
100MHz, dual trace, main and delayed time bases with independent triggering, 2mV sensitivity, trigger-view as third channel display.

Philips PM 3256 £1395
75MHz, compact ruggedized portable with shoulder strap, dual trace, 2mV sensitivity, delayed time base, trigger-view, TTL triggering.

Philips PM 3217 £895
50MHz, dual trace, delayed time base, 2mV sensitivity, TV triggering on line and frame, variable hold-off, Z modulation.

Philips PM 3215 £725
50MHz, dual trace, single time base, 2mV sensitivity, TV triggering, auto triggering with level control, X-Y operation.

Philips PM 3207 £345
15MHz, dual trace, light-weight portable, 5mV sensitivity, auto triggering from either channel, add and invert mode, X-Y operation.

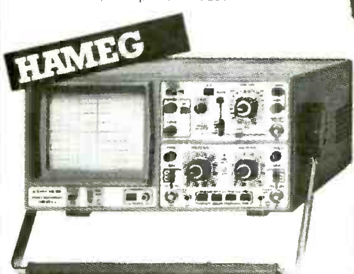


Philips PM 3206 £286
15MHz, compact portable, dual trace, 5mV sensitivity, auto and TV triggering, variable time base speed, Z modulation.

Philips PM 3219 £2795
50MHz, analogue storage with variable persistence, auto erase and auto store facilities, 2mV sensitivity, delayed time base.

Hameg HM 605 £515
60MHz, dual trace, sweep delay, maximum sensitivity 1mV, versatile triggering, Z modulation, X-Y operation, inbuilt component tester.

Hameg HM 204-2 £365
20MHz, dual trace, sweep delay, maximum sensitivity 1mV, variable hold-off, X-Y operation, Z modulation, component tester.



Hameg HM 203-5 £264
20MHz, dual trace, add and invert, maximum sensitivity 2mV, automatic and normal triggering, X-Y operation, component tester.

Hameg HM 103 £167
10MHz, single trace, maximum sensitivity 2mV, TV triggering, compact size, component tester, all Hameg oscilloscopes have 2 year warranty.

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.

Thandar TA 2160 £3450
16 channels, 20MHz logic analyser, 15nS glitch capture, 252 word data and reference memories, automatic or manual compare between memories, personality options.

Philips PM 3302 £1395
20MHz Digital Scope, 2 Channels, DC-20MHz. 1mV/cm sensitivity. Single & X-Y operation.

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. PM 2519/51 with IEEE interface £515

Philips PM 2518X/11 £199
4 digit, LCD with electroluminescent display, auto/manual ranging, true RMS, dB, relative reference, current to 20A.

Fluke 8050A £364
4½ digit, LCD, nine functions including dB, conductance, diode test, true RMS, relative reference, DC accuracy 0.03%. 8050A-01 Ni-Cd battery version £399

Fluke 8012A £324
3½ digit, LCD, low ohm resistance range, seven functions include conductance, diode test, true RMS, DC accuracy 0.1%. 8012A-01 Ni-Cd battery version £358

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.

Thurlby 1905A £325
5½ digit, bright LED, 1μV, 1mΩ, 1nA sensitivity, DC accuracy 0.015%, null and hold functions, computing functions, true RMS and IEEE interface options

ANALOGUE MULTIMETERS

Philips PM 2505 £158
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

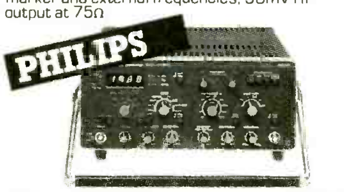
I.C.E. 680G £25
48 measuring ranges, sensitivity 20KΩ/V, DC accuracy 2%, 10cm mirror scale, overload protection

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 5712 £955
1Hz to 50MHz, 4nS, amplitude 200mV to 10V, pulse duration and delay 10nS to 100mS, double, normal or inverted pulse, ext triggering sync gating, single shot

Philips PM 5326 £1175
RF generator 100kHz to 125MHz, AM/FM modulation, 5 digit counter displays RF carrier, marker and external frequencies, 50mV RF output at 75Ω



Philips PM 5134 £1495
Function generator 0.001Hz to 20MHz, frequency display, sine, square, triangle, TTL, int or ext sweep, AM/FM modulation, output 20Vpp.

Philips PM 5133 £1145
Function generator 0.01Hz to 2MHz, frequency display, sine, square, triangle, TTL, int or ext sweep, log or lin, output 20Vpp, selectable 50Ω or 600Ω.

Philips PM 5132 £625
Function generator 0.01Hz to 2MHz, sine, square, triangle, TTL, positive and negative pulses, int or ext sweep, output 30Vpp, selectable 50Ω or 600Ω.

THEN CHECK

Electronic Brokers are leading suppliers of electronic test and measuring equipment. Our distribution division handles the major names in the industry: Philips, Fluke, Hameg, ICE, Thandar, Thurlby, GP Industrial, Claude Lyons, Coline, Compact Instruments.

These products are stocked in depth in our spacious new premises at Camden Town, ready for

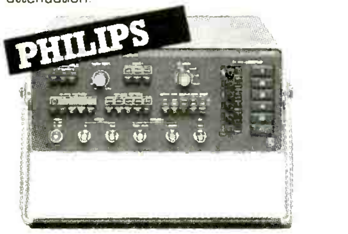
Electronic Brokers

CIRCLE 200 FOR FURTHER DETAILS.

ment Instrument Distribution Division

INVENTORY:

Philips PM 5131 **£415**
Function generator 0.1Hz to 2MHz, sine, square, tri-angle, TTL, int or ext sweep, output 30Vpp into 50Ω, stepped and variable attenuation.



Philips PM 5519I **£817**
Pattern generator, 20 combination test patterns, full RF coverage, electronic tuning with 6 preset channels, video and sound mod, comp and frame sync.

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.

Thandar TG 502 **£495**
Sweep/function generator 0.005Hz to 5MHz, sine, square, triangle, TTL, internal sweep log or lin, variable sweep rate and marker duration, sweep and pen-lift outputs.

Thandar TG 503 **£495**
Pulse/function generator 0.005Hz to 5MHz, sine, square, triangle, ramp, TTL, normal, double or delayed pulses, variable pulse width and delay, adjustable base line.

COUNTERS & COUNTER/TIMER

Philips PM 6670/01 **£595**
Counter/timer, 0.1Hz to 120MHz, period, pulse width, single and average time interval, count, phase, RPM, ratio, high resolution, 10mV sensitivity.

Philips PM 6671/01 **£719**
Counter/timer, 0.1Hz to 120MHz, as PM 6670 with LED trigger indicators, trigger level outputs, burst frequency average, arming, ext reset/start, gate open monitor.

Philips PM 6672/01 **£895**
Counter/timer, 0.1Hz to 1GHz, period, pulse width, single and average time interval, count, phase, RPM, ratio, high resolution, 10mV sensitivity to 70MHz.

Philips PM 6668/01 **£446**
Counter, 10Hz to 1GHz, 7 digit LCD display, auto triggering on all waveforms, 15mV sensitivity, high stability crystal oscillators.

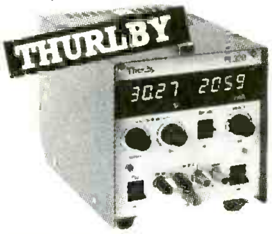
Philips PM 6667/01 **£304**
Counter, 10Hz to 120MHz, 7 digit LCD display, self diagnosis routine, auto triggering 15mV sensitivity, high stability oscillator.

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 **£149**
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 **£145**
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 **£118**
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

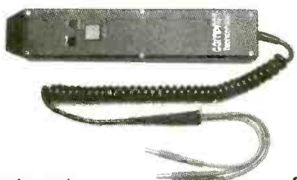
Philips PM 6303 **£725**
Philips automatic RCL bridge, 4 digit LCD display for measured value and electric dimension, accuracy 0.25%, automatic or stepping parameter menu selection.

Philips PM 6307 **£476**
Philips wow & flutter meter, crystal controlled oscillator, 3150Hz and 3000Hz selectable, high accuracy and stability, separate drift and flutter indication.

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 **£169**
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.

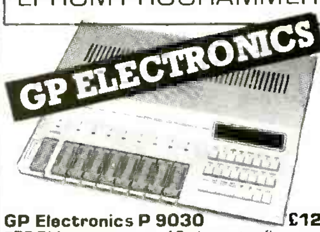
LINE CONDITIONERS

Claude Lyons LVC 500 **£330**
5A, 1200VA rating, line voltage conditioner, supply frequency 48-63Hz, incorporate ultra isolation transformer and r.f.i. filter.

Claude Lyons LVC 250 **£256**
2.5A, 600VA rating, line voltage conditioner, fast response (typically 1½ cycles), isolated input/output, compact and portable for easy installation.

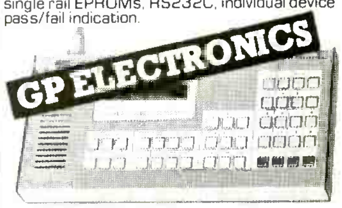
Claude Lyons LVC 65 **£175**
0.65A, 156VA rating, line voltage conditioner, unaffected by frequency variations, transient and noise suppression. All LVC units have 2 year warranty.

EPROM PROGRAMMERS



GP Electronics P 9030 **£1295**
EPROM programmer, 16 character fluorescent message display, menu selection, programmes all EPROMs, powerful editor, RS232C interface, label print feature.

GP Electronics P 9020 **£995**
EPROM programmer, 16 character display, menu device/mode selection, programmes all single rail EPROMs, RS232C, individual device pass/fail indication.



GP Electronics MFL 373 **£695**
Microsystem fault locator, range functions include Bus test, ROM test, dynamic and static RAM test, supplied with synchrous logic probe.

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

Full specifications on any products distributed by Electronic Brokers are available on request.

OUR SERVICE.

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.

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.

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

All prices exclusive of VAT. Carriage and packing charges extra on all items unless otherwise stated.
A copy of our trading conditions is available on request.
Prices correct at time of going to press.

CIRCLE 200 FOR FURTHER DETAILS.

A low-cost professional Logic Analyser
the new Thurlby LA-160 from £395 + vat

- 16 data channels, expandable up to 32
- 2,000 word data acquisition memory
- Non-volatile reference memory
- Powerful search and compare facilities
- Clock rates up to 20MHz
- Data state and logic timing displays
- Binary, octal, decimal or hex formats
- Hard-copy data print-out option

An essential instrument for today's electronics

An oscilloscope and logic probe are not enough to unravel the complexities of today's electronic equipment. A logic analyser is now the essential tool for digital electronics work both hardware and software. With prices measured in £1,000s, however, many engineers have been denied the use of one. Until now!

Innovative design and high volume production using the latest component technology provide the Thurlby LA-160 with performance exceeding many high-cost analysers but at a price measured in £100s.

The LA-160 enables digital information to be precisely recorded and then examined in detail either as a data state display or as a logic timing diagram (via the user's own oscilloscope).

Contact us now for a full colour technical data sheet.

Thurlby
designed and built in Britain

Thurlby Electronics Ltd., New Rd. St.Ives, Huntingdon, Cambs. PE17 4BG
Tel: (0480) 63570 Tlx: 32475

CIRCLE 20 FOR FURTHER DETAILS.

The world's most advanced low-cost bench multimeter!
Thurlby 1905a £325 + VAT

A complete high performance bench DMM
- 5½ digits; 0.015% acc; 1 µV, 1mΩ, 1nA.
- Full ac and current functions as standard

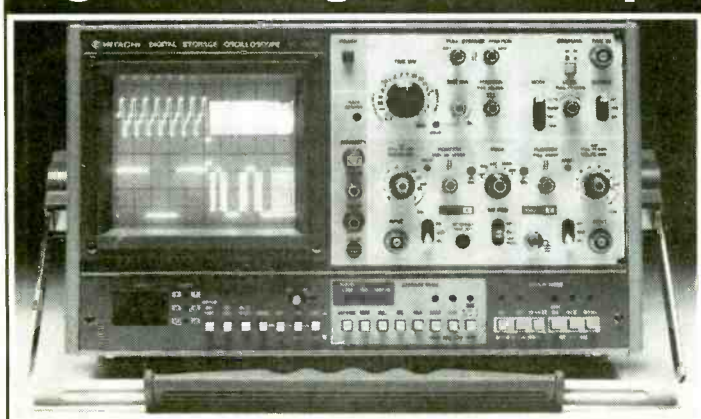
A sophisticated computing and logging DMM
- Linear scaling with offset; null/relative
- Percentage deviation; running average
- dBV, dBm general logarithmic calculations
- Limits comparison; min and max storage
- 100 reading timed data logging
- RS232 and IEEE-488 interface options

Thurlby Electronics Ltd
New Road, St.Ives, Cambs. PE17 4BG
Tel: (0480) 63570

Thurlby
designed and built in Britain

CIRCLE 21 FOR FURTHER DETAILS.

Digital storage oscilloscopes from Hitachi
more speed, more memory, more features



The new Hitachi VC-6041 combines a 40MHz A-D converter with 8K words of acquisition memory to provide ultra high resolution capture of high speed transient events.

A wealth of state-of-the-art features includes signal averaging, roll mode, variable pre-trigger, post storage expansion to X100, digital voltage and time readout, pen recorder output, and a GPIB data option.

If your application is a little less demanding choose the VC-6015, it's the easiest to use digital storage 'scope around. It has dual channel storage at 1MHz clock rate, 2K word memory, variable pre-trigger, X10 post storage magnification and a full pen recorder output, yet it costs only £1,450.

We hold the complete Hitachi 'scope range in stock for immediate availability. Ring us now to get full specifications and prices or to arrange a demonstration on **(0480) 63570.**

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

CIRCLE 22 FOR FURTHER DETAILS.

Accurate current follower

by F.J. Lidgey Ph.D., B.Sc., M.I.E.E. and C. Toumazou B.Sc.

Current mirrors and a conventional op-amp combine to form an accurate current follower. Its advantages are illustrated in a universal voltage amplifier design exhibiting high gain, bandwidth and stability.

This current-follower circuit uses a conventional operational amplifier and two current mirrors. We analyse the circuit to show its most-significant characteristics, and a prototype is shown to perform well in practice. Using this circuit together with two voltage followers we have constructed a universal voltage amplifier. Theoretically, this universal amplifier structure is extremely stable and exhibits high gain and bandwidth simultaneously; experimentation has shown this to be true.

A current follower is the antithesis of a voltage-follower. The ideal current follower has zero input impedance, infinite output impedance and unity current gain. The circuit is effectively a current-buffer enabling the maximum available current to be transferred from a signal source and fed into a nonzero-impedance load. This application together with others has been discussed by Nordholt[1] and Lidgey[2].

In this article a simple current-follower circuit is developed using a conventional op-amp and current-mirror circuits. The current-follower produced is then employed in a universal amplifier as described in the second reference. This amplifier uses only voltage and current-follower circuits together with resistors to define the closed-loop gain. The performance of such an amplifier is extremely good. The bandwidth is wide and it is not inversely related to the closed-loop gain, and no stability problems exist as there is no direct feedback from output to input.

Improved current-follower circuit

In order to appreciate the final design, it is worthwhile considering the simple current-follower circuit, Fig. 1. One end of the load is held close to zero volts by feedback action of the op-amp, however the load is essentially floating as neither side may be connected directly to ground. Despite this drawback, the circuit does have some interesting features. Input impedance is extemely low as nearly all the input current is drawn through the load by the action of negative feedback. Input current only differs from the load current by the current flowing into the op-amp which is extremely small due to the high open-loop voltage gain and input impedance of the op-amp.

Most applications require a circuit able to feed a grounded load and so a modified version of Fig. 1 is needed, Fig. 2. The feedback path from the inverting input to the op-amp output is now a short circuit which further reduces the input impedance compared with the circuit of Fig. 1.

As before, input current is drawn around the feedback path by the op-amp. Positive input current flows in a path around the feedback loop into the op-amp output and through to the supply lead of the op-amp to the negative power supply. Widlar's current-mirror current-sink[3] is used to sense this supply lead current via the diode connected transistor Tr_2 and then reflect this current in Tr_1 to the load. Similarly negative input current results in an equal positive supply current which is reflected into the load by a p-n-p current-mirror current source comprising transistors $Tr_{1,3}$.

The circuit is essentially that of an op-amp configured as a trans-resistance stage, the output of which is taken through the power supply leads. As the op-amp is directly coupled, the output effectively phase splits and the two complementary current mirror source and sink circuits recombine the split phases into a ground connected load.

Accuracy of the current following action is limited by the current mirror performance. As discussed by Lidgey[4] the ratio of image to reflected current, K, in the simple Widlar type of current mirror is given by

$$K = \beta/(\beta+2) \qquad (1)$$

Clearly an accuracy of 2% will result if the current gain, of the mirror transistors is 100. This is not regarded as acceptable and the improved current-mirror developed and analysed by Wil-

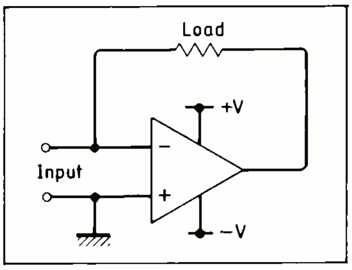


Fig. 1. **Simple current follower circuit. Although one end of the load is held close to zero volts by feedback action, the load is essentially floating and may not be grounded.**

Christofer Toumazou completed an OND in Technology in 1980 from North Gloucestershire College of Technology. He then joined Oxford Polytechnic obtaining a first class honours BSc in Engineering in 1983. Currently he is studying for an M.Phil/Ph.D on op-amp circuit design, supervised by the co-author of this article. His research programme also includes part-time lecturing at the Polytechnic.

John Lidgey is Principal Lecturer in electronics at Oxford Polytechnic. His teaching and research are both in the area of analogue circuit design and applications. In addition he is actively engaged in industrial electronics consultancy.

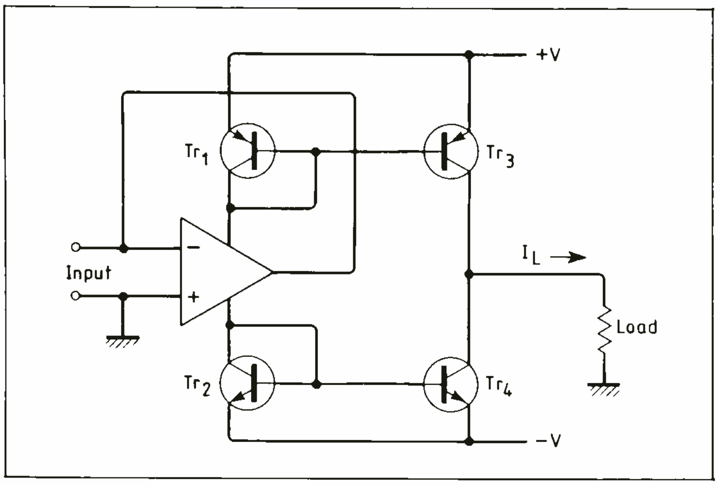


Fig.2. **Most applications require a current follower load to be grounded. Modifying Fig.1 as shown allows this.**

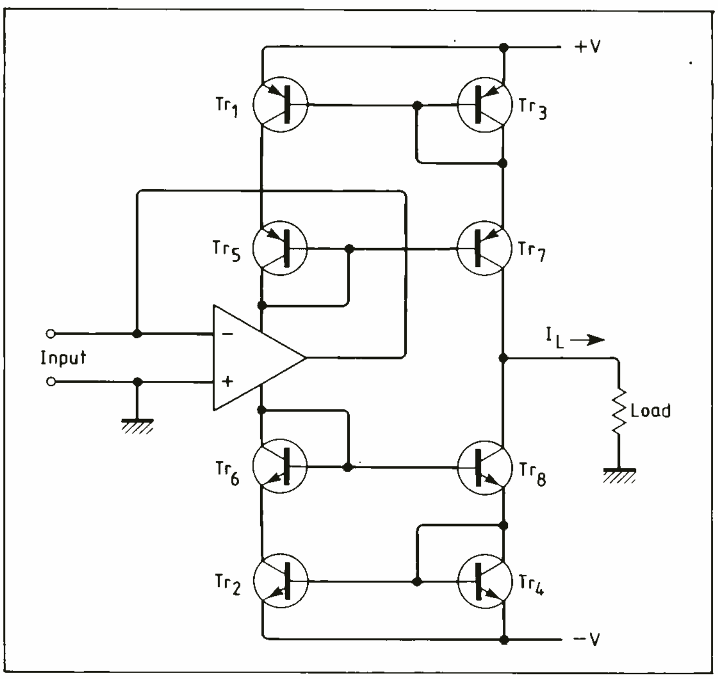


Fig.3. **Final current follower design with improved current-mirror circuits.**

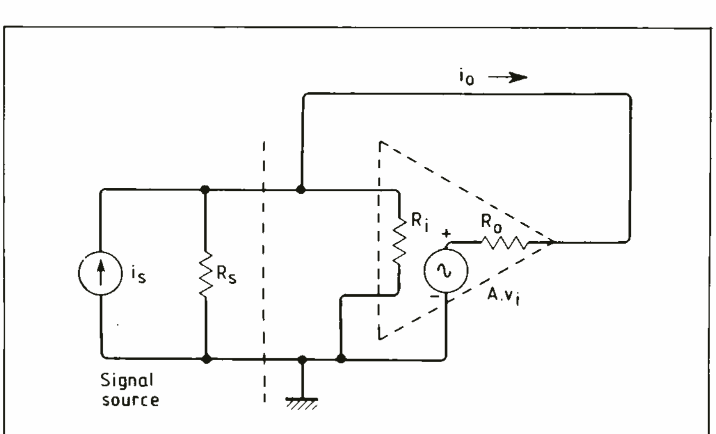


Fig.4. **Incremental model of the current follwer input stage. Open-loop input and output impedances, R_i and R_o, are typically 1M and 100Ω respectively.**

son[5] is used to replace the two Widlar type current mirrors. Figure 3 shows the final current follower circuit design using these improved current mirror circuits.

Follower analysis

The incremental model of the op-amp is shown in Fig.4. Resistance R_i, typically 1MΩ or so, is the open-loop input impedance and R_o, typically 100Ω or so, is the open-loop output impedance. The dependent voltage generator, $A.v_i$ represents the high open-loop differential voltage gain of the op-amp, where A is of the form

$$A = A_o/(1+jf/f_p) \quad (2)$$

Factor A_o is typically 10^5 or so and is the d.c. open-loop voltage gain of the op-amp. Frequency f_p, the upper −3dB cut-off frequency, is typically 10Hz or so. This upper cut-off is introduced by the manufacturer through an internal on-chip frequency compensation network to ensure that the op-amp will not oscillate when used with any value of resistive negative feedback.

Analysis of the circuit yields the current transfer ratio i_o/i_s of the form

$$i_o/i_s = 1/[1+R_o/(R_s(A+1))+R_o/(R_i(A+1))] \quad (3)$$

Practically, as $R_o << R_i$, then (3) reduces to

$$i_o/i_s \approx (A+1)/(A+1+R_o/R_s) \quad (4)$$

Clearly from (4) the current transfer ratio is close to unity for high values of A. Solving for the small-signal input impedance Z_{in} gives the following equation

$$Z_{in} = v_{in}/i_{in} = R_o/[(A+1)(1+R_o/(R_i(A+1)))] \quad (5)$$

Again, since $R_o << R_i$, (5) reduces to

$$Z_{in} \approx R_o/(A+1) \quad (6)$$

It is interesting to note that load resistance R_L is effectively isolated from the op-amp output and as a result the effect of changing the load has negligible influence on the closed-loop performance of the op-amp. Furthermore compared with Lidgey's follower circuit which gave an input impedance of

$$Z_{in} = (R_o+R_L)/(A+1) \quad (7)$$

the follower described here has a lower and therefore more ideal value of input impedance.

Consider now the frequency response of the follower. Substituting for A into (4) using (2) and so obtaining the frequency response of the current transfer ratio, then

$$i_o/i_s \approx [1+jf/(f_p(A_o+1))]/[1+K_2+j(f.K_1)/(f_p(A_o+1))] \quad (8)$$

where K_1 is $(R_s+R_o)/R_s$ and K_2 is $R_o/(R_s(A_o+1))$.

Substituting the symbol GB for the gain-bandwidth product of the op-amp, which is equal to $f_p(A_o+1)$, and negleting K_2 as generally $A_o >> R_o/R_s$, then (8) reduces to,

$$i_o/i_s \approx (1+jf/GB)/(1+jf/(GB/K_1)) \quad (9)$$

To a first order approximation one may assume that the frequency response of the current-mirror section of the circuit is much higher than the remainder and so the frequency response of the follower, dominated by the op-amp section, is given by

$$i_L/i_s \approx (i_L/i_o).(i_o/i_s) = -K(1+jf/GB)/(1+jf/(GB/K_1)) \quad (10)$$

where K is the mirror performance ratio of reflected to image current.

Equation (10) demonstrates that the bandwidth of the follower is essentially independent of the load impedance used.

General purpose voltage amplifier

Any of the four basic amplifier configurations may be constructed using up to two voltage followers and up to two current followers as described by Lidgey. The circuit of Fig.5 is a voltage amplifier built using two voltage followers cascaded with a central current follower. Resistors R_1 and R_2 define the voltage gain, A_v,

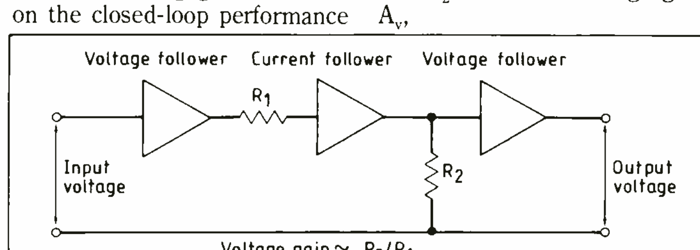
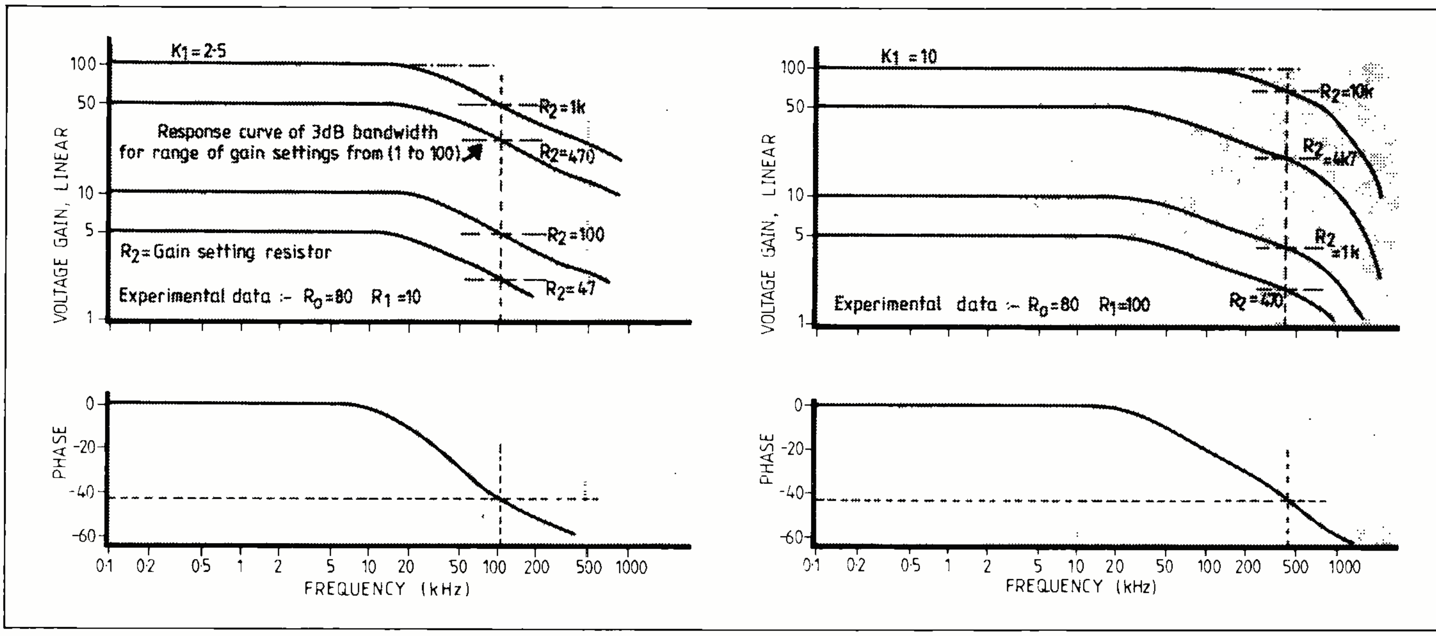


Fig.5. **Universal voltage amplifier using 741 op-amps and current mirrors constructed from bipolar transistor arrays.**



$A_v \approx R_2/R_1$ (11)

assuming that each of the three followers has precise unity gain.

A prototype circuit of Fig.5 was built using 741 op-amps and current mirrors constructed from two bipolar transistor arrays, these being a 2N3046 and a CA3096. It is essential to use single-chip well matched transistors for current mirror circuits[1]. Frequency response of the prototype is shown in Figs. 6a,b for two different values of K_1, the voltage gain being set by R_2.

One can see from the experimental results that the bandwidth does not alter when R_2 is changed to give different values of voltage gain. It is interesting to note that the conflict between gain and bandwidth generally encountered with more conventional designs using internally compensated op-amps, does not occur with this structure of amplifier.

Bandwidth of the voltage followers is approximately 1MHz and the frequency response of the circuit is limited mainly by the current follower. Increasing R_1 results in a reduction of K_1 and hence an increased frequency response of the current follower circuit, as indicated by equation (9). Although bandwidth will tend to increase by increasing R_1, to maintain a fixed voltage gain R_2 must be increased in proportion. However there is a limitation on the size of R_2 and hence the voltage gain possible due to the finite output impedance of the current follower; measured at 10kHz to be 3MΩ.

References
1. Nordholt, E.H., Extending Op-amp capabilities by using current-source power supply, *IEEE Trans. Circuit and Systems*, Vol. CAS-29, No.6, June 1982, pp.411-414.
2. Lidgey, F.J., Current Followers, Electronics and *Wireless World*, February 1984, pp.40-43.
3. Widlar, R.J., Some circuit design techniques for linear integrated circuits, *IEEE Trans. Circuit Theory*, Vol.CT-12, December 1965, pp.586-590.
4. Lidgey, F.J., Looking into Current Mirrors, *Wireless World*, October 1979, pp.57-58.
5. Wilson B., Current Mirrors, Amplifiers and Dumpers, *Wireless World*, Vol. 78, No. 1551, December 1981, pp.47-50.

Fig.6. **Frequency response of the voltage amplifier for K_1=2.5 (a) and K_1=10 (b).**

BOOKS

Ascent to Orbit, a scientific autobiography by Arthur C. Clarke: John Wiley and Sons, 226 A4 pages, hard covers. Sumptuous coffee-table book celebrating the technical writings of one of *Wireless World's* tutelary heroes. Includes numerous facsimiles of papers published both here and elsewhere, on astronautics, astronomy, tv waveforms, pentominos, flight, rocketry, the space elevator and of course communications satellites.

8086/88 Assembly Language Programming by Leo J. Scanlon: Prentice-Hall International, 214 pages, soft covers, £15.45, ISBN 0 89303 424 X. A good introduction for the newcomer. It assumes no prior knowledge of machine code, or even of binary and hexadecimal numbers. Later chapters deal with high-precision mathematics, methods of handling lists and tables and the use of the 8087 number-cruncher.

Bar Code Technology and Applications: Optosonic Press (P.O. Box 883, Ansonia Station, New York, NY10023, U.S.A.), reference PTP-055-X, $110.00 plus $10 carriage on orders from outside the U.S. Loose-leaf compendium of 140 U.S. bar-code patents covering the years 1975-1982. Other volumes deal with liquid crystal compounds and devices, surface acoustic wave devices, magnetic bubble domain devices, personal and industrial robots and fibre optics.

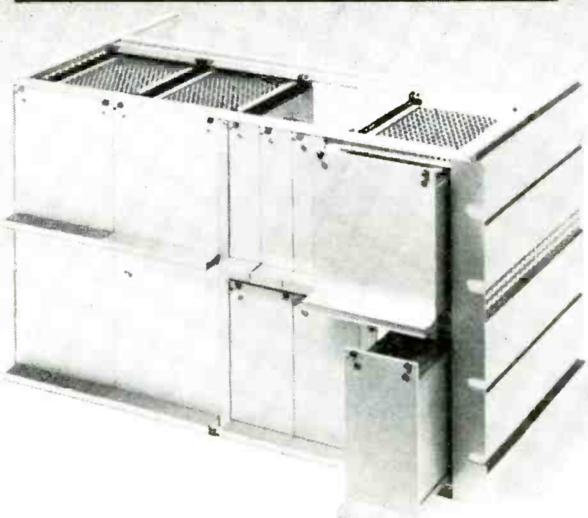
Basic and Forth in Parallel by S.J. Wainwright: Bernard Babani (Publishing), ref. BP138, 95 pages, soft covers, £1.95, ISBN 0 85934 113 5. Making the transition painlessly. Includes a Forth stack simulator written in ZX Basic for Spectrum users.

Beyond Broadcasting: Into the Cable Age by Timothy Hollins: BFI Publishing (British Film Institute), 385 pages, soft covers, £5.95, ISBN 0 85170 148 5. A detailed study of cable experience in the U.S. and Canada and a discussion of the prospects for Britain. Plans for cable systems, their likely effects on the cinema and broadcasting and so on. The author believes cable will one day be as central and valuable to our society as the telephone and broadcasting; though his post-script on some of the recent reverses for cable must have shaken his faith a little.

The BBC Micro Machine Code Portfolio by Bruce Smith: Granada Publishing, 212 pages, soft covers, £7.95, ISBN 0 246 12643 4. A collection of 75 assembly-language routines from the technical editor of *Acorn User:* among them are screen-dumps, timers, programs for handling and sorting lists, arithmetic routines, programming utilities and more. Some of the longer listings are also given in bar-code format for the MEP's bar-code reader. All are available on disc and cassette.

The BBC Micro Rom Book by Bruce Smith: Collins, 280 pages, soft covers, £9.95, ISBN 0 00 383075 6. How sideways roms work and how to write one, with programming examples drawn from Beebugsoft's Toolkit rom. Includes circuit details and software for a simple eprom programmer. Major listings are repeated in bar-code form in a 72-page appendix. Text is not always easy to follow, but at present this is the only book of its kind — or as the author puts it, twice, it's rather unique.

XIX^IN ROGER CARD FRAMES SET THE STANDARD



- Manufactured from anodised aluminium their robust design and accurate construction ensuring easy to use, trouble free operation.
- Conforms to DIN 41494 part 1, DIN 41612, DIN 41617. Connectors and Backplanes can be fitted in the same frame.
- Developed for single or double Eurocards in 3U and 6U heights.
- Delivery ex-stock in kit component form or fully assembled.
- Complete with identification and tapped strips for easy positioning.

Please send me details of how Sarel's XIX^IN 19" card frames set the standard. EWW/4/85

Name

Company

Position

Address

Telephone

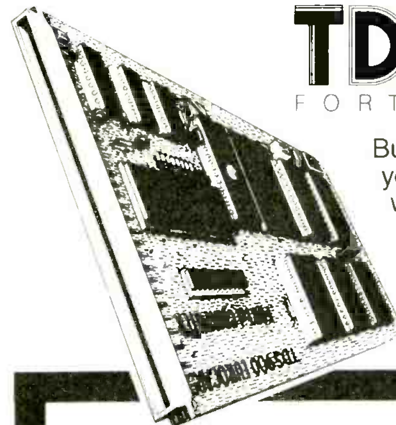
Sarel Limited
Cosgrove Way, Luton, Beds.
Telephone: Luton 20121

The infinite choice!

CIRCLE 6 FOR FURTHER DETAILS.

TDS900

FORTH COMPUTER



Build the TDS 900 into your products, program it with a VDU and your forecasts become fact.

NOW FROM £99

- ☆ Single board computer. 12k RAM and 8k ROM (expandable).
- ☆ All C-MOS for lower power. FORTH language. Compiled and fast. On-board screen-editor, compiler and debug facilities.
- ☆ Easy connection with serial and parallel channels, A/D, D/A converters, triacs, printers, keyboards and displays.

Triangle Digital Services Limited
100a Wood St., Walthamstow, London E17 England
Telephone 01-520 0442 Telex 262284 (Ref 775)

Agents in USA, France, Switzerland, Netherlands, S.Africa, Australia

CIRCLE 25 FOR FURTHER DETAILS.

Andelos 68000 SYSTEM

Powerful 68000 runs at 10MHz without wait states. Up to 32KB EPROM and 4 or 16KB fast static RAM. 24 line programmable parallel I/O port. RS232 programmable serial port. Comprehensive monitor in 2764 Eproms. Optional plug-in Eprom programmer card. Cross Assemblers for Z80 based microcomputers. Code can be developed, downline loaded to 68000, debugged, and then written into Eprom.

* 10MHz 68000 CPU Board.................from **£295+VAT**
* EPROM PROGRAMMER card....................**£95+VAT**
* CROSS ASSEMBLER for Z80 hosts... from **£55+VAT**

Andelos Systems Telephone: (0635) 201150
Solina, Bucklebury Alley, Cold Ash, Newbury, Berkshire RG16 9NN

CIRCLE 66 FOR FURTHER DETAILS.

ELECTRONICS & Wireless World

Any Production Queries Please phone Brian Bannister on 01-661 8648 or Jackie Perry on 01-661 8649

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System
BBC Computer & Econet Referral Centre
BBC Computers:

Model B: **£300 (a)** B+DFS: **£346 (a)**
Model B+Econet: **£335 (a)** B+Econet+DFS **£399 (a)**
ACORN 10 Mbyte Hard Disc £1300 (a)
ACORN 2nd Processors: 6502: **£175 (a)** Z80: **£352 (a)**
TORCH UNICORN: Z80 Card: **£275 (a)** Z80 Disc Pack: **£650 (a)**
UNICOMM Communications Package: £159 (b)
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: RX80FT **£225 (a); FX80 £315 (a)** FX100 **£435 (a);** RX100 **£345 (a)** RX80T **£215 (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)**

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)
EPSON Ribbons: MX/RX/FX80 **£5.00;** MX/RX/FX100 **£10** (d).
JUKI: Serial Interface **£65** (c); Tractor Attach, **£99** (a); Sheet Feeder **£199** (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 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**

TELEMOD 2:
Complies with CCITT V23 1200/75 Duplex and 1200/1200 half Duplex standards that allow communications with VIEWDATA services like PRESTEL, MICRONET etc. as well as user to user communications. Mains powered. **£62 (b)**

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. **£52 (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**

ATTENTION

All prices in this double page advertisment are subject to change without notice.
ALL PRICES EXCLUDE VAT
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 8KX8 bytes, can be used as stand alone unit for editing and duplicating EPROMS, as a slave programmer or as an eprom emulator £695(a)

DISC DRIVES

These drives, fitted with high quality JAPANESE mechanisms are supplied in attractive steel cases painted in BBC colour. The drives are fully Shuggart A4000 compatible. All dual drives are supplied with integral power supply whilst singles are supplied with or without power supply. All drives come complete with data & power cables, manual and BBC formatting disc.

1×100K 40T SS: TS55A **£100 (b)**; CS55A with psu **£125 (b)**
1×200K 40/80T SS: CS55E with psu **£150 (b)**
1×200K 40T DS **£115 (a)**
1×400K 40/80T DS: TS55F **£125 (a)**; CS55F with psu **£169 (b)**
2×100K 40T SS: TD55A with psu **£250 (a)**
2×400K 40/80T DS: TD55M with psu **£310 (a)**
2×400K 40/80T DS: TD55MP in flat pack with built-in plinth **£325 (a)**
CS100 TEC with psu **£125 (a)**; CS55F with psu **£169 (a)**

Authorised Distributor
Data Recording Products
3M

3M FLOPPY DISCS

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

40 Track SS DD	**£15 (c)**	40 Track DS DD	**£18 (c)**
80 Track SS DD	**£22 (c)**	80 Track DS DD	**£24 (c)**

DRIVE ACCESSORIES

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

Single Disc Cable **£6** (d)	Dual Disc Cable **£8.50** (d)
10 Disc Library Case **£1.80** (d)	30 Disc Storage Box **£6** (c)
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 **£210 (a);**
1451 Med Res **£240 (a)**; 1441 Hi Res **£399 (a);**
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 **£235 (a)**; Vision III Super Hi Res **£340 (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 **£179 (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. **£245** (a).
Cable set £30.

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

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

D CONNECTORS

No of Ways

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

TEXTOOL ZIF

SOCKETS 24-pin £5.75
28 pin £8.00 40-pin £9.75

EDGE CONNECTORS

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

EURO CONNECTORS

DIN 41612

2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B	275p	
IDC Skt A + C	350p	

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

AMPHENOL CONNECTORS

36 way plug Centronics (solder **500p** (IDC) **475p**
36 way skt Centronics (solder) **550p** (IDC) **500p**
24 way plug IEEE (solder) **475p** (IDC) **475p**
24 way skt IEEE (solder) **500p** (IDC) **500p**
PCB Mtg Skt Ang Pin
24 way **700p** 36 way **750p**

GENDER CHANGERS
25 way D type

Male to Male £10
Male to Female £10
Female to Female £10

RS 232 JUMPERS

(25 way D)

24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female Female	£10.00
24" Male Male	£9.50
24" Male Female	£9.50

DIL SWITCHES

4-way	90p	6-way	105p
8-way	120p	10-way	150p

TELEPHONE CONNECTORS

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

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	
16-way	60p	40-way	
20-way	85p	50-way	
26-way	120p	64-way	

DIL HEADERS

	Solder	ID
14 pin	40p	10
16 pin	50p	11
18 pin	60p	–
20 pin	75p	–
24 pin	100p	15
28 pin	200p	–
40 pin	200p	22

MISC CONNS

21 pin Scart Connector 2
8 pin Video Connector 2

74 SERIES

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

74LS SERIES

74LS00 0.24
74LS01 0.24
74LS02 0.24
74LS03 0.24
74LS04 0.24
74LS05 0.24
74LS08 0.24
74LS09 0.24
74LS10 0.24
74LS11 0.24
74LS12 0.24
74LS13 0.34
74LS14 0.50
74LS15 0.24
74LS20 0.24
74LS21 0.24
74LS22 0.24
74LS24 0.50
74LS26 0.24
74LS27 0.24
74LS28 0.24
74LS30 0.24
74LS32 0.24
74LS33 0.24
74LS37 0.24
74LS38 0.24
74LS40 0.24
74LS42 0.50
74LS43 1.50
74LS47 0.80
74LS48 0.90
74LS51 0.24
74LS54 0.24
74LS55 0.24
74LS73A 0.30
74LS74A 0.35
74LS75 0.45
74LS76A 0.36
74LS78 0.42
74LS83A 0.70
74LS85 0.75
74LS86 0.35
74LS90 0.48
74LS91 0.90
74LS92 0.35
74LS93 0.54
74LS95B 0.75
74LS96 0.90
74LS107 0.40
74LS109 0.40
74LS112 0.45
74LS113 0.45
74LS114 0.45
74LS122 0.70
74LS123 0.80
74LS124 1.40
74LS125 0.50
74LS126 0.50
74LS132 0.65
74LS133 0.50
74LS136 0.45
74LS138 0.55
74LS139 0.55
74LS145 0.95
74LS147 1.75
74LS148 1.40
74LS151 0.65
74LS152 2.00
74LS153 0.65
74LS154 1.60
74LS155 0.65
74LS156 0.65
74LS157 0.50
74LS158 0.65
74LS160A 0.75
74LS161A 0.75
74LS162A 0.75
74LS163A 0.75
74LS164 0.75
74LS165A 1.10
74LS166A 1.50
74LS168 1.30
74LS169 1.00
74LS170 1.40
74LS173A 1.00
74LS174 0.75
74LS175 0.75
74LS181 2.00
74LS183 1.90
74LS190 0.75
74LS191 0.75
74LS192 0.80
74LS193 0.80
74LS194A 0.75
74LS195A 0.75
74LS196 0.80
74LS197 0.80
74LS221 1.00
74LS240 0.80
74LS241 0.80
74LS242 0.90
74LS243 0.90
74LS244 0.80
74LS245 1.00
74LS247 1.10
74LS248 1.10
74LS249 1.10
74LS251 0.75
74LS253 0.75
74LS256 0.90
74LS2457A 0.70
74LS258A 0.70
74LS259 1.20
74LS260 0.75
74LS261 1.20
74LS266 0.60
74LS273 1.25
74LS279 0.70
74LS280 1.90
74LS283 0.80
74LS290 0.80
74LS292 9.00
74LS293 0.80
74LS295 1.40
74LS297 9.00
74LS298 1.00
74LS299 2.20
74LS321 3.70
74LS322A 3.90
74LS323 3.00
74LS324 3.20
74LS348 2.00
74LS352 1.20
74LS353 1.20
74LS356 2.10
74LS363 1.80
74LS364 1.80
74LS365 0.50
74LS366 0.50
74LS367 0.52
74LS368 0.50
74LS373 0.90
74LS374 0.90
74LS375 0.75
74LS377 1.40
74LS378 0.95
74LS379 1.40
74LS381 4.50
74LS390 0.60
74LS393 0.95
74LS395A 0.60
74LS399 1.00
74LS445 1.80
74LS465 1.20
74LS467 1.20
74LS490 1.50
74LS540 1.00
74LS541 1.00
74LS608 7.00
74LS610 19.00
74LS612 19.00
74LS624 3.50
74LS626 2.25
74LS628 2.25
74LS629 1.40
74LS640 3.00
74LS640-1 3.00
74LS641 2.00
74LS642 2.50
74LS642-1 3.00
74LS643 2.50
74LS643-1 3.00
74LS644 3.50
74LS645 2.00
74LS45-1 4.00
74LS668 0.90
74LS669 0.90
74LS670 1.80
74LS682 3.20
74LS684 6.50
74LS687 5.50
74LS688 5.50
74LS783 21.00

74S SERIES

74S00 0.50
74S02 0.50
74S04 0.50
74S05 0.50
74S08 0.50
74S10 0.50
74S11 0.75
74S20 0.50
74S22 1.00
74S30 0.50
74S32 0.60
74S37 0.60
74S38 0.75
74S40 0.50
74S51 0.45
74S64 0.45
74S74 0.75
74S85 4.50
74S86 1.00
74S112 1.50
74S113 1.20
74S114 1.20
74S124 5.50
74S132 1.00
74S133 0.60
74S138 1.80
74S139 1.80
74S140 1.00
74S151 1.50
74S153 1.50
74S157 2.10
74S158 2.00
74S163 4.00
74S169 7.00
74S174 3.00
74S175 3.20
74S188 1.80
74S189 2.25
74S194 3.00
74S195 3.00
74S196 3.50
74S200 4.50
74S201 3.20
74S225 5.20
74S240 4.00
74S241 4.00
74S244 5.00
74S251 2.50
74S257 2.50
74S258 2.50
74S260 1.00
74S261 3.00
74S262 11.00
74S283 2.70
74S287 2.25
74S288 2.00
74S289 2.25
74S299 5.50
74S373 4.00
74S374 4.00
74S387 2.25
74S472 4.75
74S473 4.75
74S474 4.00
74S475 4.50
74S570 6.50
74S571 3.00
74S573 5.00

74C SERIES

74C00 0.70
74C04 0.50/ 4069
74C08 0.70
74C10 0.70
74C14 0.50/ 40106 4584
74C20 0.70
74C32 1.00
74C42 1.50
74C48 1.50
74C73 1.00
74C74 1.20
74C76 1.00
74C83 2.00
74C85 2.25
74C86 0.50/40/70 4507
74C90 1.90
74C93 1.50
74C95 1.60
74C107 1.00
74C150 5.00
74C151 2.00
74C157 2.50
74C160 1.80
74C161 1.80
74C162 1.80
74C163 1.80
74C173 1.00/ 4076
74C174 1.50
74C175 1.50
74C192 1.50
74C193 1.50
74C194 1.50
74C195 1.50
74C221 2.50
74C244 2.00
74C245 2.25
74C373 2.25
74C374 2.25
74C902 1.20
74C911 9.00
74C912 4.50
74C922 6.00
74C923 6.50
74C925 6.50
74C926 7.50

74ALS SERIES

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

4000 SERIES

4000 0.20
4001 0.24
4002 0.25
4006 0.70
4007 0.25
4008 0.60
4009 0.45
4010 0.50
4011 0.24
4012 0.25
4013 0.36
4014 0.60
4015 0.60
4016 0.36
4017 0.50
4018 0.60
4019 0.80
4020 0.60
4021 0.80
4022 0.70
4023 0.30
4024 0.48
4025 0.24
4026 0.90
4027 0.40
4028 0.60
4029 0.75
4030 0.40
4031 1.25
4032 1.00
4033 1.25
4034 2.50
4035 0.70
4036 2.50
4037 1.10
4038 1.00
4039 2.50
4040 0.60
4041 0.55
4042 0.60
4043 0.60
4044 0.60
4045 1.00
4046 0.60
4047 0.60
4048 0.55
4049 0.30
4050 0.35
4051 0.60
4052 0.60
4053 0.60
4054 0.80
4055 0.80
4056 0.80
4059 4.00
4060 0.70
4063 0.85
4066 0.40
4067 2.30
4068 0.25
4069 0.24
4070 0.24
4071 0.24
4072 0.24
4073 0.24
4075 0.24
4076 0.65
4077 0.25
4078 0.25
4081 0.25
4082 0.25
4085 0.60
4086 0.75
4089 1.20
4093 0.35
4094 0.90
4095 0.90
4096 0.90
4097 2.70
4098 0.75
4099 0.90
4501 0.36
4502 0.55
4503 0.36
4504 0.95
4505 3.60
4506 0.90
4507 0.35
4508 1.20
4510 0.55
4511 0.55
4512 0.55
4513 1.50
4514 1.10
4515 1.10
4516 0.55
4517 2.20
4518 0.48
4519 0.32
4520 0.60
4521 1.15
4522 0.80
4526 0.70
4527 0.80
4528 0.65
4529 1.00
4531 0.75
4532 0.65
4534 3.80
4536 2.50
4538 0.75
4539 0.75
4541 0.90
4543 0.70
4551 1.00
4553 2.40
4555 0.36
4556 0.50
4557 2.40
4560 1.40
4561 1.00
4566 1.40
4568 2.40
4569 1.70
4572 0.45
4583 0.90
4584 0.48
4585 0.60
4724 1.50
14411 7.50
14412 7.50
14416 2.60
14419 4.20
14490 4.00
14495 6.50
14500 2.00
14599 2.00
22100 3.50
22101 7.00
22102 7.00
40014 0.48
40085 1.20
40097 0.36
40098 0.40
40100 1.50
40101 1.25
40102 1.30
40103 2.00
40104 1.20
40105 1.50
40106 0.48
40107 0.55
40108 3.20
40109 0.80
40110 2.25
40114 2.25
40117 2.80
40163 1.00
40173 1.00
40174 1.00
40175 1.00
40192 1.00
40193 1.00
40194 1.00
40244 1.50
40245 1.80
40257 1.80
40373 1.80
40374 1.80
80C95 0.75
80C97 0.75
80C98 0.75

DISPLAYS

DL704RED 1.40
DL707RED 1.40
FND357 1.00
FND500/
TIL730 1.00
FND507/
TIL729 1.00
MAN74/
DL704 1.00
MAN71/
DL707 1.00
MAN3640 1.75
MAN4640 2.00
MAN6610 2.00
NSB5881 5.70
TIL311 6.50
TIL729 1.00
TIL730 1.00
MAN8910 2.50
MAN8940 2.50

DISPLAY DRIVERS

9368 4.50
9370 4.50
LM3914 3.50
LM3915 3.50
LM3916 3.50
UDN6118 3.20
UDN6184 3.20
ULN2003 0.90
ULN2004 0.90
ULN2068 2.90
ULN2802 1.90
ULN2803 1.80
ULN2804 1.90
75491 0.70
75492 0.70

OTHERS

2N5777 0.50
BPX25 1.80
BPW21 2.80
OCP71 1.80
ORP12 1.20
ORP60 1.20
ORP61 1.20
SFH205 1.00
TIL32 0.55
TIL78 0.55
TIL31B 1.20
TIL81 1.20
TIL100 0.75

LINEAR ICs

AD7581 15.00
ADC0808 11.90
AM7910DC 25.00
AN103 2.00
AY-1-5050 1.00
AY-3-1270 7.50
AY-3-1350 3.50
AY-3-8910 4.00
AY-3-8912 5.00
CA3019A 1.00
CA3028A 1.10
CA3046 0.70
CA3059 3.25
CA3060 3.50
CA3080E 0.70
CA3086 0.60
CA3089E 2.10
CA3090AQ 3.75
CA3130E 0.90
CA3130T 1.00
CA3140E 0.45
CA3140T 1.00
CA3146 2.25
CA3160E 0.90
CA3161E 1.60
CA3162E 4.40
CA3189E 2.70
CA3240E 1.50
CA3280G 2.70
CAD7002 12.10
DAC1408-8 2.25
DAC0800 2.25
DAC0808 2.25
DG308 3.00
HA1366 1.90
ICL7106 6.75
ICL7611 0.95
ICL76500 4.00
ICL7660 2.50
ICL8038 3.00
ICM7216B 22.00
ICM7217 7.50
ICM7555 0.90
ICM7556 1.40
LC7120 3.00
LC7130 3.00
LC7131 3.50
LC7137 3.50
LF347 1.50
LF351 0.50
LF353 0.90
LF355 0.90
LF356N 1.10
LF357 1.00
LF13331 3.50
LM10CLH 4.50
LM301A 0.30
LM307 0.45
LM308CNI 0.75
LM310 2.25
LM311 0.60
LM318 1.50
LM319 1.80
LM324 0.45
LM334Z 1.15
LM335Z 1.30
LM336 1.60
LM339 0.40
LM348 0.80
LM358P 0.50
LM377 2.10
LM380N-8 1.50
LM380N 1.00
LM381AN 1.70
LM382 2.00
LM383 3.25
LM384 2.20
LM386N-1 1.00
LM387 2.70
LM389 1.80
LM391 1.80
LM392N 1.10
LM393 0.85
LM394CH 3.75
LM709 0.35
LM710 0.48
LM711 1.00
LM723 0.60
LM7245CN 3.00
LM733 0.65
LM741 0.16
LM747 0.70
LM748 0.30
LM1011 4.80
LM1014 1.50
LM1801 3.00
LM1830 2.50
LM1871 3.00
LM1872 3.00
LM1886 6.00
LM1889 4.50
LM2917 3.00
LM3302 0.75
LM3900 0.60
LM3909 1.00
LM3911 1.80
LM3914 3.50
LM3915 3.40
LM3916 3.40
LM13600 1.50
M51513L 2.30
M51516L 4.50
MB3712 2.00
MB3730 4.00
MC1310P 1.50
MC1413 0.75
MC1445 2.50
MC1458 0.45
MC1495L 2.50
MC1496 0.70
MC3340P 2.00
MC3401 0.60
MC3403 0.65
MF10CN 3.40
MK50240 9.00
MK50398 7.90
ML920 5.00
ML922 4.00
MM6221A 3.00
NE529 2.00
NE531 1.20
NE544 1.90
NE555 0.22
NE556 0.60
NE564 4.00
NE565 1.20
NE566 1.50
NE567 1.25
NE570 4.00
NE571 3.00
NE592 0.90
NE5532P 1.50
NE5533P 1.60
NE5534P 1.60
NE5534AP 1.50
OP-07EP 5.00
PLL02A 5.00
RC4136 0.55
RC4151 2.00
RC4195 1.50
RC4558 0.55
S566B 2.20
S50240 9.00
SAA1900 16.00
SAD1024A 11.50
SFF96364 8.00
SL490 3.00
SN76013N 3.00
SN76023N 3.00
SN76033N 3.00
SN76115N 2.15
SN76477 6.00
SN76489 4.00
SN76495 4.00
SN76660 1.20
SPO256AL2 7.00
SP8515 7.50
TA7120 1.20
TA7130 1.40
TA7204 1.50
TA7205 0.90
TA7222 1.50
TA7310 1.50
TBA641BX1 4.00
TBA231 1.20
TBA800 0.80
TBA810 0.90
TBA820 0.80
TBA820M 0.75
TBA920 2.00
TBA950 2.25
TC9109 5.00
TCA210 3.50
TCA220 3.50
TCA270 3.50
TCA940 1.75
TDA1004A 5.00
TDA1010 2.25
TDA1022 4.50
TDA1024 1.10
TDA1170S 3.00
TDA2002 3.25
TDA2003 1.90
TDA2004 2.40
TDA2006 3.20
TDA2020 3.20
TDA2030 1.80
TDA2541 4.00
TDA2591 4.00
TDA2593 5.00
TDA2653 7.00
TDA3560 9.90
TDA3810 7.50
TDA7000 3.50
TEA1002 7.00
TL061CP 0.40
TL062 0.60
TL064 0.90
TL071 0.40
TL072 0.70
TL074 1.10
TL081 0.35
TL082 0.55
TL083 0.75
TL084 1.00
TL090 2.00
TL430C 1.20
UAA1003-3 9.35
UA759 3.20
UA2240 1.20
UAA170 1.70
UCN4801A 5.50
ULN2001A 0.75
ULN2002A 0.75
ULN2003A 0.75
ULN2004A 0.75
ULN2068 2.90
ULN2802 1.90
ULN2803 1.80
ULN2804 1.90
URC575 2.75
UPC592H 2.00
UPC1156H 3.00
UPC1185H 5.00
XR210 4.00
XR2206 3.50
XR2207 3.75
XR2211 5.75
XR2216 6.75
XR2240 1.20
ZN404 1.00
ZN414 0.80
ZN419P 1.75
ZN423E 1.30
ZN424E 1.30
ZN425E8 3.00
ZN426E8 3.00
ZN427E8 6.00
ZN428E8 4.50
ZN429E8 2.25
ZN447E 9.00
ZN450E 7.50
ZN459CP 3.00
ZN1034E 2.00
ZN1040 6.60
ZNA134J 23.00
ZNA234E 9.50
8703CJ 12.00

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TO220

	+VE		-VE	
5V	7805	0.45	7905	0.50
6V	7806	0.50	7906	0.50
8V	7808	0.50	7908	0.50
12V	7812	0.45	7912	0.50
15V	7815	0.50	7915	0.50
18V	7818	0.50	7918	0.50
24V	7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V	78L05	0.30	5V	79L05	0.45
6V	78L06	0.30	12V	79L12	0.50
8V	78L08	0.30	15V	79L15	0.50
12V	78L12	0.30			
15V	78L15	0.30			

OTHER REGULATORS

Fixed Regulators
LM309K 1A 5V 1.40
LM323K 3A 5V 3.50
78H05KC 5A 5V 5.40
78H12 5A 12V 6.40
78P05 10A 5V 9.00

VARIABLE REGULATORS
LM305AH 2.50
LM317T TO-220 1.50
LM317K TO3 2.40
LM337T 2.25
LM350T 10A+VAR 4.00
LM396K 10A+VAR 15.00
LM723N 0.50
78H05KC 5A 5V 5.90
78HGKC 5A+VAR 7.00
78GUIC 1A+VAR 2.25
79HGKC 5A–VAR 7.75
79GUIC 1A–VAR 2.50

SWITCHING REGULATORS
ICL7660 2.50
SG3524 3.00
TL494 3.00
TL497 3.00
78S40 2.50
RC4195 1.50

OPTO-ISOLATORS

[illegible]

LEDS

0.125"
RED TIL209 0.12
GRN TIL211 0.16
YEL TIL 212 0.20
Rect LEDs (R/G/Y) 0.30
CXQ (Bi Colour) 1.00
10 LED BarGraph
Red 2.25
Grn 2.25

0.2"
TIL220 0.15
TIL222 0.18
TIL226 0.22

COUNTERS

74C925 6.50
74C926 6.50
74C928 6.50
72168 22.00
ZN1040 6.70

REAL TIME CLOCK

MC6818P 4.50
M5817AN 8.50
MSM5832RS 3.50

TELETEXT DECODER

SAA5020 6.00
SAA5030 7.00
SAA5041 16.00
SAA5050 9.00

COMPUTER COMPONENTS

CPU

1802CE 6.50
2650A 10.50
6502 3.50
65C02 12.00
6502A 5.50
6502B 8.00
6800 2.50
6802 3.00
6809 6.50
6809E 12.00
68B09 12.00
68B09E 16.00
68000-L8 36.00
8035 3.50
8039 4.20
8080A 4.20
8085A 3.00
8086 22.00
8088 17.50
8741 16.00
8748 18.00
TMS1601 12.00
TMS9980 12.00
TMS9995 12.00
WD55 14.50
Z80 2.80
Z80A 3.25
Z80B 7.00
8287 4.25
8288D 11.00
8755A 16.00
TMS9903 25.00
TMS9911 18.00
TMS9911 14.00
Z80P10 2.60
Z80APIO 2.75
Z80CTC 2.60
Z80ACTC 2.75
Z80DART 6.50
Z80ADART 7.00
Z80DMA 7.00
TMS4500 14.00
TMS9901 5.00
TMS9902 5.00
Z80ADMA 7.50
Z80ASIO 7.00

SUPPORT DEVICES

2651 12.00
3242 8.00
3245 4.50
6520 3.00
6522 3.50
6522A 5.50
6532 4.80
6551A 5.25
68B21 2.20
6829 12.50
6840 3.75
68B40 6.00
6850 1.60
68B50 2.50
6852 2.50
6854 6.50
68B54 8.00
6875 5.00
8154 8.50
8155 3.80
8156 3.80
8205 2.25
8212 2.20
8216 1.60
8224 P.A.O.
8226 4.25
8228 4.50
8243 2.60
8250 9.50
8251A 3.25
8253C-5 3.50
8255AC-5 3.80
8256 18.00
8256 24.00
8257C-5 4.00
8259C-5 4.00
8271 P.O.A.
8275 29.00
8279C-5 4.80
8284 4.60
8282 4.50
8283 4.00

MEMORIES

2016-150 4.00
2101 4.00
2102 2.50
2107B 5.00
2111A-35 4.00
2114-2L 3.50
2114-3L 2.50
2114-4L 2.00
2147 3.20
4027-3 3.00
4116-15 2.00
4116-20 1.50
4118-3 5.00
4164-15TI 5.00
4164-15 4.50
4164-20 4.20
4164-20 4.50
4416-15 5.00
4532-20 2.50
4816AP-3 2.00
5101/5501 3.70
5516 6.50
6116P-3 4.50
6116LP-3 5.00
6264P-15 22.00
6514-45 2.50
6810 1.60
74S189 2.25
74S201 3.50
74S289 2.25
93415 6.00
93L422 9.50
93425 6.00

PROMs

28L22 4.00
24S10 2.50
18S030 2.00
18SA030 2.00
74S188 1.80
74S287 2.25
74S288 1.80
74S387 2.25
74S473 4.75
74S474 5.50
74S570 3.20
74S571 3.50
74S571 3.00
74S573A 3.50
82S23 1.50
82S123 1.50
82S129 1.75

EPROMs

2516+5V 3.50
2516–35 5.50
2532 4.50
2532 5.50
2564 6.50
2708 3.00
2716+15V 3.50
2716–35 5.50
2732 4.50
2732A–2 7.00
2732A–30 6.00
2732A-35 5.00
2764–25 4.90
27256–30 54.00
27256–25 60.00
27C64–25 14.00
27128–25 12.00
27128–30 11.50
27256-25 36.00
TMS2716 5.00

CRT CONTROLLER

CRT5027 18.00
CRT5037 12.00
CRT6545 9.00
EF9364 8.00
EF9365 25.00
EF9366 25.00
EF9367 36.00
MC6845 6.50
MC6845SP 6.50
MC6847 6.50
SFF96364 8.00
TMS9918 15.00
TMS9927 7.50
TMS9928 10.00
TMS9929 10.00

INTERFACE ICs

ADC0808 12.00
AD561J 20.00
AM25S10 3.50
AM25LS2521 3.50
AM25LS2538 3.50
AM26LS31 1.20
AM26LS32 1.20
AM7910DC 25.00
DAC80-CB1-V 28.00
DM8131 6.00
DP8304 3.50
DS3691 5.00
DS8830 1.40
DS8831 1.50
DS8832 1.50
DS8833 2.25
DS8836 1.50
DS8838 2.25
LF13201 4.50
MC1488 0.60
MC1489 0.60
MC3446 2.50
MC3459 4.50
MCS3470 4.75
MC3480 8.50
MC3486 2.25
MC3487 2.25
MC4024 6.00
MC4044 6.00
MC14411 9.00
MC14412 7.50
75107 0.90
75108 0.90
75109 1.20
75110 0.90
75112 1.60
75113 1.20
75114 1.40
75115 1.40
75121 1.40
75122 1.40
75150P 1.20
75154 1.20
75159 2.20
75160 5.00
75161 3.50
75162 4.00
75172 3.00
75182 0.90
75188 0.60
75189 0.60
75365 1.50
75450 0.80
75451 0.50
75452 0.50
75453 0.70
75454 0.70
75480 1.50
75491 0.65
75492 0.65
8T26 1.20
8T28 1.20
8T95 1.20
8T96 1.20
8T97 1.20
8T98 1.20
81LS95 1.40
81LS96 1.40
81LS97 1.40
81LS98 1.40
88LS120 5.00
9602 3.00
9636A 1.60
9637AP 1.60
9638 1.60

DISC CONTROLLER ICs

6843 8.00
8271 P.O.A.
8272 18.00
FD1771 20.00
FD1791 20.00
FD1793 20.00
FD1795 28.00
FD1797 22.00
WD2793 36.00
WD2797 32.00
WD1691 15.00
WD2143 8.00

CHARACTER GENERATORS

RO32513UC 7.50
RO32513LC 7.00
DM86S64 12.00
MCM66760 7.50
SN74S262AN 10.00

KEYBOARD ENCODERS

AY52376 11.50
AY53600 7.50
74C922 6.50
74C923 6.50

BAUD RATE GENERATORS

MC14411 7.50
COM8116 6.50
4702B 7.50

UARTS

AY31015P 3.00
AY51013P 3.00
COM8017 3.00
IM6402 3.60
TR1602 3.00

MODULATORS

6MHZ 3.75
8MHZ 4.50

SOUND & VISION

12MHZ 12.00

CRYSTALS

32 768KHZ 1.00
1.00MHz 2.70
1.8432MHz 2.25
2.00MHz 2.25
2.45760MHz(L) 2.00
2.45760Mhz(S) 2.50
2.5MHz 2.50
2.662MHz 1.75
3.276MHz 1.50
3.5795MHz 1.00
4.00MHz 1.50
4.194MHz 2.00
4.43MHz 1.00
4.608MHz 2.50
4.9152MHz 2.50
5.00MHz 1.50
6.00MHz 1.40
6.144MHz 1.40
7.00MHz 1.50
7.16MHz 1.75
8.00MHz 1.50
8.867MHz 1.75
10.00MHz 1.75
10.50MHz 2.50
10.70MHz 1.50
11.00MHz 3.00
12.00MHz 1.50
14.00MHz 1.75
14.31MHz 1.60
14.756 2.50
15.00MHz 2.00
16.00MHz 2.00
17.734MHz 2.00
18.00MHz 1.70
18.432MHz 1.50
19.969MHz 1.50
20.000MHz 1.75
24.000MHz 1.50
48.000MHz 1.75
116MHz 2.50
PXO1000 12.00

LOW PROFILE SOCKETS BY TI

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TI

8 pin	30p	18 pin	50p	24 pin	75p
14 pin	42p	20 pin	66p	28 pin	100p
16 pin	45p	22 pin	75p	40 pin	130p

TURNED PIN LOW PROFILE SKTS.

8 pin	14 pin	16 pin	18 pin	20 pin	24 pin	28 pin	40 pin
25p	32p	36p	40p	45p	60p	75p	160p

TRANSISTORS

AD161 2 45p
BC107 8 18p
BC109C 20p
BC169C 18p
BC172 18p
BC177 8 30p
BC179 30p
BC182 3 15p
BC184 16p
BC187 30p
BC212 3 16p
BC214 18p
BC237 16p
BC327 16p
BC337 16p
BC338 16p
BC461 40p
BC477 8 36p
BC516 7 50p
BC547B 20p
BC548C 16p
BC549C 16p
BC557B 18p
BC559C 24p
BCY70 30p
BCY71 36p
BD131 75p
BD132 80p
BD135 6 40p
BD139 40p
BD140 40p
BD189 60p
BD232 60p
BD233 75p
BD235 85p
BD241 60p
BD242 60p
BD379 60p
BD380 60p
BD677 40p
BF244B 40p
BF256B 50p
BF257/8 40p
BF337 36p
BFR39 32p
BFR40 1 32p
BFR79 32p
BFR80 1 32p
BFR96 180p
BFX29 45p
BFX30 45p
BFX84/5 30p
BFX86 7 30p
BFX88 30p
BFX89 180p
BFY50 30p
BFY51 2 30p
BFY56 33p
BFY90 90p
BRY39 45p
BSX19/20 30p
BU104 225p
BU105 190p
BU108 250p
BU109 225p
BU126 150p
BU180A 120p
BU205 200p
BU208 200p
BU406 145p
BUX80 600p
BUY69C 350p
E310 50p
MJ413 250p
MJ802 400p
MJ2501 225p
MJ2955 90p
MJ3001 225p
MJ4502 400p
MJE340 60p
MJE2955 150p
MJE3055 120p
MPF102 40p
MPF103 4 40p
MPF105 40p
MPSA06 30p
MPSA12 50p
MPSA13 50p
MPSA20 50p
MPSA42 50p
MPSA43 50p
MPSA56 30p
MPSA70 50p
MPSA93 40p
MPSU06 63p
MPSU07 60p
MPSU45 90p
MPSU65 78p
TIP29A 35p
TIP29C 40p
TIP30A 35p
TIP30C 40p
TIP31A 40p
TIP31C 45p
TIP32A 45p
TIP32C 40p
TIP33A 70p
TIP33C 80p
TIP34A 90p
TIP34C 120p
TIP35A 120p
TIP35C 140p
TIP36A 140p
TIP36C 150p
TIP41A 50p
TIP41C 55p
TIP42A 60p
TIP42C 65p
TIP54 160p
TIP55 180p
TIP120 75p
TIP121 75p
TIP122 80p
TIP125 75p
TIP126 80p
TIP142 120p
TIP147 120p
TIP2955 90p
TIP3055 70p
TIS93 30p
VN10KM 50p
VN66AF 90p
VN88AF £1
ZTX108 16p
ZTX300 18p
ZTX452 45p
ZTX500 20p
ZTX502 20p
ZTX504 22p
ZTX552 55p
ZTX652 60p
ZTX752 70p
2N697 35p
2N698 45p
2N706A 36p
2N708 36p
2N918 45p
2N930 30p
2N1131 2 50p
2N1613 36p
2N1711 36p
2N2102 70p
2N2160 350p
2N2219A 30p
2N2222A 30p
2N2369A 30p
2N2484 30p
2N2646 50p
2N2904/5 30p
2N2906A 30p
2N2907A 30p
2N2926 12p
2N3053 36p
2N3054 60p
2N3055 55p
2N3442 140p
2N3553 240p
2N3584 250p
2N3643 4 48p
2N3702 3 16p
2N3704 5 16p
2N3706/7 16p
2N3708 16p
2N3773 200p
2N3819 40p
2N3823 30p
2N3866 90p
2N3902 700p
2N3904 18p
2N3906 18p
2N4036 65p
2N4037 65p
2N4123 4 27p
2N4125 6 27p
2N4401 3 25p
2N4427 90p
2N4871 50p
2N5087 27p
2N5089 27p
2N5172 27p
2N5191 90p
2N5245 40p
2N5401 60p
2N5459 30p
2N5460 60p
2N5485 36p
2N5875 250p
2N5883 375p
2N6027 30p
2N6052 300p
2N6059 325p
2N6107 65p
2N6247 190p
2N6254 130p
2N6290 65p
2SC1306 100p
2SC1307 150p
2SC1957 90p
2SC1969 150p
2SC2028 80p
2SC2029 200p
2SC2078 160p
2SC2335 200p
2SC2612 200p
3N128 200p
3N140 200p
3N141 200p
3N201 200p
3N204 200p
40290 250p
40361/2 75p
40595 120p
40673 90p
40871 2 100p

1A 400V 25p
1A 600V 30p
2A 50V 30p
2A 100V 35p
2A 400V 45p
3A 200V 60p
3A 600V 72p
4A 100V 95p
4A 400V 100p
6A 50V 80p
6A 100V 100p
6A 400V 120p
10A 400V 200p
25A 400V 400p

TRIACS PLASTIC

3A400V 60p
6A400V 70p
6A500V 88p
8A400V 75p
8A500V 95p
12A400V 85p
12A500V 105p
16A400V 220p
16A500V 130p
T2800D 130p
TIC206D 60p
TIC226D 75p
TIC246D 110p

DIODES

BY127 12p
BYX36300 20p
OA47 10p
OA90/91 9p
OA95 9p
OA200 9p
OA202 10p
1N914 4p
1N916 7p
1N4148 4p
1N4001/2 5p
1N4003/4 6p
1N4005 6p
1N4006/7 7p
1N5401/2 12p
1N5403/4 14p
1N5404/5 14p
1N5404/7 19p
IS920 9p

BRIDGE RECTIFIERS

1A 50V 19p
1A 100V 20p

THYRISTORS

3A400V 45p
8A600V 180p
12A400V 160p
16A100V 180p
16A400V 180p
C106D 45p
MCR101 36p
2N3525 130p
2N4444 180p
2N5060 30p
2N5061 32p
2N5064 35p

ZENERS

2.7V 33V
400mW 9p
1W 15p

TECHNOMATIC LTD

MAIL ORDERS TO: 17 BURNLEY ROAD, LONDON NW10 1ED
SHOPS AT: 17 BURNLEY ROAD, LONDON NW10
(Tel: 01 208 1177 4 lines) Telex: 922800
305 EDGWARE ROAD, LONDON W2

PLEASE ADD 50p p&p & 15% VAT
(Export: no VAT, p&p at Cost)
Orders from Government Depts. & Colleges etc. welcome.
Detailed Price List on request.
Stock items are normally by return of post.
Minimum Telephone Order £5

CIRCLE 73 FOR FURTHER DETAILS.

by J.J. Wiseman

How long is a piece of wire?

Efficiency and radiation resistance of electrically short transmitting antennas — especially of the inverted-L kind — leave a lot to be desired.

The International Maritime Organisation is presently rearranging maritime radio with greater emphasis on use of 2182kHz for distress and intership working. There will be a temptation to use only whips. At 2182kHz they will have a small radiation resistance, under 1 ohm, and the current problem of 500kHz short-wire aerials having this kind of radiation resistance, swamped by leakage losses in rough weather, will then be repeated. Nothing will have been gained by the change over...

Bibliography

Cutting, F. Simple method of calculating radiation resistance. *Proc. IRE* April 1922.

Everitt, W.L. Communication Engineering. McGraw, 1937

Jasik, H. (ed) Antenna Engineering Handbook. McGraw Hill, 1961

Laport, E.A. Radio Antenna Engineering, McGraw Hill, 1952

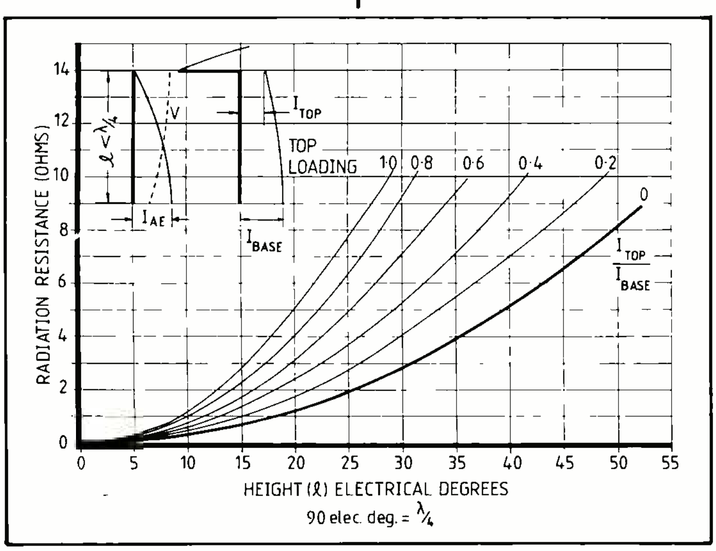
Lindenblad & Brown, Main considerations in Antenna Design *Proc.IRE* Jun 1926

Brown, W.W. Radio frequency tests on antenna insulators *Proc.IRE* Oct 1923

Wiseman, J.J. Anybody seen our ship? *Nautical Review* May 1979

Ballantyne, S. Radiation resistance of simple vertical antenna at wavelengths below the fundamental *Proc.IRE* Dec 1924.

Smith & Johnson, Performance of short antennas. *Proc.IRE* Oct 1947.



Technical literature on transmitting antennas, as found in libraries and bookstores or published in popular journals, seems to fall into two categories. The subject is either presented as page after page of complex mathematics, written by PhDs to be read by other PhDs, or it comes as a cookbook or catechism, which everybody 'knows' by heart but few really understand in-depth but find convenient for every day practical use. Thus "A quarter-wave vertical has 50ohm feed, a half-wave dipole 74 ohms, end-fed half-waves have 600ohm line" and there are similar psalms to be sung for Yagis, rhombics and other exotica. As all have a radiation resistance far greater than any likely losses, they all work without problems and with good and predictable efficiency. Amen and praise the mathematicians, who made it all possible and put it in a book of revelations. When multiband specials are described, their design often contains more 'art' than science, and performance is assessed subjectively. They are usually justified in terms of s.w.r., which doesn't necessarily say everything about efficiency as a radiator.

People to whom 'bigger' usually means 'better' have become accustomed to seeing very satisfactory mobile communications carried out with antennas less than a metre in length (at v.h.f/u.h.f.), and some have come to believe that 'short' is good enough at any frequency, and it is the layman — the coathanger bender — more often than not who puts up the money and 'does it himself'. In h.f. mobile applications, land vehicles, small boats (and even *large* boats), the whip or short wire antenna will be all that is possible, yet may be required to operate over a wide frequency spectrum. Accurate information on performance is hard to find. All that the ARRL Antenna Book has to say is that "Information about the radiation resistance of antennas of less than quarter wavelength is difficult to come by" and leaves it at that. This is the 'no mans land' of aerials.

Antennas of less than $\lambda/4$ are not supposed to exist, but at very low and low frequencies they cannot really be avoided; it is hardly possible to erect a $\lambda/4$ 1500-metre vertical for a 50kHz military transmitter. It is in this area that the performance of the electrically short antenna has been most thoroughly studied; the enormous cost in engineering structures involved has made it essential. Such antennas may have to operate with radiation resistance of only 0.05ohm. The subject had been well covered by the 1930s but was published not in books, rather in *Proceedings of I.R.E.*, and similar, and therefore inaccessible to the general reader. The experience is transferrable to other short antennas.

Radiation resistance is plotted against *actual* antenna height in the graph below in degrees ($\lambda/4$ = 90°). Various 'rules of thumb' exist for computing radiation resistance for short antennas. The 1930 Admiralty Handbook of Wireless Telegraphy, offers the rule $R_r = 160\pi^2 h^2/\lambda^2 = 1580h^2/\lambda^2$ and Martin and Carter of RCA Laboratories, N.Y., (1961) repeat the same equation. 'h' is the effective height of the antenna, equal to actual height (l) when base current is equal to top current. For any other current distribution, effective height is that of a rectangle having equal base and equal in area to that under the curve of current distribution. Laport gives $R_r = 10G_o^2$ where G_o is the electrical height of the antenna in radians and transforms this into $R_r = 0.1215A^2$ where A is the degree-ampere area of the plot of current distribution. In any event, the curve of R_r: l is a parabola, or a family of parabolas. For R_r = 1ohm, aerial height (without top loading) has to be about 18 electrical degrees, or with top loading, giving linear current distribution, 9 degrees. Compare this with R_r for a $\lambda/4$ grounded vertical: 36.57ohms according to Everitt, who provides the full mathematical derivation. This R_r will be "the same for an antenna 2.5 metres high at 30MHz, 250 metres high at 300kHz or 777 miles high at 60Hz". Similar considerations will apply for antennas of less height. How fortunate were the early aviators who could reel out their trailing aerial to any convenient $\lambda/4$!

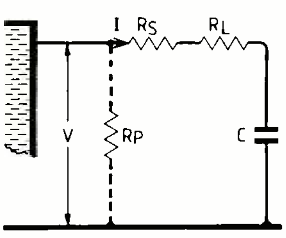
A '22-foot' whip is a popular antenna for small water craft. It can be required to operate in marine R/T bands, at, or close to 2, 4, 6, 8, 12, 16 and 22MHz.

The 22ft whip has a physical length of 6.7 metres, $\lambda/4$ at 11.19MHz (neglecting 'and effect'), near $^{\lambda}/_{4}$ at 12MHz, $3\lambda/8$ at 16 and $^{\lambda}/_{2}$ at 22MHz. But at 2MHz it is only 0.045λ, and at 6MHz only 0.13 of a wavelength. At these frequencies it is "electrically short." Table 1 reveals the shift in performance.

Losses will occur by inductive heating of material of the whip and any adjacent metal, and in the earth connection. Low-loss connection to the water may be difficult to achieve with a wood or glass fibre hull. Assuming lumped losses of 1, 3 and 5 ohms then

$$\text{efficiency} = \frac{R_r}{R_r + R_{loss}} \times 100\%.$$

Efficiency is given in Table 2 for a 22ft whip, Tables 3 & 4 give equivalent data for a 12 ft whip. When the whip is operating at less than $^{\lambda}/_{4}$ it is capacitive. Parallel leakage at the base insulator can be converted to series equivalent resistance



Rp Insulator leakage
Rs Series equivalent of Rp
RL Copper losses & radiation resistance (constant)

For equivalence, power absorbed in R_p must equal power absorbed in R_s:

$$\frac{V^2}{R_p} = I^2 R_s = R_s\left(\frac{V^2}{R_s^2 + X_c^2}\right)$$

$$\frac{1}{R_p} = \frac{R_s}{R_s^2 + 1/\omega^2C^2}$$

$$\therefore\ R_p = \frac{1}{R_s\omega^2C^2} + R_s.$$

As R_s is very small compared to R_p, last term can be neglected, giving

$$R_p \approx \frac{1}{R_s\omega^2C^2} \text{ and } R_s \approx \frac{1}{R_p\omega^2C^2}$$

series equivalent leakage being *inversely* proportional to f^2 & C^2. If C = 40pF, f = 2MHz, and R_p = 1MΩ, then R_s is about 4 ohms, about doubling or trebling the existing lumped losses. If this halves Q, then I_{ae} is also halved, and so is Z_r, resonant input impedance of parallel circuit formed by the whip and its associated tuning inductance. If the coupling can't cope, the reduced load offered to the p.a. valve or transistor reduces its efficiency as a generator, *further* reducing I_{ae}.

With a wire antenna, given the voltage distribution — highest at the far end, then leakage at the far end will have worse effect than the same leakage at the feed point ($z_r = E/CR_s$).

Merchant ship antennas

Forty metres of wire bent into an L, with a 15 metre vertical portion is not untypical. This length is better than $^{\lambda}/_{4}$ at 2MHz (vertical portion 36 degrees, $R_r > 16$ ohms and low L/C ratio), better than one wavelength at 8MHz or higher; radiation resistance is 30ohms or more in any h.f. band, and h.f. efficiency is high under any conditions. At 500kHz, the vertical portion has an actual height of 9 electrical degrees, the remaining 15 degrees (25 metres) being 'top loading'. According to the commercial designers, the top loading does not radiate; it is called the 'suppressed portion'. They concentrate attention on radiation from the vertical portion to achieve a desired field strength at a given distance, and include any radiation from the top and its associated radiation resistance in the 'losses'. A well designed *symmetrical* top with equal currents flowing in opposite directions might not radiate much at all (e.g. T-antenna), but an inverted-L is going to radiate two components, that from the vertical section being the most predictable and most useful.

The full 40 metres of wire (24°) in the inverted-L has a potential radiation resistance of about 1.9ohms at 500kHz, (not necessarily fully realised). As shown right, the current distribution in the vertical portion is, for practical purposes, a trapezium of the dimensions indicated

Area

$$= \frac{(0.2588+0.04067)}{2} \times 9 = 2.995$$

Effective height

$$= \frac{2.995}{0.4067} = 7.36°\ (12.27\text{m})$$

Radiation resistance

$$= 1580\left(\frac{h}{\lambda}\right)^2 = 0.66\text{ohms}$$

Table 1. Performance of 22ft whip aerial

Frequency (MHz)	2	4	6	8	12
Length (electrical deg.)	16	32	48	64	96
Radiation resistance (Ω)	0.78	3	7	12	37
Current to radiate 50W(A)	8.0	4.08	2.67	2.04	1.16
Power radiated by 1A current (W)	0.78	3	7	12	37

Table 2. Efficiency of 22ft whip aerial

Frequency (MHz)	2	4	6	8	12
1 Ω loss	44%	75%	87.5%	92%	97.4%
3 Ω loss	20.6%	50%	70%	80%	92.5%
5 Ω loss	13.5%	37.5%	58%	70%	88%

Table 3. Performance of 12ft whip aerial

Frequency (MHz)	2	4	6	8	12
Length (electrical deg.)	8.8	17.5	26.3	35	52.6
Radiation resistance (Ω)	0.25	1.0	2.0	3.7	8
Current to radiate 50W(A)	14	7.1	5	3.7	2.5
Power radiated by 1A current (W)	0.25	1.0	2.0	3.7	8.0

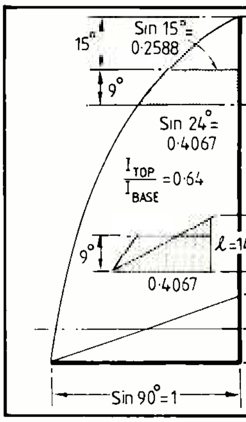
Table 4. Efficiency of a 12ft whip aerial

Frequency (MHz)	2	4	6	8	12
1 Ω loss	20%	50%	67%	85%	89%
3 Ω loss	7.7%	25%	40%	55.2%	72.7%
5 Ω loss	4.8%	16.7%	28.6%	42.5%	61.5%

Looking at it another way, the trapezium is equivalent in area to a triangle of equal base and height l, so that 0.4067×l/2 = 2.995, so that l = 14.73° (24.55 metres).

So the top loading effectively increases actual antenna height, *as far as the vertical portion is concerned,* from 9 to 14.73°. An antenna of this height without top loading also has $R_r \approx 0.66$ohms, as can be verified from the curves on page 24.

If a 400-watt transmitter puts 10 amps up such an aerial, the power radiated from the vertical portion, omnidirectional and vertically polarized, will be 66 watts, and best efficiency about 16.5%. *If leakage causes I_{ac} to fall to 1 amp, then power radiated drops to 0.66 watts,* and transmitter-antenna efficiency down to a miserable 0.165%! Current in the capacitive branch of a parallel resonant circuit (the aerial) = I_c = QI. Introduction of 20Ω series resistance, equivalent to 20kΩ parallel leakage, would decimate the Q, and the loss of resonant impedance Z_r that goes with it adds loss of p.a. generator efficiency, or simply trips the overload. At the same time it is difficult to ignore the fact that at 10 amp base current, current at the 'bend' is 10 × 0.2588/0.4067 = 6.4A. The top is 15° in length, R_r at least 0.68ohm, and power radiated from the top = $(6.4)^2 \times 0.68$ = 28W, most of it fired off in the direction of other planets, and



not to other ships. Total power radiated is 23.5%, 16.5 usefully. When radiation from the flat top exceeds that from the vertical portion, a limit is reached.

Perhaps an inverted-L is not a very good investment. The optimum top loading for this antenna would be about 81° non radiating, producing a rectangular pattern of current distribution in the 9° vertical and accepting more current at less potential. Area of current distribution is then 9, and a triangle on the same base has height 18°, R_r about 1ohm. Further increase in R_r would require an increase in vertical height beyond the present 9°.

Optimum top loading doubles the effective height and quadruples radiation resistance (R_r for a simple 9° aerial is 0.25Ω). Even then, to maintain a radiated 10 watts, 3.2A aerial current is required.

Auto repeat for Hall-effect keys

Surplus Hall-effect keyboards can be obtained cheaply, but they often lack a repeat key or auto-repeat function. Many Hall-effect keys produce a single pulse when pressed, as opposed to a continuous output, and so do not lend themselves to this function. This design provides delayed auto-repeat on such keyboards and requires only three connections to the existing circuit.

The key matrix of a Hall effect keyboard is powered by a d.c. souce, usually +5V or +12V. The pulse produced by pressing a key is translated into an Ascii value and a strobe pulse by the keyboard conroller. This additional circuit switches the power supply to the matrix so that while a key is pressed, a pulse is produced each time that the supply goes from low to high, resulting in multiple strobe pulses. Supply to the controller is continuous of course.

Auto repeat at 10Hz starts about 1s after pressing a key. Repeat frequency is determined by R_1/C_1 and delay period by the 4518 dividers; both are adjustable. The only connections between this and the existing circuit are the strobe pulse, power supply and key-matrix supply driver. Keys on which auto-repeat is not required may be connected to the continuous supply.

An extended strobe pulse is available. This is for use in terminals or computers using keyboard polling where the normal strobe pulse may be too short. All i.cs are cmos so adaptation for other supply voltages is easy. Note that the transistor is not intended to switch large capacitive loads, so make sure that there are no large decoupling capacitors in the key-matrix supply circuit.

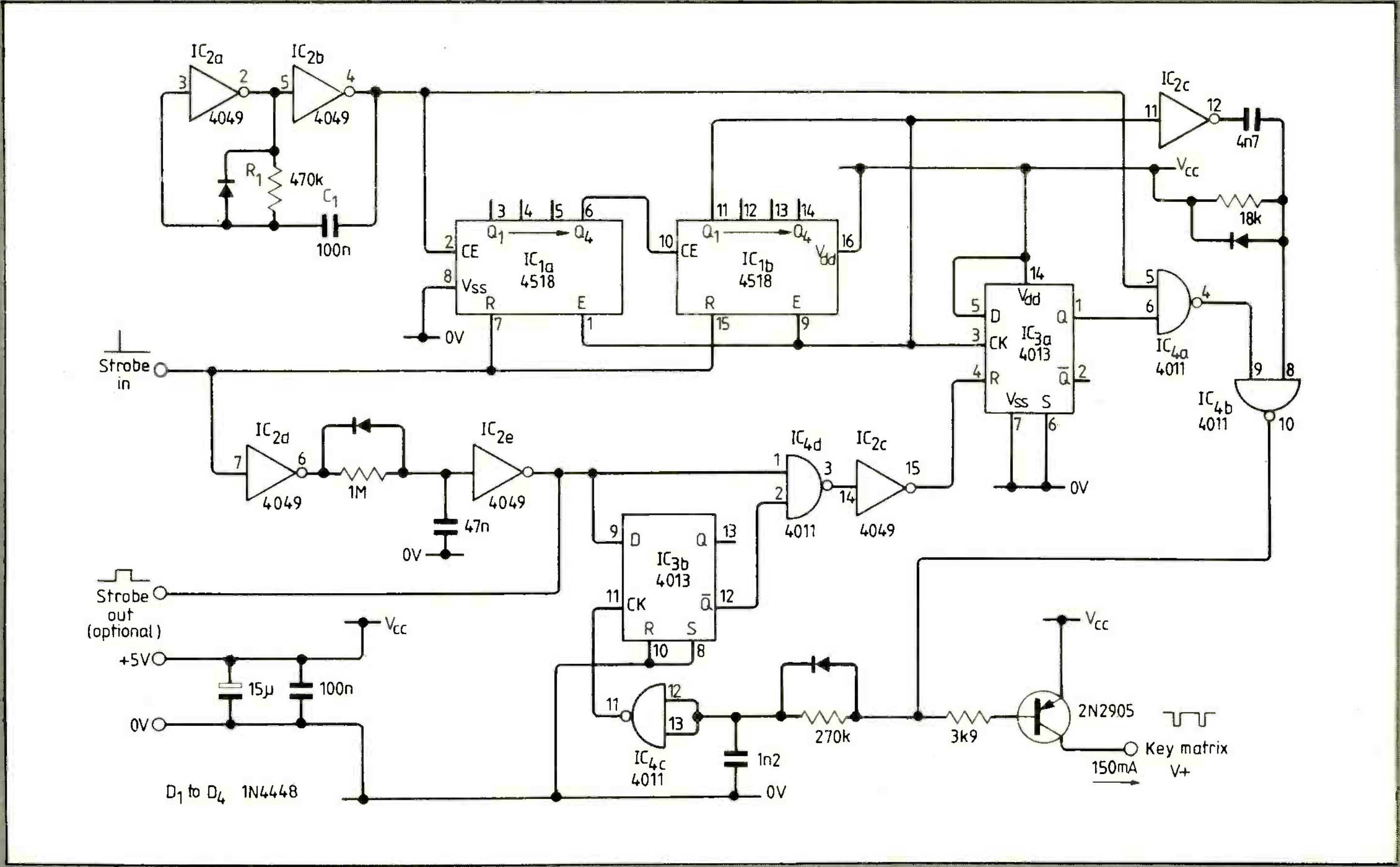
In steady state or after power up, IC_{3a} is reset and IC_{4a} pin six is low. Pins eight and nine of IC_{4b} are both high so the transistor is saturated and a continuous current flows through the key matrix.

Pressing a key produces a positive strobe pulse at the input and resets both counters, $IC_{1a,b}$. After this narrow pulse, both counters count up to 20, output Q_1 of IC_{1b} becomes high and the counter stops.

The counter output low-to-high transition generates a pulse to drive the transistor base and clock input of IC_{3b}. The transistor opens for a short time, producing one pulse in the matrix. If at this point the key is still pressed, a new strobe pulse occurs and restarts the counters; this pulse is stretched to around 10ms by the circuit around $IC_{2d,c}$. This strobe pulse is fed to the D input of a bistable device, IC_{3b}. Clock input of this device is triggered by the delayed matrix pulse through IC_{4c}, IC_{3b} is set and the reset condition of IC_{3a} is removed through IC_{4d} and IC_{2f}.

At the next counter time-out, IC_{3a} is set and asymmetrical clock pulses from $IC_{2a,b}$ are sent through $IC_{4a,b}$ to the transistor. The matrix is now switched at the clock rate until the key is released. After release, the strobe pulses disappear, IC_{3b} is reset and the circuit returns to its steady state.

Karel Pauwels
Melsele
Belgium



Asynchronous data separator for modems

An economical solution is shown for the asynchronous data separator requirement in modems having a three-to-two frequency ratio.

Timings shown relate to a standard recommended by the EEA* for data transmission over radio systems. At 1200 baud, a logical one is defined as one cycle of 1200Hz and a logical zero as one and a half cycles of 1800Hz, transmitted with phase continuity, Fig.1. The signalling rate may also be 600 baud, when a logical one is two cycles of 1200Hz and a logical zero three cycles of 1800Hz.

The system is a synchronous one in that the receiver must be brought into synchronism with the transmitter in order to retrieve the data with the least chance of errors. Since it is necessary to derive the bit rate from the data transitions themselves, a means of asynchronous data separation must be used first, Fig.2.

Received tones are limited to provide a square wave sequence with zero crossings corresponding to those of the input waveform. The sequence is then delayed by one and a half bit periods at 1200 baud and exclusive or'd with itself. This process is then repeated, but with a delay of one sixth of a bit period, to provide the retrieved data, as shown in the timing diagram. No modification is required for 600 baud operation. The bit pattern used in the example is 110011 at 1200 baud or 101 at 600 baud.

The practical example shown uses a 4731 quad 64-bit shift register as the delay element. Three of the registers are connected in tandem to provide the half bit-period delay.

Dividing a 3.6864MHz crystal oscillator by eight conveniently provides the 460.8kHz clock. Since the delay is achieved by a sampling method, a one-bit uncertainty on the 460.8kHz clock exists in the delay value. This takes the form of glitches varying in width between zero and two microseconds at the output. These are removed by RC filtering at the output gate.

L. Thomas
Comdial Communications
Cardiff
Wales

Fig.1. Data format

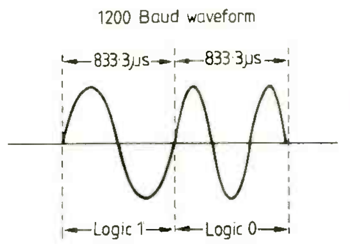


Fig.2. Separator

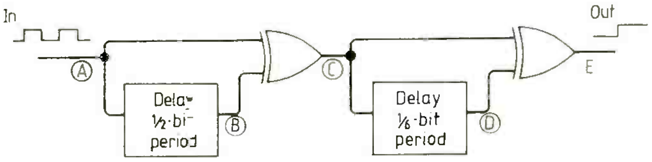


Fig.3. Timing diagram

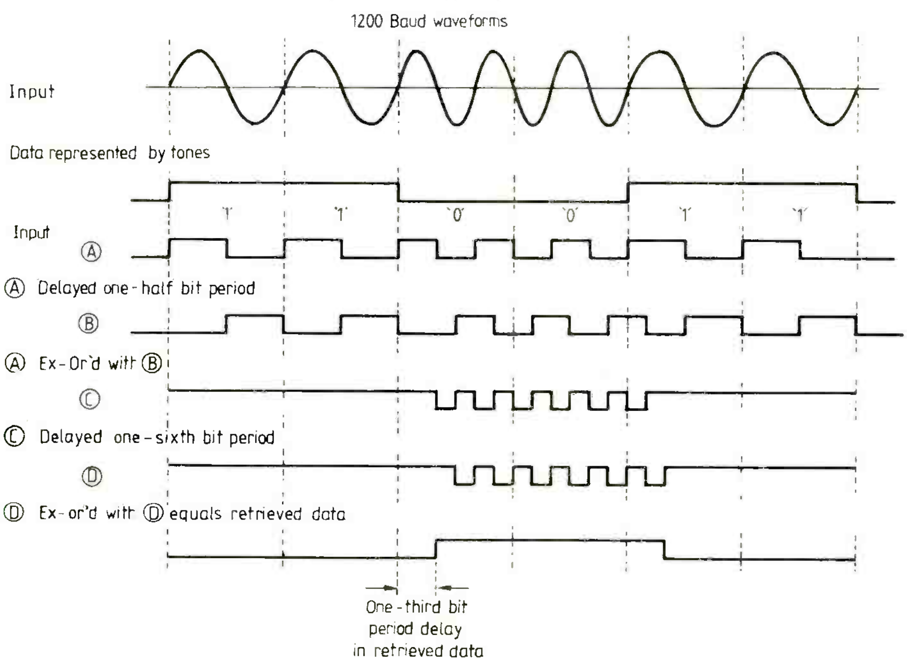
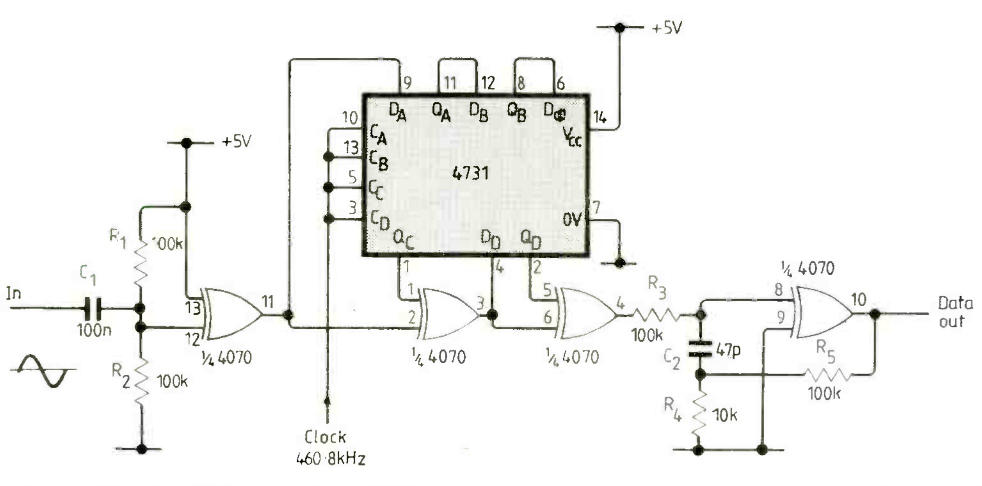
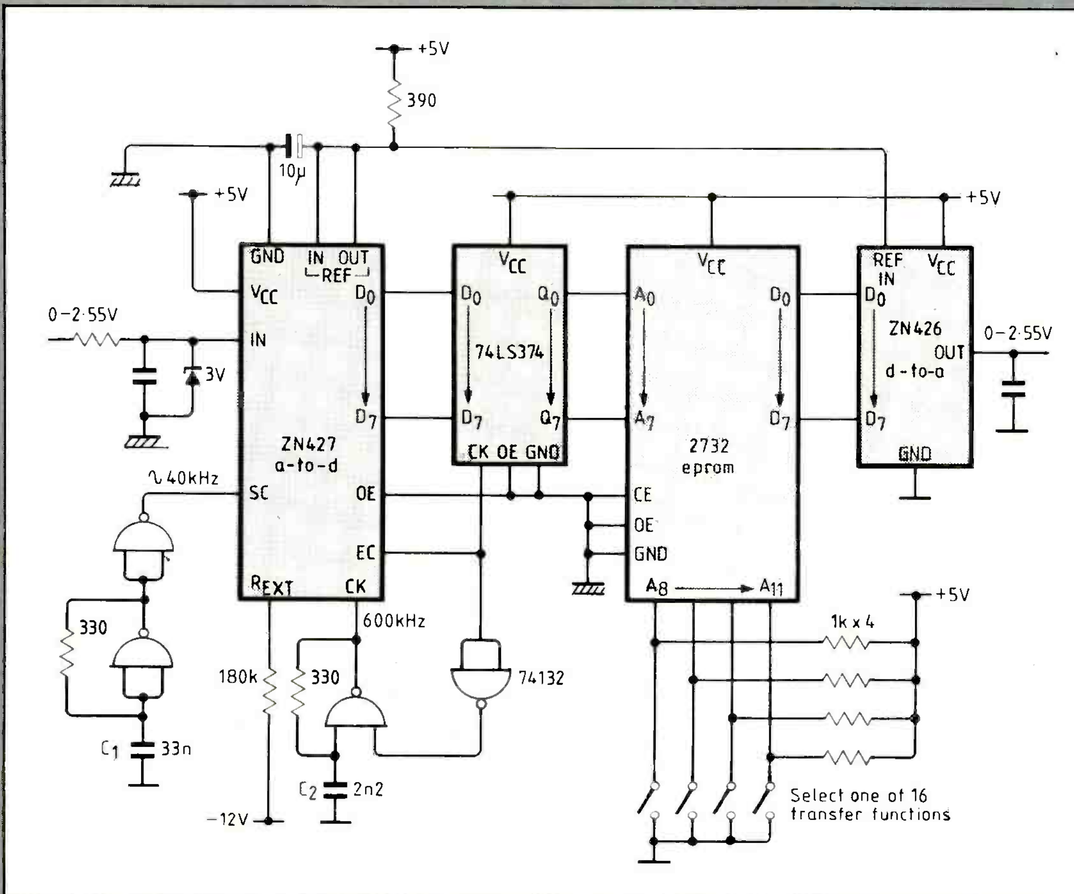


Fig.4. Practical implementation



*Electronic Engineering Association, Leicester House, 8 Leicester Street, London WC2H 7BN.



Digital distorter

While working on a digital sound processing system, I hit upon the idea of using an eprom to distort the waveform coming into the system. Distortion can vary from simple clipping, which simulates an overdrive pedal, to as complex a non-linear function as required.

In my system, two eproms provide 16-bit resolution and 16 transfer functions are stored including linear, which has no effect on the signal, and full-wave rectify which doubles the frequency of a sinewave input. This circuit is an 8-bit version for simplicity and cheapness. One of 16 functions is selected using four switches.

Capacitors C_1 and C_2 are chosen to give the required sample rate and conversion times respectively. Input and output low-pass filters are essential and it is also useful to be able to adjust input gain for the best s/n ratio.

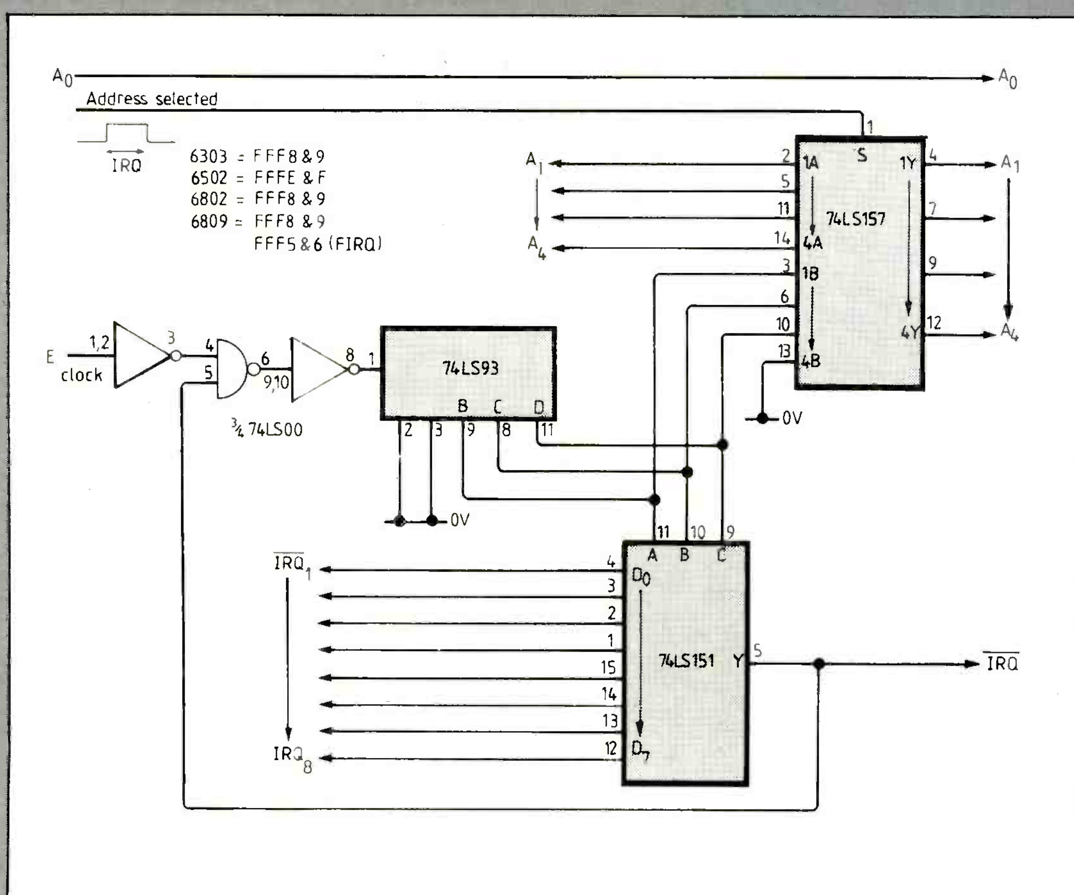
G. Hardy
Department of Physics
Nottingham University

Vectored interrupts on 68-series processors

There is only one IRQ interrupt-request address for all peripherals on 68xx-series microprocessors but eight or more are possible using continuous scanning under control of the processor E clock. When an interrupt signal is detected, it is latched and the counter holds a value corresponding to the interrupting peripheral. The counter content is used by the processor as part of the service address for its interrupt-service routine; note that address line A_4 is changed to zero. This gives a pair of bytes to each peripheral in the range FFE0 to $FFFF_{16}$.

The number of peripherals can be increased to 16 by an extra 74LS150 and gates to make A_5 zero when the IRQ service occurs. On the 6809, a dual system can be implemented for IRQ and FIRQ.

A.W. Roscoe
Enfield
Middlesex



What you make with our boards is up to you !

85000 Processor Board
Fully buffered 8085 processor
User defined memory size 2K to 96K bytes
RS232C serial interface with D connector
Field selectable addresses
Can be used as single board computer
64 way bus connectors between boards
Single Eurocard 220 x 100 mms

85001 Display Board
For use with EPSON alphanumeric LCD's
Sizes from 16 X 1 to 40 X 4 characters
Local memory for message storage
Bus also directly compatible with MCS 51
Spare 8-bit I/O port on board
Prototyping area drilled to accept
BICC-VERO Speedwire pins

85002 Communications Board
Programmable serial interface
On board baud rate generator
Five 8-bit programmable timer/counters
Two 8-bit programmable parallel I/O ports
8 level priority interrupt controller
Prototyping area drilled to accept
BICC-VERO Speedwire pins

Automation and Control Technology

Cofton Road, Marsh Barton, Exeter EX2 8QW Tel: 37190

CIRCLE 11 FOR FURTHER DETAILS.

ORIENTATION LTD
DESOLDERWICK A mm SERIES
SOLDER ABSORBING WICKS
FOR SOLDERED JOINT REPAIR
NO PLANT CAPITAL EXPENDITURE
☆ INSTANT CLEAN ACTION
☆ COLOURLESS FLUXING
NEW SIZE RANGE

EVALUATION PACK
2 Metres av. of each width 1mm, 2mm, 4mm. **£3** + LS.A.E. (TOTAL)

ORIENTATION LTD ☎ +44 (0)209 719700
P.O. BOX 17 CAMBORNE TR14 8XG ENGLAND

CIRCLE 29 FOR FURTHER DETAILS.

FIELD ELECTRIC LTD.

3 SHENLEY ROAD, BOREHAMWOOD, HERTS.
Telephone: 01-953 6009
OPEN SIX DAY'S A WEEK 9AM-5PM THURSDAY 9 AM-1 PM
CALLER'S WELCOME.

SPECIAL OFFER FARNELL FAN COOLED P.S.U.+−5/+−12 £28:00 c/p 3:50.

SHUGART 801 8" D.DRIVE'S COMPLETE WITH P.S.U. ETC: IN CASE £200:00+15% V.A.T. RING FOR C/P

PLESSEY 2/4 MEGABYTE (MAX) GENERAL PURPOSE RANDOM ACCESS MEMORY SYSTEM CAN BE USED FOR MAINFRAME/MINI MICROPROCESSOR'S P.O.A.

NEW & BOXED GOULD 6V.D.C. 40AMP SWITCH MODE P.S.U. £60:00 C/P 2:00

ALL PRICE'S INC VAT UNLESS STATED.

CIRCLE 57 FOR FURTHER DETAILS.

VISIT OR PHONE OPEN 6 DAYS A WEEK ALL STOCKS ON DISPLAY

HENRY'S AUDIO ELECTRONICS

Equipment • Communications • Computers • Components

INSTRUMENTS STOCKED

SCOPES (UK C/P £6.50)

*HAMEG	
HM203/5 Dual 20MHZ	£264.00
HM204 Dual 20MHZ	£365.00
HM605 Dual 60MHZ	£515.00
*CROTECH	
3030 15MHZ Portable	£179.00
3035 15MHZ Bench	£198.00
3132 Dual 20MHZ	£297.00
(*HAMEG/CROTECH INCLUDE COMPONENT TESTERS)	
HITACHI	
V212 Dual 20MHZ	£329.00
V222 Dual 20MHZ*	£395.00
V223 Dual 20MHZ*	£450.00
V423 Dual 40MHZ*	£650.00
V650 Dual 60MHZ*	£880.00
*with probes	

THANDAR

SC110A 10MHZ battery/mains	£175.00

SCOPE PROBES

X1-X10	£10.00

GENERATORS (UK C/P £1.00)

(F) Function (P) Pulse (A) Audio (R) RF

500 0.1HZ-500KHZ (F)	£110.00
TG101 0.02HZ-200KHZ (F)	£110.00
TG102 0.2HZ-2MHZ (F)	£160.00
TG501 0.005HZ-5MHZ (F)	£295.00
TG105 5HZ-5MHZ (P)	£105.00
TG502 As TG 501 + SWEEP (F)	£495.00
TG503 As TG501 + PULSE (F) (P)	£495.00
AG202A 20HZ-200KHZ (A)	£95.00
LAG27 10HZ-1MHZ (A)	£115.00
SG402 100HZ-30MHZ (R)	£77.00
LSG17 100HZ-150MHZ (R)	£115.00
AG203 10HZ-1MHZ (A)	£149.00

POWER SUPPLIES (UK C/P £2.00)

* Twin meter • Single meter (switched) + Digital

•241 0/30v 0/1AMP	£33.00
•242 0/30v 0/3AMP	£52.13
•154 5/15v 0/4AMP	£43.43
*230N 0/30v 0/1AMP	£97.74
*330N 0/30v 0/3AMP	£178.90
*2302 0/30v 0/2AMP + 5v 1A AND PULSE GEN	£230.00
+ PL310 0/30v 1AMP	£118.00
+ PL320 0/30v 2AMP	£145.00
+ PL154 0/15v 4AMP	£149.00

COUNTERS (UK C/P £1.00)

+ LED • LCD All 8 digit

+ 100 100MHZ	£99.00
+ 600 600MHZ	£126.00
+ 1000 1000MHZ	£175.00
+ TF600 600MHZ	£132.50
•TF200 200MHZ	£175.00

TV EQUIPMENT (UK C/P £1.00)

TC40 VHF/UHF F/S meter	£208.00
LTC910A Tube Tester	£199.00
MC321 PAL(UK) Colour gen.	£252.00
MC328 PAL(B) Colour gen.	£252.00
LHM80A 40Kv meter	£30.00

STOCK SELECTION

(•UK C/P 65p *UK C/P £1.50)

•LP1 10MHZ Logic Probe	£24.95
•DP70 30MHZ Logic Probe	£25.00
•DP71 50MHZ Logic Probe	£52.00
•ST300 AC Clamp Meter	£30.87
•YF501 Elec. Ins. Tester	£59.13
•DM6013 Digital Cap Meter	£60.43
•KDm6 200MHZ TR DIP Meter	£48.70
*LCR740 LCR Bridge	£230.00
*OM358 Scope Multiplexer	£169.00
•HZ65 Scope Comp. Tester	£24.00
•TC1 Transistor Tester	£24.30
*CM200 Bench Dig. Cap. Tester	£89.00

HAND DMM's 3½ digit (UK C/P 65p)

(R) Rotary (PB) Push-Button • With case

3500 10A AC/DC (R)	£36.75
3510 Plus Hfe & Buzzer (R)	£40.45
ME540 10A AC/DC Auto/Man (R)	£41.50
3100 Pentype	£39.75
•KD615 10A DC Hfe Tester (R)	£34.75
6010 10A AC/DC (PB)	£37.83
7030 10A AC/DC 0.1% (PB)	£46.91
•KD55C 10A AC/DC (R)	£38.70
•DM3350 10A AC/DC Auto (R)	£43.44
•KD528T Minature with Hfe test	£29.52

PLUS BENCH DMM's IN STOCK THURLBY • THANDAR • SOAR • METRIX • ANALOGUE MULTIMETERS • LARGE RANGE IN STOCK

SOFTWARE

(Please state format required and machine)

MDIS Intelligent Disassembler for all CP/m based	£50.00
IVC HI-RES Provides Pseudo high resolution graphics	£15.00
DISKPEN (VG3) Low cost word processor for multiboard based overlays for diskpen	£50.00
MAXIFILE	£20.00
SPOOLER	£15.00
HENRY'S CP/m UTILITIES 41 Programs	£15.00
ALL DISC Variable disc format for GEMINI/NASCOM CP/m's	£150.00
PREZTEL 2 Interface Galaxy or Nascom to Modem for use with BT Prestel service	£26.04

ASC11 KEYBOARDS

69S D5 Compact 64 key + 5 function keys. Hall effect keyboard with reprogrammable (2716) ASC11 output decoder EPROM. Steel key frame for good rigidity. Negative going strobe. Requires + 5 volt − 12 volt supplies. (UK C/P £1.00) **£21.70**

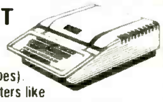
2070 COMPACT 58 KEY KEYBOARD

Contactless capacitive high reliability keys. Full 128 ASC11 codes. Steel key frame for positive rigidity. 1mS strobe, single + 5 volt supply. Repeat key, control and caps. lock. (UK C/P £1.00) **£28.26**

COMPUTER POWER SUPPLY

Switched mode. Stabilised. S/C protecting S/C protected, etc. 220/240V AC + 5V 3.3A + 12V 2.4A, 40% cycle − 5V 0.5A − 12V 0.5A. Suitable Apple replacement (UK C/P £1.50) **£50.00**

ITT 2020 CABINET



Professional computer case with keyboard cutout. 18 x 15.5 x 4.5 (front slopes) ideal for single board computers like the Nascom or Gemini Multi-board (3 cards, etc). Very heavy gauge (.25) plastic with metal base. Attractive silver grey finish. (UK C/P £1.78) **£19.95**

MODEM CARDS/COUPLER

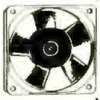
Brand new. Tested, answer and originate 300 BAUD uncased acoustic modem card by famous manufacturer. RS232 input/output, power supply + / − 12V at 180mA. Requires 2 magnetic ear-pieces, 2 switches, 2 LEDs and connectors to complete. Data supplied.

Card only	£26.04
Card and remainder of small components	£29.09

Telephone Direct Line coupler type LTU11 MKII. Suitable for direct coupling PRESTEL adaptors and the above acoustic modems. Integral Line select and autodial relays requiring TTL inputs data supply. £13.00

1200 BAUD receive 75 BAUD send direct coupled modem, or PRESTEL. Requires + 5V supply with TTL Inputs for data. Line select and autodial. LTU 11 direct coupler required. See above. Data supplied. PRESTEL modem card. £13.00

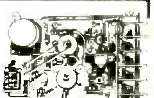
COMPUTER FANS



(UK C/P 60p each, £1.00 per pair)

4¾ 220/230V AC Brand new	£6.52
4¾ 220/240V AC Ex-units	£4.78
4¾ 110/115V AC Ex-units	£4.35

CASSETTE MECHANISMS



Fitted counter. Motor. Stereo record and erase heads. Autostop, solenoid. Brand new available 6V DC or 12V DC (state which) (UK C/P 65p) **£5.17**

ALSO miniature stereo cassette replay mechanism 12v. 105 x 100 x 40mm. (UK C/P 65p) **£4.78**

LARGE STOCKS OF COMPONENTS FOR UK AND EXPORT. ENQUIRIES INVITED

INSTRUMENTS CATALOGUE

(Large 25p sae) Free to Companies/Colleges, etc. (Upon written request).

SUPPLIERS OF ELECTRONICS FOR EVERY PURPOSE — Official Orders Welcome (subject to confirmation)

ORDER BY POST OR PHONE
Up to £1000 instant credit Available through Lombard Tricity Finance

301 Edgware Road, London W2
Test Equipment, Audio, Communications 01-724 3564
404 Edgware Road, London W2
Computers 01-402 6822
Equipment 01-724 0323
Components 01-723 1008

ASK HENRY'S FIRST

ALL PRICES EXCLUDE VAT

CALL IN AND SEE FOR YOURSELF

CIRCLE 52 FOR FURTHER DETAILS.

GPIB instruments

Some additions to our March list

Anorad produce a range of precision servo-controlled positioning tables. Their Intelligent Axis Control System is a rack-mounting unit capable of accepting up to six axis control cards. Inputs can be from optical or mechanical switches, or direct from laser interferometers. Automatic calibration is provided. Laser Lines Ltd, Beaumont Close, Banbury, Oxfordshire OX16 7TQ. EWW250

Aerotech's Unidex III positioning system is a fast programmable movement controller for use with d.c. servos or stepping motors. The rack-mounting control unit can store up to 99 randomly-accessible programs. Up to 32Kbytes of battery-backed storage can be provided. Laser Lines Ltd, Beaumont Close, Banbury, Oxfordshire OX16 7TQ. EWW251

Bentham: the model 266 a-to-d converter is a dual 12-bit integrating converter with programmable sensitivity. It can poll up to 16 inputs and can read any two of them simultaneously. The price is £750. There is a dual drive unit for stepping motors complete in a box with its own power supply at £605, for use with (among other things) a range of movable positioning stages giving up to 250mm of travel with a positioning accuracy as close as 0.5 microns. A programmable monochromator photometer system allows the user to analyse optical radiation in the ultra-violet, visible and infra-red regions. Applications include measurements of spectral loss in optical fibres and end-point detection in plasma etching. Two software packages are available for the HP-85 microcomputer. Bentham Instruments Ltd, 2 Boulton Road, Reading, Berkshire RG2 0NH. EWW252

Druck make a range of pressure-measuring equipment based on silicon strain-gauges. Instruments with GPIB interface include digital pressure indicators for up to 15 channels (from £920), available with a variety of integral or remote transducers for pressures great and small (from about £300 extra); and a pressure controller-indicator (from about £2500). Druck Ltd., Fir Tree Lane, Groby, Leicester LE6 0FH. EWW253

IMS offer a multi-channel measurement and control interface. The chassis unit holds up to four modules which can be chosen from a range embracing high-resolution a-to-d and d-to-a converters, thermocouple inputs and relay units. Optional extras include a penal-mounting dot-matrix printer and a 32K ram module. IMS Electronics, Unit R6, Riverside Industrial Estate, Bridge Road, Littlehampton, West Sussex BN17 5DF. EWW254

Kepco produce in the USA an extensive range of linear and switch-mode power supplies, including modules for o.e.m. use, hardware and accessories. The range includes models for bench or laboratory use and for automatic test systems and there are high-voltage and bi-polar versions. All programmable models are GPIB-compatible, and in some cases even such features as over-voltage protection can be programmed. Techmation Ltd., 58 Edgware Way, Edgware, Middlesex HA8 8JP. EWW255

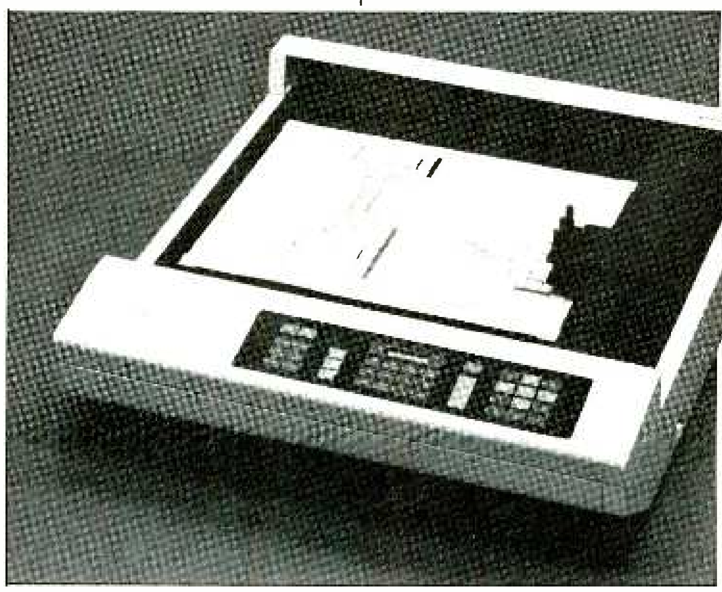
Microlink is a low-cost modular interface for connecting laboratory instruments to microcomputers. Plug-in units are available for applications in electronics and physics, engineering, chemistry and life sciences. Among them are counters and timers, a real-time clock, a stepper-motor controller and a heart-rate timer. Basic mainframe for seven modules costs £420; module prices range from £105 for an analogue input to £450 for a temperature unit. Control software can be supplied for Apricot, Apple, BBC, CBM, IBM, Hewlett-Packard and Sirius microcomputers. Biodata Ltd, 6 Lower Ormond Street, Manchester M1 5QF. EWW256

Mowlem Microsystems' Autonomous Data Acquisition Unit allows monitoring of up to 16 transducer channels simultaneously. An internal microcomputer with battery-backed memory offers a wide range of data logging functions, giving the unit a substantial degree of independence from the host computer. Modules include a-to-d inputs, signal conditioners, analogue outputs, cards for thermocouples and platinum resistance devices, a dual stepping-motor controller card, a relay card and a choice of strain-gauge cards. For closed-loop control an optional process control interface is available. Prices for a working system start at about £2,900. Mowlem Microsystems Ltd, Eastman Way, Hemel Hempstead, Hertfordshire HP2 7HB. EWW257

Rikadenki produce a series of graphics plotters extending from one-pen and two-pen flat-bed types to multi-pen recorders with up to 10 channels. Plug-in input modules can be chosen from a range which covers temperature, pressure and torque as well as a.c. and d.c. electrical measurements. Other modules offer features such as auto-ranging and automatic zero suppression. Rikadenki Mitsui Electronics (U.K.) Ltd, Oakcroft Road, Chessington, Surrey KT9 1SA. EWW258

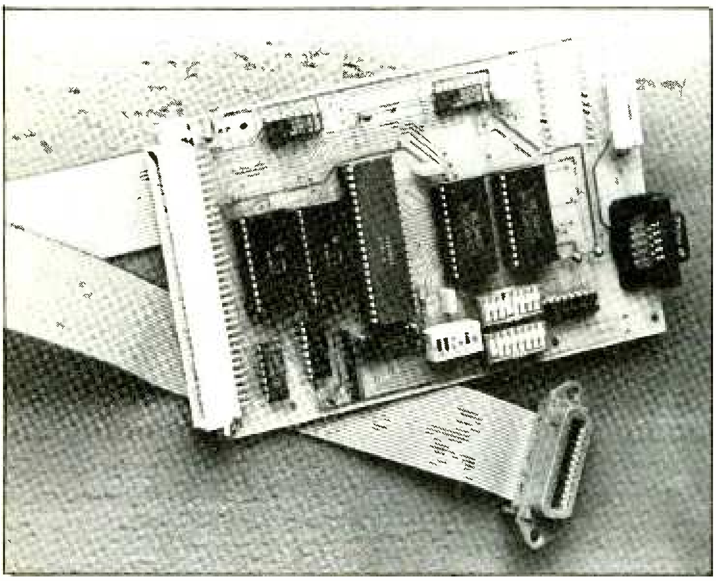
Saunders and Associates manufacture two GPIB-controllable crystal impedance meters. Low and high frequency versions are available, covering quartz crystals

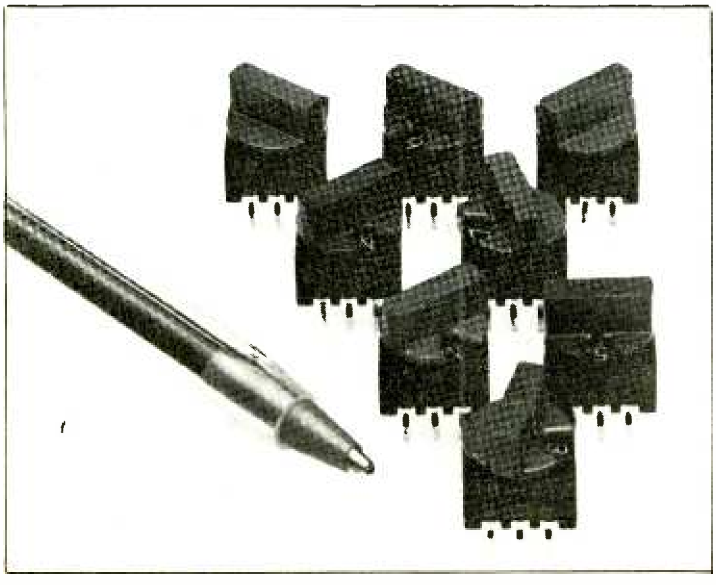
Below: **An A3-size graphics plotter from Rikadenki; and (bottom) the Druck DPI500 pressure instrument which can measure or control pressures in any specified units.**



The Guildline digital platinum resistance thermometer mentioned in last month's survey costs less than we thought: the current price is £1,780.

Below: IEEE488 communications card for the Triangle TDS900 Forth computer; and (bottom) an Amplicon model 87 digital panel meter with GPIB control software running on an IBM personal computer.





in the ranges 8kHz to 1MHz and 1MHz to 60MHz. The crystal to be evaluated is mounted in an environmental test chamber (also bus-controlled) where it can be heated or cooled as required. Roditi International Corporation Ltd, Carrington House, 130 Regent Street, London W1R 6BR. EWW259

Techne make a range of laboratory equipment which includes environmental test enclosures, thermo-regulators, water baths, stirrers, coolers, sample concentrators and density gradient columns. Techne Cambridge Ltd., Duxford, Cambridge CB2 4PZ. EWW260

Time Electronics specialize in calibration instruments. Their 9800 series includes voltage and current sources and calibrators (from £975), resistance boxes (from £820), a 24-way relay-switch unit with six command modes (£580), two precision power supplies (from £595), a speech synthesizer with a 280-word industrial vocabulary, a rotary trimmer adjuster (£620) and a scanner system (master control frame costs £490, 10-channel modules £120 each). All can be supplied free-standing or in rack mounts. Also available is a complete multimeter calibration set based on an HP86 microcomputer. Calibration certificates can be provided and are traceable to the National Physical Laboratory. Time Electronics, Botany Industrial Estate, Tonbridge, Kent TN9 1RS. EWW261

YEW products are available from Martron Ltd, Park Street, Princes Risborough, Buckinghamshire. EWW262

GPIB and your micro

As an alternative to the purpose-built GPIB controllers available from several of the manufacturers in our lists, it is possible to use a microcomputer with a suitable interface and software. Sources of interfaces for some common micros are listed below:

Apple II: £250 from E.D.A. (Software) Ltd, 10 Victory Road, Chertsey, Surrey. EWW263

Apple II: £130 from CIL Microsystems Ltd, Decoy Road, Worthing, Sussex BN14 8ND. EWW264

BBC Micro: IEEE interface and software in rom, £282. Acorn Computers Ltd, Fulbourn Road, Cherry Hinton, Cambridge CB1 4JN. EWW265

BBC Micro (CST Procyon) and Sinclair QL: from Cambridge Systems Technology, 30 Regent Street, Cambridge. EWW266

Apricot (£285), **Apple II** (£242), **BBC** (£235), **IBM-pc** (£376): interface cards and software (from £95) from Biodata Ltd, 6 Lower Ormond Street, Manchester M1 5QF. EWW267

DEC Rainbow and **IBM-pc:** Amplicon Electronics supply an IBM interface card (£499) by National Instruments. Software includes a comprehensive program for configuring the bus (£66) and Labtech Notebook (£975), a program for data acquisition, control and analysis (it also interfaces to Lotus 1-2-3 and Symphony). Amplicon Electronics Ltd, Richmond Road, Brighton, East Sussex BN2 3RL. EWW268

Sharp MZ80B: GPIB card (£149) and cable (£49) from Sharp Electronics (U.K.) Ltd, Thorp Road, Newton Heath, Manchester M10 9BE. EWW269

Several microcomputer board systems have GPIB controllers either as a standard feature or as options:

CMS: Cambridge, Microprocessor Systems, 44a Hobson Street, Cambridge CB1 1NL. EWW270

IBS Z80 computer: Irvine Business Systems Ltd, 1 Montgomery Place, Irvine, Ayrshire KA12 8PN. EWW271

Triangle TDS900 Forth computer: IEEE communications card from Triangle Digital Services Ltd, 100a Wood Street, London E17 3HX. EWW272

Instrument distributors

Carston Electronics Ltd, (second-hand test equipment, new and used computer equipment): 99 Waldegrave Road, Teddington, Middlesex TW11 8LL. EWW273

Electronic Brokers Ltd, (new and used electronic test and measuring equipment, computers and peripherals): 140-146 Camden Street, London NW1 9PB. EWW274

Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Hertfordshire SG8 5HH. EWW275

Instrument Rentals: this company also has some second-hand instruments for sale. Dorcan House, Meadfield Road, Langley, Slough, Berkshire SL3 8AL. EWW276

Lawtronics Ltd, 139 High Street, Edenbridge, Kent. EWW277

Livingston Hire, Shirley House, 27 Camden Road, London NW1 9NR. EWW278

Rental Electronics Ltd, 7 Arkwright Road, Reading, Berkshire RG2 0LU. EWW279

STC Instrument Services, Edinburgh Way, Harlow, Essex CM20 2DF. EWW280

Further reading

International Electrotechnical Commission IEC publication 625-1.

IEEE Standard Digital Interface for Programmable Instrumentation. The Institute of Electrical and Electronics Engineers, 30 November 1978.

IEEE bus standard, P.R. Ellefsen, *Wireless World*, June 1980, pp. 75-78.

Fisher and Jensen's Pet and the IEEE488 from Osborne (1980), although written specifically for Pet users, gives a technical description of GPIB and lists manufacturers, mainly in North America, of controllers, instruments, connectors and peripheral devices. It also includes a comprehensive bibliography.

Many manufacturers produce application notes and technical descriptions relating to GPIB.

Sowter Transformers

With 40 years' experience in the design and manufacture of several hundred thousand transformers we can supply:

AUDIO FREQUENCY TRANSFORMERS OF EVERY TYPE

YOU NAME IT! WE MAKE IT!

OUR RANGE INCLUDES

Microphone transformers (all types), Microphone Splitter/Combiner transformers, Input and Output transformers, Direct Injection transformers for Guitars, Multi-Secondary output transformers, Bridging transformers, Line transformers, Line transformers to G.P.O. Isolating Test Specification, Tapped impedance matching transformers, Gramophone Pickup transformers, Audio Mixing Desk transformers (all types), Miniature transformers, Microminiature transformers for PCB mounting, Experimental transformers, Ultra low frequency transformers, Ultra linear and other transformers for Transistor and Valve Amplifiers up to 500 watts, Inductive Loop Transformers, Smoothing Chokes, Filter, Inductors, Amplifier to 100 volt line transformers (from a few watts up to 1,000 watts), 100 volt line transformers to speakers, Speaker matching transformers (all powers), Column Loudspeaker transformers up to 300 watts or more.

We can design for RECORDING QUALITY, STUDIO QUALITY, HI-FI QUALITY OR P.A. QUALITY. OUR PRICES ARE HIGHLY COMPETITIVE AND WE SUPPLY LARGE OR SMALL QUANTITIES AND EVEN SINGLE TRANSFORMERS. Many standard types are in stock and normal dispatch times are short and sensible.
OUR CLIENTS COVER A LARGE NUMBER OF BROADCASTING AUTHORITIES, MIXING DESK MANUFACTURERS, RECORDING STUDIOS, HI-FI ENTHUSIASTS, BAND GROUPS, AND PUBLIC ADDRESS FIRMS. Export is a speciality and we have overseas clients in the COMMONWEALTH, E.E.C., USA, MIDDLE EAST, etc.
Send for our questionnaire which, when completed, enables us to post quotations by return.

E. A. Sowter Ltd.

Manufacturers and Designers

E. A. SOWTER LTD. (Established 1941) : Reg. No. England 303990
The Boat Yard, Cullingham Road, Ipswich IP1 2EG, Suffolk
P.O. Box 36, Ipswich, IP1 2EL, England
Phone: 0473 52794 and 0473 219390
Telex 987703G Sowter

CIRCLE 91 FOR FURTHER DETAILS.

Happy Memories

Part type	1 off	25-99	100 up
4116 200ns	1.25	1.15	1.10
4164 150ns Not Texas	3.35	3.10	2.90
2114 200ns Low Power	1.75	1.60	1.55
2016 150ns Like 6116	3.65	3.35	3.10
6116 200ns Low power	7.75	Call	Call
6264 150ns Low power	14.85	13.75	13.20
2716 450ns 5 volt	3.85	3.45	3.30
2732 450ns Intel type	4.75	4.25	4.10
2732A 350ns	5.25	4.69	4.50
2532 450ns Texas type	3.85	3.45	3.30
2764 300ns Suit BBC	5.40	5.00	4.80
27128 300ns Suit BBC	10.50	9.50	8.65

Low profile IC sockets:									
	Pins	8	14	16	18	20	24	28	40
	Pence	12	13	14	16	18	24	27	38

Available now — The ROAM BOARD for the BBC Micro. Reads Roms via a Low Insertion Force Socket and saves their contents as files, then reloads a file into its sideways Ram as required. Full details on request.

74LS series TTL, wide stocks at low prices with DIY discounts starting at a mix of just 25 pieces. Write or 'phone for list.

Please add 50p post & packing to orders under £15 and VAT to total. Access welcome, 24hr 'phone service on (054 422) 618 Non-Military Government & Educational orders welcome., £15 minimum.

HAPPY MEMORIES (WW)
Gladestry, Kington
Herefordshire HR5 3NY
Tel: (054 422) 618 or 628

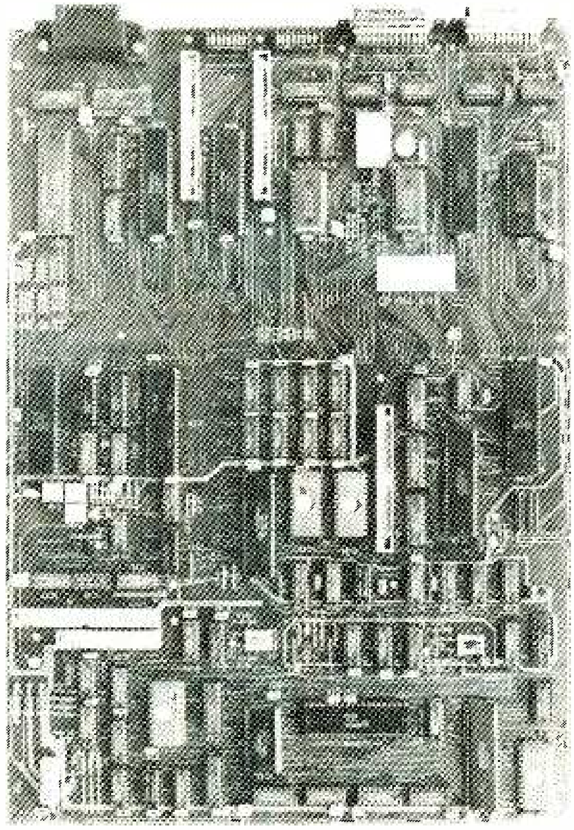
CIRCLE 53 FOR FURTHER DETAILS.

IRVINE BUSINESS SYSTEMS LTD

IBS

1 Montgomery Place
Irvine, Ayrshire
KA12 8PN
Telex 777582
(mark: attn IBS)

THE ENGINEERS Z80 COMPUTER WITH IEEE 488



* **2 × Z80 CPU's (4MHz)**
* **64K DYNAMIC RAM**
* **UP TO 32K EPROM**
* **FLOPPY DISK CONTROLLER FOR 3", 5" and 8" Disk Drives**
* **2 × RS232 SERIAL I/O CHANNELS**
* **I/O MAPPED VIDEO GEN. 80 Cols. 24 Lines**
* **4 × PARALLEL I/O CHANNELS**
* **PARALLEL KEYBOARD PORT (POWERED)**
* **IEEE 488 INTERFACE**
* **HARDWARE REAL TIME CLOCK**
* **2 × 8 BIT SWITCHES (I/O MAPPED)**
* **MONITOR PROGRAM IN PROM**
* **PROM BASED SOFTWARE AVAILABLE such as ASSEMBLER/EDITOR, and XTAL BASIC WITH IEEE DRIVERS**

The IBS 750 is an Industrial Quality Product designed for reliability and ease of use. It is normally supplied fully-built and tested but is also available in a number of partially-built options.
The Monitor PROM contains 22 user commands which will assist in writing and de-bugging of the SBC's console and printer requirements by just opening or closing links on the PCB. The same configured version of CP/M 2.2 is available for various Disk sizes. A complete Development System and Desk Top Computer based on this board is available with a variety of Disk Drive sizes and case styles to suit users requirements and environment.

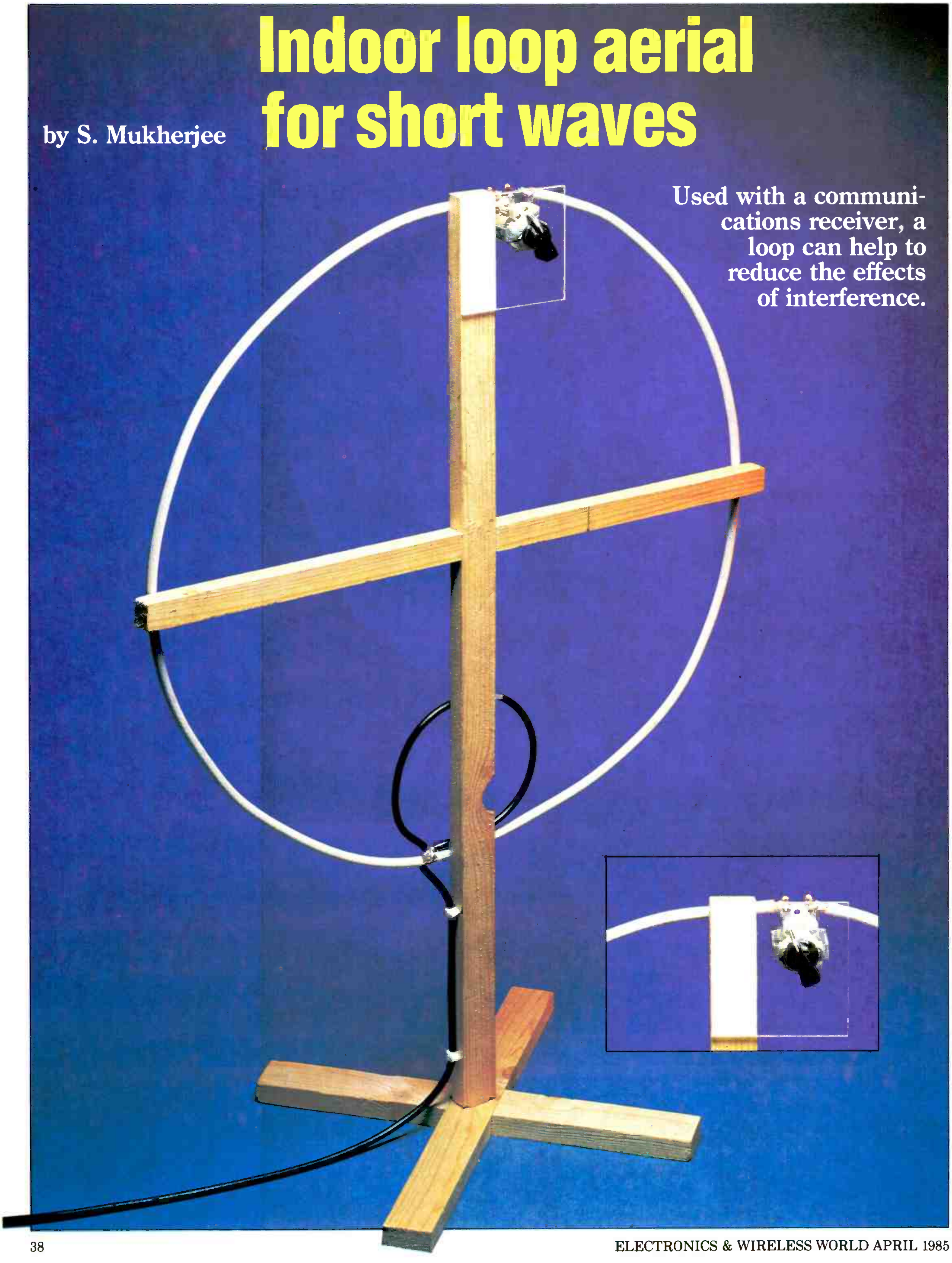
Tel (0294) 75000/73333

CIRCLE 85 FOR FURTHER DETAILS.

Indoor loop aerial for short waves

by S. Mukherjee

Used with a communications receiver, a loop can help to reduce the effects of interference.



Loop antennas are useful indoors, where they often provide rather more protection than a rod aerial against noise from electrical appliances. If an outdoor whip or long wire antenna cannot be used for short wave reception, it may be worth constructing a compact indoor loop.

The loop antenna illustrated here has a main loop which is tuned to the band being received, and a small coupling loop which extracts the signal at a low-impedance level for connection to the receiver via coaxial cable. Both loops are screened against interference by making them from coaxial cable with a short gap in the outer conductor at the top of the loop. The screening (coax.outer) is earthed symmetrically at the bottom of each loop, using the outer of the downlead as an earth connection.

You can make a frame for the loop from wooden laths or bamboo poles using simple tools. Ideally, the frame should allow for easy rotation of the antenna (to maximize pickup and avoid unwanted nulls in the figure-eight shaped directional pattern). It should also be easy to move about to find the best spot in the room which, in general, is likely to be a short distance behind a window, but which varies from building to building.

Diameter of main loop	700	440	350	mm
Diameter of coupler	140	105	80	mm
Tuning cap. max.	500	200	100	pF
Tuning range	4-9	8-18	18-26	MHz

Best results will be obtained using a well-screened communications receiver fitted with a low impedance (50-80 ohm) antenna socket: with poorly screened receivers, stray pickup will bypass the loop and increase vulnerability to interference.

Tune the loop to a weak but steady transmission, using a large, insulated knob on the tuning capacitor to reduce hand effects (better with an insulated extension spindle as well). Mount the capacitor on a panel or platform of insulating material fixed near the top of the main loop.

In some receivers the antenna terminals sit at a d.c. potential above 'earth'; with these, insert blocking capacitors (say 10nF) between antenna and receiver.

The table gives dimensions for circular loops but square loops of equal area may also be used.

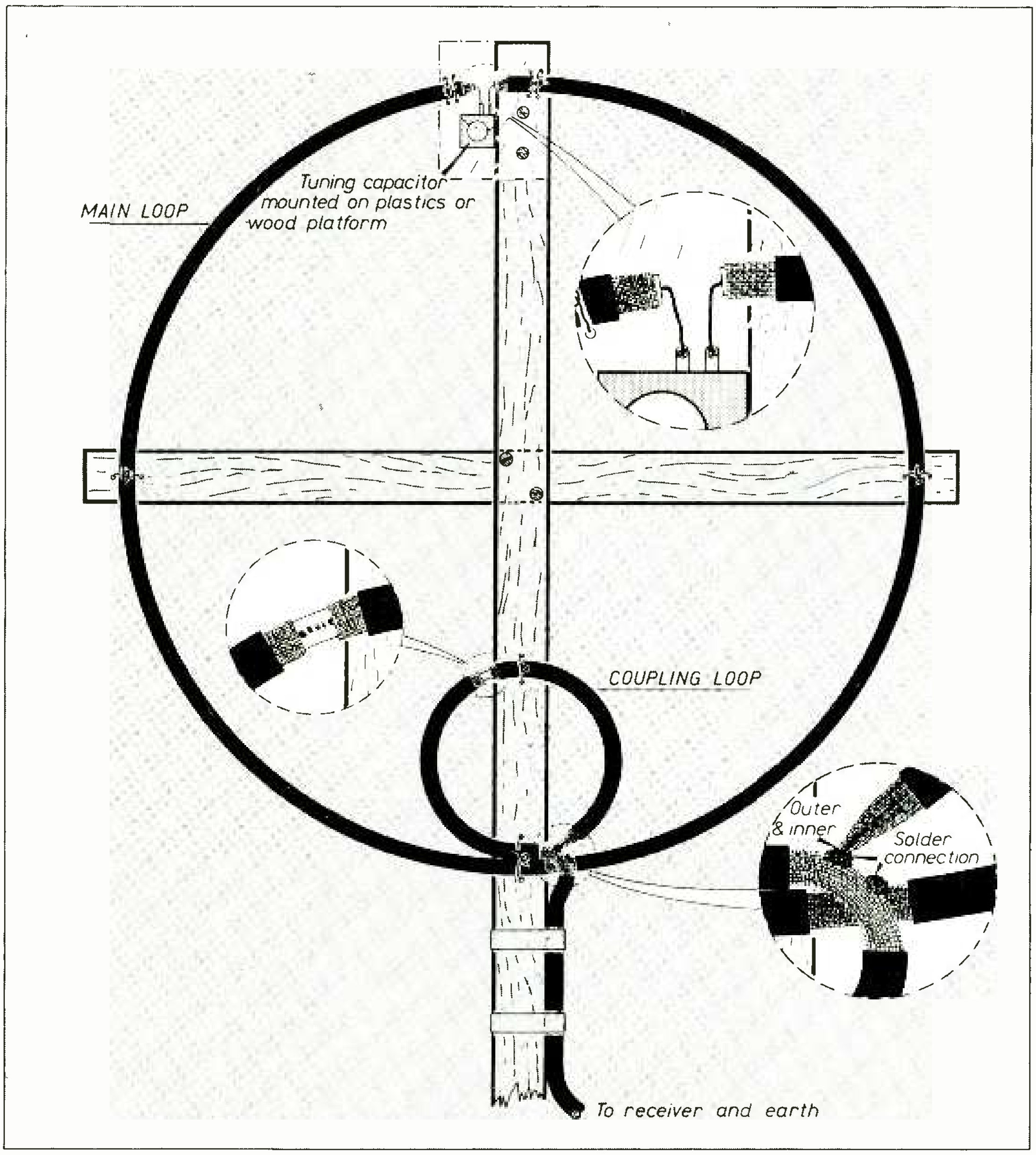


Fig.1 (facing page). **Finished aerial, with (inset) detail of tuning capacitor.**

Fig.2 **Construction of aerial**

PHONE 0474 813225 3 LINES

P. M. COMPONENTS LTD

SELECTRON HOUSE, WROTHAM ROAD MEOPHAM GREEN, MEOPHAM, KENT DA13OQY

TELEX 966371 PM COMP

A SELECTION FROM OUR STOCK OF BRANDED VALVES

- A1714 18.50
- A1834 7.50
- A1998 11.50
- A2087 11.50
- A2134 14.95
- A2293 6.50
- A2599 37.50
- A2792 27.50
- A2900 11.50
- A3042 24.00
- A3283 24.00
- AC/HL/DD 4.00
- AC/THI 4.00
- ACT22 59.75
- AH221 39.00
- AH238 39.00
- AL60 6.00
- AN1 14.00
- ARP12 0.70
- ARP34 1.25
- ARP35 2.00
- ATP4 2.50
- AX50 5.50
- AZ11 4.50
- AZ31 2.50
- BL63 2.00
- BS450 67.00
- BS810 55.00
- BS814 55.00
- CIK 19.00
- C3JA 21.00
- C6A 9.00
- C1108 54.95
- C112G 70.00
- C1134 32.00
- C1148A 115.00
- C1149/1 130.00
- C1150/1 135.00
- C1534 32.00
- CCA 2.60
- CC3L 0.90
- CL33 2.00
- CV Nos Prices on request
- D63 1.20
- DA41 22.50
- DA42 17.50
- DA90 4.50
- DA100 125.00
- DAF91 0.70
- DAF96 0.65
- DC70 1.75
- DC90 1.20
- DCX4-1000 12.00
- DCX4-5000 25.00
- DET16 28.50
- DET18 28.50
- DET23 35.00
- DET24 39.00
- DET25 22.00
- DET29 32.00
- DF91 0.70
- DF92 0.60
- DF96 0.65
- DF97 1.00
- DH63 1.20
- DH77 0.90
- DH79 0.56
- DH149 2.00
- DK91 0.90
- DK92 1.20
- DK96 2.50
- DL35 2.50
- DL63 1.00
- DL70 2.50
- DL73 2.50
- DL91 1.50
- DL92 0.95
- DL93 1.10
- DL94 2.50
- DL96 2.50
- DLS10 13.50
- DLS16 10.00
- DM70 1.95
- DM160 2.75
- DY51 1.50
- DY86/87 0.65
- DY802 0.72
- E8?.uF 25.00
- E81L 12.00
- E82CC 3.50
- E83CC 3.50
- E83F 5.50
- E86C 9.50
- E88C 7.95
- E88CC 3.50
- E90CC 7.95
- E90F 7.95
- E91H 4.50
- E92CC 3.95
- E99F 6.99
- E130L 19.95
- E180CC 6.50
- E182CC 9.00
- E180F 6.50
- E186F 8.50
- E188CC 7.50
- E1T 15.00
- E280F 19.50
- E283CC 10.00
- E288CC 13.50
- E810F 18.50
- E88CC Siemans Special 6.95
- E1148 1.00
- E1524 6.95
- EA50 1.00
- EA76 1.95
- EA79 1.95
- EABC80 0.70
- EAC91 2.50
- EAF42 1.20
- EAF801 2.00
- EB34 1.50
- EB41 3.95
- EB91 0.85
- EBC33 2.50
- EBC41 1.95
- EBC81 1.50
- EBC90 0.90
- EBC91 0.90
- EBF80 0.65
- EBF83 0.65
- EBF85 0.95
- EBF89 0.70
- EBF93 0.95
- EBL1 2.50
- EBL21 2.00
- EC52 0.75
- EC70 1.75
- EC80 9.50
- EC81 7.95
- EC86 1.00
- EC88 1.00
- EC90 1.10
- EC91 5.50
- EC92 1.75
- EC93 1.50
- EC95 7.00
- EC97 1.10
- EC8010 12.00
- ECC32 3.50
- ECC33 3.50
- ECC35 3.50
- ECC81 1.15
- ECC81 Special Quality 1.95
- ECC82 0.55
- ECC82 Philips 1.95
- ECC83 0.65
- ECC83 Brimar 1.35
- ECC83 Philips 1.95
- ECC84 0.50
- ECC85 0.60
- ECC86 2.75
- ECC88 0.95
- ECC91 2.00
- ECC180 0.72
- ECC189 0.78
- ECC801S 3.50
- ECC803S 3.50
- ECC804 0.60
- ECC2000 12.00
- ECF80 1.15
- ECF82 1.15
- ECF86 1.70
- ECF200 1.85
- ECF202 1.85
- ECF801 0.85
- ECF804 6.00
- ECF805 2.50
- ECF806 10.25
- ECH3 2.50
- ECH4 3.00
- ECH35 3.50
- ECH42 1.00
- ECH81 0.65
- ECH83 0.78
- ECH84 0.69
- ECH2000 1.50
- ECL80 0.80
- ECL82 0.65
- ECL83 2.50
- ECL84 0.74
- ECL85 0.69
- ECL86 0.80
- ECL805 0.69
- EF37A 2.00
- EF39 1.10
- EF41 3.50
- EF42 3.50
- EF50 2.50
- EF55 4.95
- EF70 1.20
- EF71 1.50
- EF72 1.20
- EF73 1.00
- EF80 0.55
- EF83 3.50
- EF85 0.50
- EF86 2.25
- EF86 Special Quality 3.15
- EF89 1.50
- EF91 1.95
- EF92 2.15
- EF93 0.95
- EF94 0.95
- EF95 1.50
- EF97 0.90
- EF98 0.90
- EF183 0.65
- EF184 0.65
- EF730 1.80
- EF731 3.50
- EF732 3.50
- EF800 11.00
- EF805S 13.50
- EF806S 14.50
- EF812 0.65
- EFL200 1.50
- EH90 0.72
- EK90 0.72
- EL32 0.95
- EL33 4.00
- EL34 2.25
- EL34 Mullard/Philips 4.50
- EL36 1.95
- EL37 9.00
- EL38 4.75
- EL41 3.50
- EL42 2.00
- EL81 6.95
- EL83 5.95
- EL84 0.75
- EL85 4.50
- EL86 0.85
- EL90 1.75
- EL91 6.00
- EL95 0.70
- EL153 12.15
- EL183E 3.50
- EL18P 3.50
- EL360 6.75
- EL500 1.40
- EL504 1.40
- EL509 5.25
- EL519 6.95
- EL802 3.65
- EL821 8.50
- EL822 12.95
- EM1 9.00
- EM4 9.00
- EM80 0.70
- EM81 0.70
- EM84 1.65
- EM85 3.95
- EM87 2.50
- EN32 1.50
- EN91 1.10
- EN92 4.50
- ESU150 14.95
- ESU872 25.00
- EY51 0.80
- EY81 2.35
- EY83 1.50
- EY84 5.95
- EY86/87 0.50
- EY88 0.55
- EY91 5.50
- EY500A 1.50
- EY802 0.70
- EZ35 0.75
- EZ40 2.75
- EZ41 2.75
- EZ80 0.75
- EZ81 0.75
- EZ90 1.50
- F6064 2.95
- FW4/800 2.95
- G55/1K 9.00
- G180/2M 9.00
- G240/2D 9.00
- GC10B 17.50
- GC10D 17.50
- GC10/4B 17.50
- GC10/4E 17.50
- GC12/4B 17.50
- GD86W 6.00
- GDT120M 5.00
- GE10 9.00
- GN4 6.00
- GN10 15.00
- GR10G 4.00
- GS10C 16.50
- GS10H 12.00
- GS12D 12.00
- GT1C 14.00
- GT1C S/S 13.00
- GTE175M 8.00
- GTR150W 1.00
- GU20 35.00
- GU50 17.50
- GXU1 13.50
- GXU3 24.00
- GXU50SS 14.50
- GY501 1.20
- GY802 1.00
- GZ30 1.00
- GZ31 1.00
- GZ32 1.00
- GZ33 4.50
- GZ34 2.15
- GZ34 U L 3.95
- GZ37 4.50
- HAA91 1.00
- HABC80 0.90
- HBC90 0.75
- HBC91 0.80
- HF93 0.75
- HF94 1.50
- HK90 1.05
- HL2K 3.50
- HL23DD 4.00
- HL41 3.50
- HL42DD 3.50
- HL90 0.70
- HL92 1.50
- HL133/DD 3.50
- HR2 4.00
- HY90 1.00
- HVR2 3.00
- JP9-7A 60.00
- K3118 85.00
- KR6/3 45.00
- KT8C 7.00
- KT33C 3.50
- KT36 2.00
- KT44 4.00
- KT45 4.00
- KT61 4.00
- KT63 2.00
- KT66 OSRAM 15.00
- KT66 USA 9.95
- KT66 GEC 14.95
- KT77 Gold Lion 10.95
- KT81 7.00
- KT88 USA 10.95
- KT88 G Lion 18.95
- KT67 9.00
- KTW61 2.50
- KTW62 2.50
- KTW63 2.00
- KTZ63 2.50
- L63 1.50
- L102/2K 6.95
- L120/2K 12.00
- LB7-20 95.00
- LS9B 6.95
- M502A 60.00
- 85.00
- M537A 60.00
- M5143 155.00
- M8079 6.00
- M8082 7.50
- M8083 3.25
- M8091 7.50
- M8096 3.00
- M8098 5.50
- M8099 5.00
- M8100 5.50
- M8136 7.00
- M8137 5.50
- M8161 6.50
- M8162 5.50
- M8163 5.50
- M8190 4.50
- M8195 6.50
- M8196 5.50
- M8204 5.50
- M8223 4.50
- M8224 2.00
- M8225 3.50
- ME1401 29.50
- ME1402 29.50
- ME1501 14.00
- MH4 3.50
- MHLD6 4.00
- ML4 4.50
- MS4B 5.50
- MU14 1.50
- MZ1-100 125.00
- N37 12.50
- N78 9.85
- OA2 0.85
- OA2WA 1.50
- OA3 2.50
- OB2 0.85
- OB2WA 1.25
- OC2 2.50
- OC3 1.50
- OD3 1.70
- OM4 1.00
- OM5B 3.00
- OM6 1.75
- ORP43 2.50
- ORP50 3.95
- ORP93 12.00
- P61 2.50
- P41 2.50
- PABC80 0.50
- PC86 0.75
- PC88 0.75
- PC92 3.50
- PC97 1.10
- PC800 1.10
- PC900 1.25
- PCC84 0.40
- PCC85 0.54
- PCC88 0.70
- PCC89 0.70
- PCC189 0.70
- PCC805 0.70
- PCC806 0.80
- PCE82 0.80
- PCF80 0.65
- PCF82 0.60
- PCF84 0.65
- PCF86 1.20
- PCF87 0.40
- PCF200 1.80
- PCF201 1.80
- PCF800 0.40
- PCF801 1.35
- PCF802 0.60
- PCF805 1.25
- PCF806 1.00
- PCF808 1.25
- PCH200 1.50
- PCL82 0.85
- PCL83 2.50
- PCL84 0.75
- PCL85 0.80
- PCL86 0.85
- PCL800 0.80
- PCL805 0.90
- PD500 3.50
- PD510 3.65
- PE1-100 69.00
- PEN25 2.00
- PEN40DD 2.50
- PEN45 3.00
- PEN45DD 3.00
- PEN46 2.00
- PEO6-40N 42.00
- PFL200 0.95
- PL21 2.50
- PL36 0.95
- PL38 1.50
- PL81 0.72
- PL81A 0.72
- PL82 0.60
- PL83 0.52
- PL84 0.78
- PL88 1.00
- PL95 1.75
- PL302 1.00
- PL345 12.50
- PL500 1.10
- PL504 1.15
- PL508 1.75
- PL509 4.85
- PL519 4.95
- PL802 5.95
- PL802T 3.50
- PL820 2.95
- PL5557 29.50
- PY32 0.60
- PY33 0.50
- PY81 0.70
- PY82 0.70
- PY83 0.70
- PY88 0.65
- PY500A 1.95
- PY800 0.79
- PY801 0.79
- QB3-300 54.95
- QE03-10 3.50
- QE08-200 145.00
- QF40 65.00
- QP25 1.00
- QQE03-12 6.50
- QQE03-20 27.00
- QQV02-6 19.50
- QQV03-10 5.50
- QQV03-10 Mullard 15.00
- QQV03-20 25.00
- QQV03-20B 32.00
- QQV06-40A 27.50
- QQV07-50 63.50
- QQZ03-20 42.50
- QS75-20 1.50
- QS75/40 3.00
- QS92/10 5.00
- QS95/10 4.85
- QS108/45 4.00
- QS150/15 6.95
- QS150/30 1.15
- QS150/45 7.00
- QS1200 3.95
- CS1202 3.95
- CS1203 4.15
- CS1205 3.95
- QS1206 1.05
- CS1207 0.90
- QS1208 0.90
- QS1209 3.15
- QS1210 1.50
- QS1211 1.50
- QS1212 3.20
- QS1213 5.00
- QS1215 2.10
- QS1218 5.00
- QU37 9.50
- QV03-12 4.95
- QV05-25 1.75
- QV06-20 29.50
- QV08-100 145.00
- QV2-250C 45.00
- QY3-125 65.00
- QY4-250 70.00
- QY4-400 76.00
- R10 4.00
- R16 12.00
- R17 1.50
- R18 2.50
- R19 2.50
- R20 1.20
- R1169 55.00
- RG1-125 4.95
- RG1-240A 14.50
- RG3-250A 3.50
- RG3-1250A 35.00
- RK2K25 62.50
- RK-20A 12.00
- RL16 1.50
- RPL16 12.00
- RPY13 2.50
- RPY43 2.50
- RPY82 2.50
- RR3-250 15.00
- RR3-1250 35.00
- RS613 45.00
- RS685 54.95
- RS688 52.15
- S6F17 5.95
- S6F33 28.95
- S11E12 38.00
- S30/2K 12.00
- S104/1K 10.00
- S109/1K 15.00
- S130 5.95
- S130P 5.95
- SC1/800 5.50
- SC1/1100 6.00
- SC1/1200 5.00
- SC1/1300 6.00
- SC1/2000 9.00
- SD6000M 45.00
- SP41 5.00
- SP42 3.00
- SP4B 4.95
- SS501 35.00
- ST11 1.50
- STV280/40 11.95
- STV280/80 19.95
- SU42 4.95
- TB2.5/300 85.00
- TB2-300 45.00
- TB3/2000 3.95
- TBL-2-300 275.00
- TD1-100A 25.00
- TD03-10F 35.00
- TD3-12 4.00
- TDD4 5.50
- TP25 1.50
- TSP4 7.00
- TT11 1.50
- TT15 34.95
- TT21 45.00
- TT22 45.00
- TT100 57.00
- TTR-31MR 65.00
- TY2-125A 85.00
- TY4-400 70.00
- TY8-600W 365.00
- TYS2/250 375.00
- U18-20 2.75
- U19 11.95
- U24 2.00
- U25 0.90
- U26 0.90
- U37 9.00
- U41 6.95
- U50 2.00
- U82 3.00
- U191 0.70
- U192 1.00
- U193 0.65
- U251 1.00
- U801 0.75
- UABC80 0.65
- UAF42 1.00
- UBF80 0.60
- UBC41 2.95
- UBC81 1.50
- UBF89 0.60
- UBL21 1.75
- UC92 1.20
- UCC84 0.70
- UCC85 0.60
- UCF80 1.00
- UCH21 1.20
- UCH41 2.50
- UCH42 2.50
- UCH81 0.65
- UCL82 1.75
- UF41 1.15
- UF42 1.15
- UF80 0.80
- UF85 1.20
- UF89 2.50
- UL41 4.50
- UL44 3.50
- UL84 0.85
- UU5 3.50
- UU7 8.00
- UU8 9.00
- UY41 3.50
- UY85 0.70
- V235A/1K 250.00
- V238A/1K 295.00
- V240C/2K 225.00
- V241C/1K 195.00
- V2464A/2K 315.00
- V339 3.50
- V453 12.00
- VLS631 10.95
- VP4B 4.50
- VP133 2.00
- VR75/30 3.00
- VR101 2.00
- VR105/30 1.50
- VR150/30 1.15
- VT52 2.50
- VU29 4.50
- VU39 1.50
- W21 4.50
- W77 5.00
- W729 1.00
- W739 1.50
- X24 1.00
- X66/X65 4.95
- X76M 1.95
- XC24 1.50
- XC25 0.50
- XFW47 1.50
- XFW50 1.50
- XG2-6400 135.00
- XG5-500 22.50
- XL1-5V 1.50
- XL628FT 7.50
- XNP12 2.50
- XR1-1600A 49.50
- XR1-3200A 79.50
- XR1-6400A 99.50
- Y503 25.00
- Y65 6.95
- Y602 12.00
- YD1100 75.00
- YJ1060 265.00
- YL1020 29.00
- YL1070 130.00
- YL1071 135.00
- YL1290 65.00
- Z77 1.20
- Z302C 12.00
- Z359 9.00
- Z505S 15.00
- Z520M 4.00
- Z521M 8.00
- Z700U 3.00
- Z749 0.60
- Z759 19.85
- Z800U 3.00
- Z803U 18.95
- ZA1000 12.50
- ZA1001 1.50
- ZA1002 1.50
- ZC1040 8.00
- ZM1005 8.00
- ZM1020 8.95
- ZM1021 8.00
- ZM1023 7.95
- ZM1041 14.00
- ZM1082 9.00
- ZM1084 10.00
- ZM1177 9.00
- ZM1202 55.00
- ZM1263 4.00
- ZM1612 3.00
- 1A3 4.50
- 1AC6 1.20
- 1B3GT 1.95
- 1B22 10.00
- 1B24 14.95
- 1B35A 29.50
- 1BC2A 2.50
- 1C1 2.50
- 1C5GT 2.50
- 1D5 2.50
- 1FD1 2.50
- 1G3GT 2.50
- 1K3GT 2.50
- 1L6 1.50
- 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 55.00
- 4-250A 65.00
- 4B32 35.00
- 4BQ7A 1.75
- 4BZ6 1.95
- 4C27 25.00
- 4C28 25.00
- 4CB6 1.95
- 4CX250B EIMAC 49.00
- 4CX250BM EIMAC 75.00
- 4CX250K EIMAC 95.00
- 4CX125C EIMAC 125.00
- 4CX350A 95.00
- 4D26 75.00
- 4GS7 2.25
- 4GV7 2.25
- 4J52 75.00
- 4JC6A 2.95
- 4X150A 35.00
- 5A/102D 9.50
- 5A152M 9.00
- 5A163K 10.00
- 5A170K 6.25
- 5A-180M 9.00
- 5A-206K 10.00
- 5AMB 2.15
- 5ANB 1.20
- 5AR4 2.00
- 5AU4 1.50
- 5B8 2.50
- 5B.110M 10.00
- 5B-254M 14.50
- 5B-255M 19.50
- 5B-256M 9.00
- 5B-257M 9.00
- 5B-258M 14.50
- 5C22 125.00
- 5R4GB 3.50
- 5R4GY 3.50
- 5T4 5.95
- 5U4G 2.50
- 5U4GB 2.50
- 5V4G 1.25
- 5Y3GT 1.95
- 5Z4GT 0.85
- 6/30L2 0.70
- 6A/203K 9.00
- 6A7 4.95
- 6A8G 1.50
- 6AC7 2.00
- 6AF4A 2.50
- 6AF9 4.15
- 6AG5 1.50
- 6AG7 1.95
- 6AH6 2.50
- 6AJ4 2.00
- 6AJ7 2.00
- 6AK5 1.50
- 6AK6 2.50
- 6AL5 0.60
- 6AM4 3.25
- 6AM5 6.00
- 6AM6 1.50
- 6AN5 2.65
- 6AN8A 2.65
- 6AQ5 1.75
- 6AQ8 0.85
- 6AR5 5.95
- 6AR8 3.95
- 6AS5 1.50
- 6AS6 2.50
- 6AS7G 4.50
- 6AT6 0.75
- 6AT8 1.75
- 6AU4 2.00
- 6AU6 0.95
- 6AV6 0.75
- 6AW8A 2.50
- 6AZ8 5.95
- 6B7 2.80
- 6B8G 1.50
- 6BA6 0.95
- 6BA7 4.50
- 6BA8A 3.50
- 6BC8 1.00
- 6BD4 1.50
- 6BD6 2.50
- 6BE6 0.72
- 6BF5 1.60
- 6BG6G 3.00
- 6BH6 1.95
- 6BH8 1.50
- 6BJ6 1.20
- 6BK4 4.00
- 6BK7A 1.95
- 6BM8 0.58
- 6BN4 1.65
- 6BN6 1.65
- 6BN7 4.50
- 6BN8 3.95
- 6BQ5 0.75
- 6BQ7A 0.72
- 6BL7GTA 3.95
- 6BL8 0.65
- 6BL8 1.15
- 6BR5 0.70
- 6BR7 4.95
- 6BR8 2.15
- 6BR8A 2.15
- 6BS7 5.50
- 6BW4 1.50
- 6BW6 5.35
- 6BW7 1.50
- 6BW8 4.00
- 6BX6 0.48
- 6BX7GT 3.50
- 6BZ6 2.50
- 6BZ7 2.95
- 6C4 1.10
- 6C5 1.95
- 6C6 2.50
- 6C8G 1.50
- 6C11 2.50
- 6C15 2.50
- 6C18 2.50
- 6CA4 4.95
- 6CA7 3.50
- 6CB5 3.95
- 6CB6 1.95
- 6CD6GA 4.50
- 6CF6 1.50
- 6CG7 2.25
- 6CH6 6.95
- 6CL3 3.95
- 6CL6 3.25
- 6CL8A 1.50
- 6CM5 1.60
- 6CM7 2.95
- 6CS6 0.75
- 6CW4 6.50
- 6CY5 1.00
- 6D6 2.50
- 6DC6 2.35
- 6DJ8 0.95
- 6DK6 1.15
- 6DQ5 4.95
- 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 1.50
- 6HF8 0.95
- 6HS6 4.95
- 6J4 2.15
- 6J4WA 3.15
- 6J5 2.50
- 6J6 0.65
- 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) 3.95
- 6L6GT 1.50
- 6LD20 0.60
- 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
- 6SQ7 1.35
- 6SS7 1.95
- 6U4GT 1.75
- 6U8 1.15
- 6U8A 1.50
- 6V6GT 1.15
- 6X2N 1.00
- 6X4 1.50
- 6X5GT 1.00
- 6X5GTY 1.00
- 6X8A 2.25
- 7A6 4.50
- 7A7 2.00
- 7AD7 1.75
- 7B6 3.50
- 7B7 2.50
- 7C5 3.50
- 7C6 2.50
- 7E7 2.50
- 7H7 3.50
- 7AU7 1.50
- 7J7 5.50
- 7Y4 2.50
- 8B8 2.50
- 8B10 2.50
- 8BQ5 1.95
- 8FQ7 1.95
- 10D2 1.25
- 10DE7 2.50
- 10F1 0.75
- 10GK6 1.95
- 10P14 2.50
- 10P18 0.78
- 10LD11 1.00
- 10LD12 0.65
- 11E3 55.00
- 12A6 3.95
- 12AD6 1.50
- 12AG8 1.50
- 12AL5 1.00
- 12AT6 0.95
- 12AT7 1.15
- 12AT7WA 2.50
- 12AU6 1.50
- 12AU7 0.55
- 12AV6 1.95
- 12AV7 2.50
- 12AX4GT 1.00
- 12AX7 0.65
- 12AX7WA 2.50
- 12AY7 3.95
- 12AZ7A 1.95
- 12B4A 3.50
- 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 28.00
- 12GN7 3.95
- 12HG7 4.50
- 12HG7A 4.50
- 12J7GT 3.50
- 12K5 1.00
- 12K7GT 0.60
- 12K8 1.10
- 12SA7GT 1.00
- 12SG7 4.75
- 12SH7 1.00
- 12SK7 1.00
- 12SJ7 0.60
- 12SN7GT 1.85
- 12SR7 2.50
- 12SQ7GT 1.50
- 13D3 3.20
- 13D7 3.20
- 13D9 3.20
- 13DE7 2.50
- 13DR7 2.95
- 13E1 115.100
- 13EM7 3.50
- 14S7 1.00
- 17DW4A 2.95
- 17EW8 0.95
- 17JZ8 4.50
- 18D3 1.60
- 19AU4GT 2.50
- 19G3 17.00
- 19H4 23.95
- 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
- 30C17 0.40
- 30C18 1.48
- 30F5 0.95
- 30FL1 1.00
- 30FL2 1.35
- 30FL12 0.95
- 30FL13 1.10
- 30FL14 1.25
- 30L1 0.45
- 30L15 0.60
- 30L17 0.60
- 30P4MR 1.00
- 30P12 1.00
- 30P18 0.60
- 30P19 1.00
- 30PL1 2.50
- 30PL13 0.60
- 30PL14 1.75
- 31JS6A 5.50
- 33A/158M 19.50
- 35A5 4.50
- 35L6GT 2.00
- 35W4 0.70
- 35Z3 1.85
- 38HE7 4.50
- 40KD6 5.50
- 42 6.95
- 47 6.00
- 50A5 1.50
- 50C5 0.95
- 50CD6G 1.15
- 50EH5 1.50
- 50JY6 2.95
- 52KU 2.00
- 53CG 15.00
- 61SPT 4.50
- 75B1 3.50
- 75C1 2.50
- 83 8.50
- 84 3.00
- 85A1 6.50
- 85A2 1.50
- 90AV 10.00
- 90C1 2.70
- 90CG 13.50
- 90CV 12.50
- 91AG 9.00
- 92AG 19.50
- 92AV 12.50
- 95A1 6.50
- 108C1 1.50
- 150B2 6.95
- 150C2 1.50
- 150C4 2.15
- 155UG 25.00
- 185BT 1.50
- 274A 15.00
- 307 5.00
- 328A 15.00
- 388A 17.50
- 425A5 8.00
- 431U 2.00
- 705A 8.00
- 708A 8.00
- 715A 6.00
- 715C 45.00
- 725A 275.00
- 803 14.95
- 805 39.00
- 807 1.95
- 810 45.00
- 811A 12.95
- 813 18.50
- 813USA 45.00
- 829B 14.50
- 833A 60.00
- 866A 4.50
- 872A 27.50
- 873 60.00
- 884 5.50
- 930 9.95
- 931A 13.95
- 954 1.00
- 955 1.00
- 958A 1.00
- 1299A 0.60
- 1619 2.50
- 1625 3.00
- 1626 3.00
- 2050W 4.50
- 2050 3.95
- 3545 4.00
- 404A 10.95
- 927 15.00
- 1927 25.00
- 4212E 250.00
- 4313C 4.00
- 4328D 9.00
- 5642 9.50
- 5651 2.50
- 5654 1.95
- 5663 1.95
- 5670 3.25
- 5672 4.50
- 5687 4.50
- 5692 3.50
- 5696 2.75
- 5704 3.50
- 5718 6.15
- 5725 2.50
- 5726 1.50
- 5727 1.95
- 5749 2.50
- 5750 1.85
- 5751 2.95
- 5763 4.95
- 5814A 3.25
- 5829WA 6.50
- 5636 5.50
- 5678 7.50
- 5840 3.50
- 5842 11.00
- 5847 10.95
- 5879 8.50
- 5886 13.95
- 5894 39.50
- 5899 4.50
- 5963 1.75
- 5965 2.25
- 6005 1.85
- 6012 16.00
- 6021 3.65
- 6057 2.50
- 6058 3.95
- 6059 3.75
- 6060 2.25
- 6062 4.50
- 6063 2.00
- 6064 3.25
- 6067 1.95
- 6072 4.20
- 6080 8.50
- 6080WA 8.50
- 6096 2.85
- 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 2.00
- 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
- 7233 7.95
- 7239 17.50
- 7247 2.95
- 7360 13.50
- 7462 15.00
- 7475 5.00
- 7486 75.00
- 7551 6.95
- 7558 9.45
- 7586 11.00
- 7587 26.95
- 7591A 4.95
- 7609 47.00
- 7733 5.50
- 7788 25.00
- 7868 3.95
- 8012 15.00
- 8042 55.00
- 8102 3.95
- 8106 2.95
- 8136 1.00
- 8156 10.95
- 8245 107.50
- 8298A 6.50
- 8417 5.95
- 9001 1.50
- 9006 0.90
- 18042 10.00
- 18045 10.00

THERMISTORS

- VA1040 0.23
- VA1056S 0.23
- VA1104 0.70
- VA8650 0.45
- VA1097 0.25

CALLERS WELCOME

★ ENTRANCE ON A227

50 YDS SOUTH OF MEOPHAM GREEN

CAR PARKING AVAILABLE

Open Mon-Thurs 9am—5.30pm Fridays 9am-5.00pm

★ 24 HOUR ANSWERPHONE SERVICE ★
ACCESS AND BARCLAYCARD ORDERS WELCOME
★ MANY OTHER ITEMS AVAILABLE ★

UK ORDERS P&P 50p PLEASE ADD V.A.T. AT 15%

EXPORT ORDERS WELCOME. CARRIAGE/POST AT COST

CIRCLE 53 FOR FURTHER DETAILS.

COMPACT disc DIGITAL AUDIO

Principles of optical storage – 2

by J.R. Watkinson

Focus and tracking mechanisms

The Compact Disc and its supporting equipment uses a dramatic cross-section of modern technology. The use of data converters, lasers, l.s.i. circuits, servos, error correction, advanced channel codes, video equipment, photochemistry, moulding and electroplating alone makes the CD system worthy of study by anyone interested in contemporary electronics. This series describes the system in detail and shows how many of the parameters were arrived at. Mathematics is kept to a minimum and buzzwords defined as they occur.

The requirement for a monochromatic light source is economically met using a semiconductor laser. The laser output requires stabilization, since the output is very temperature dependent. To prevent thermal runaway, a feedback photodiode controls the current source feeding the laser. To extract a useful signal, the pickup must be capable of separating the reflected light from the incident light. Fig.7 shows two schemes to do this.

In (a) a half-silvered mirror reflects some of the returning light into the photosensor. This is not very efficient as some of the reflected light is lost by transmission. In the example shown at (b) the separation is by polarization. A polarizing prism passes light from the laser which is polarized in a plane at right angles to the page. This light is passed through a quarter-wave plate that rotates the plane of polarization through 45°. Following reflection from the disc, the light is again rotated through 45°, making the plane of polarization parallel to the page. The polarizing prism reflects this light into the sensor.

Stresses set up by moulding plastic can cause birefringence, so there have been some reservations about the feasibility of the second approach. The quality of disc moulding achieved, however, meant that birefringence could be neglected, and the polarizing beam splitter is used widely in the Sony consumer CD players, for example. Sony professional players and Philips players retain the semi-silvered mirror approach.

As the frequency response of he replay mechanism (unrelated to the audio response) of the spot size, care must be taken to keep the beam focused on the information layer. Disc warp and thickness irregularities cause focal plane movement beyond the depth of focus of the optical system, and a focus servo is needed. The depth of focus of the optical system, and a focus servo is needed. The depth of field is related to the numerical aperture which is defined, and the required accuracy of the focus servo follows from that: approximately $\pm 1\mu m$.

The focus servo moves a lens along the optical axis to keep the spot in focus. Because dynamic focus changes are largely due to warps, the focus system must have a frequency response in excess of the disc rotational speed. A moving coil actuator is often used for this owing to the small moving mass which this permits. A cylindrical magnet assembly is used, coaxial with the light beam; Fig.8 shows that it is almost identical to that of a loudspeaker.

Focus error system

A focus error system is necessary to drive the lens: Here are a number of ways in which this can be derived.

A cylindrical lens is installed between the beam spliter and photosensor, Fig.9. its effect is that the beam has no focal point on the sensor. In one plane, the lens appears parallel-sided, and has negligible effect on the focal length. The image is an ellipse whose aspect ratio changes as a function of position. Between the two foci, the image will be circular. The aspect ratio of the ellipse, and hence the focus error, is determined by dividing

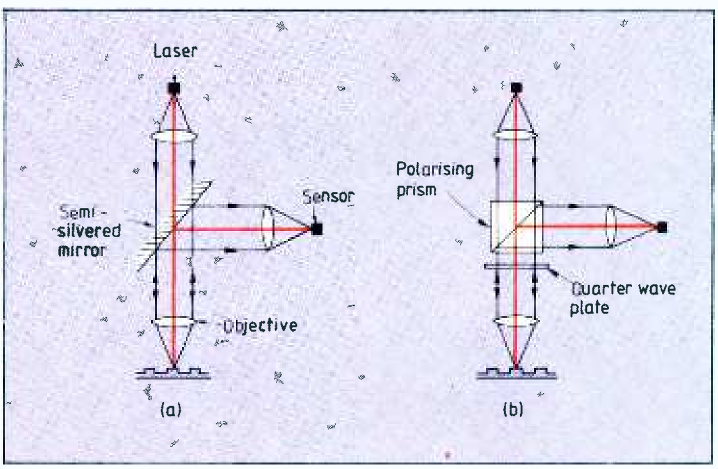


Fig.7. **Two schemes to separate reflected and incident light. Light from the disc can be directed to the sensor by a semi-silvered mirror (a), or a combination of polarizing prism and quarter-wave plate can separate the beams (b).**

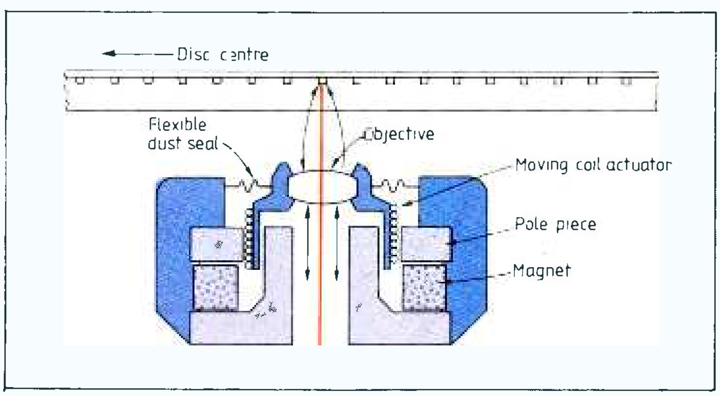


Fig.8. **Moving-coil focus servo can be coaxial with the light beam. Magnet assembly is almost identical to that of a loudspeaker.**

Fig.9. **In the cylindrical lens or astigmatic focus method an elliptical spot on the sensor, whose aspect ratio is detected by its four-quadrant nature, produces a focus error signal.**

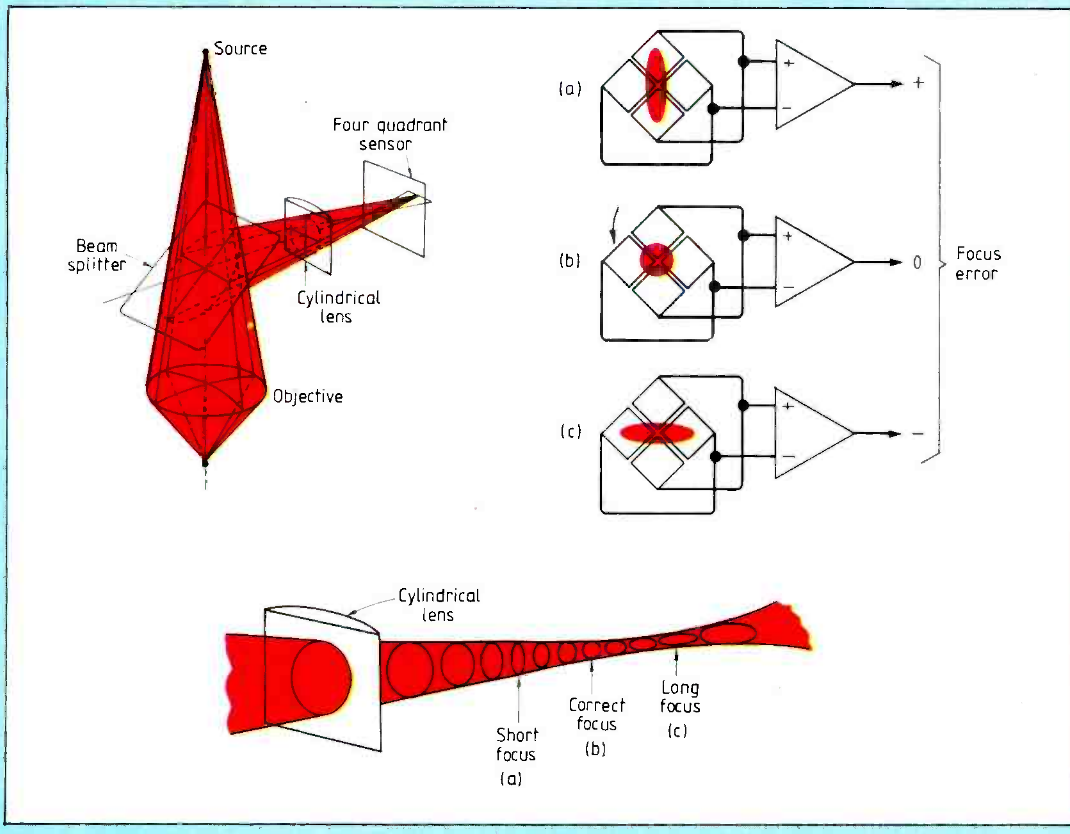
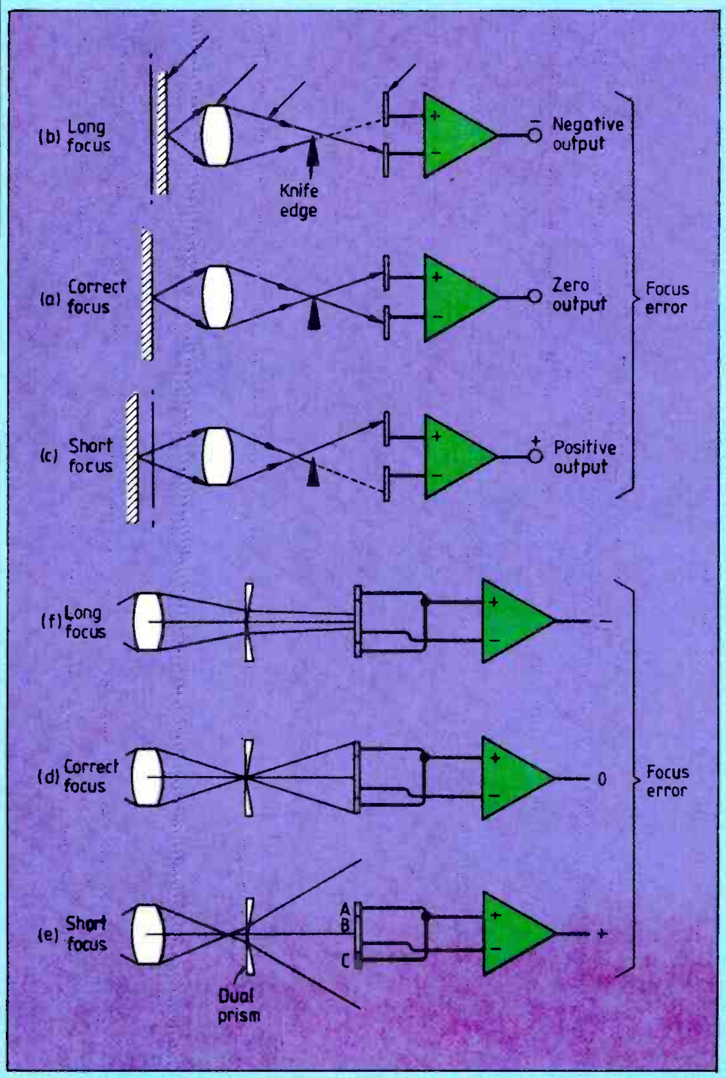


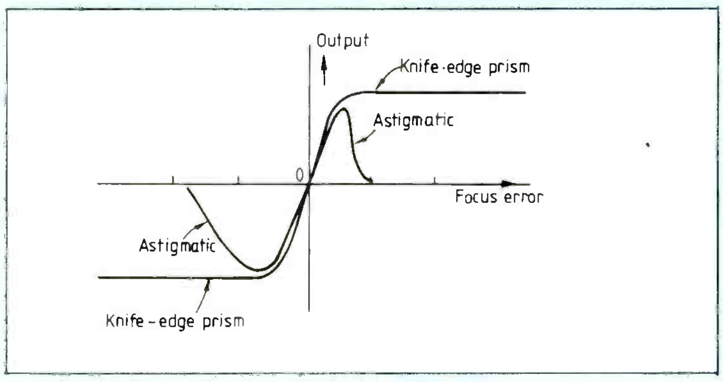
Fig.10. **Knife-edge focus method requires only two sensors, but is very critical on knife-edge position.**

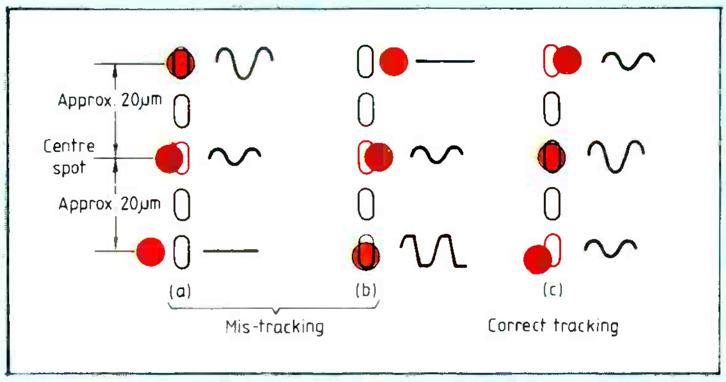


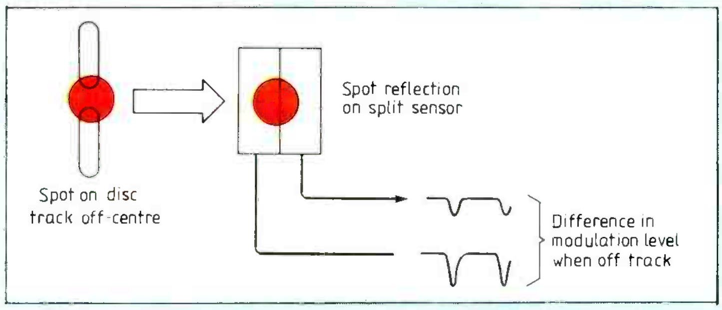
the sensor into four quadrants. Connected as shown, a focus error signal is generated. The readout signal is the sum of the four quadrant signals.

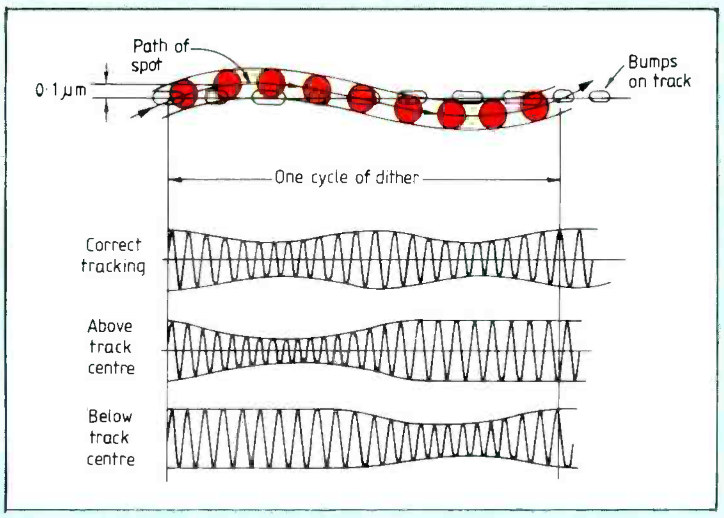
In the knife-edge method of determining focus, a split sensor is also required, Fig.10. At (a) the focal point is coincident with the knife-edge, and it has no effect on the beam. At (b) the focal point is to the right of the sensor. At (c) the focal point is to the left of the knife-edge and descending rays are interrupted, reducing the output of the lower sensor. The focus error is produced by comparing the output of the two halves of the sensor. A drawback of the knife-edge system is that the lateral position of the edge is critical, and adjustment is necessary. To overcome this problem, the knife-edge is replaced with a pair of prisms, shown at (d) to (f). Mechanical tolerances only affect the sensitivity, without causing a focus offset.

The cylindrical lens method is compared with the knife-edge prism method in Fig. 11, which shows that the cylindrical lens method has a much smaller capture range. A focus-search mechanism will be required, which moves the focus servo over its entire travel, looking for a zero crossing. At this









time the feedback loop can be completed and the focus servo will remain on the linear part of the characteristic. The spiral track of CD starts in the centre and works outwards. This is deliberately arranged because there will be less vertical run-out near the hub, and initial focusing easier.

Track following

The track pitch is only 1.6μm, much smaller than the accuracy to which the player chuck or the disc centre hole can be made. A track-following servo keeps the spot centralized on the track in one of several ways.

In the three-spot method, two additional light beams are focused on the disc track, one offset to each side of the track centreline. Fig.12 shows that the amplitude of the side spot modulation changes differentially with tracking error. The laser head contains a diffraction grating to produce the side spots, and two extra photosensors onto which the reflections of the side spots are focused. The side spots feed a differential amplifier.

A tracking error can be derived from a split sensor, because one side detects more modulation than the other when off track, Fig.13. Such a technique may be prone to develop an offset, due either to component drift or to contamination of the optical system and a further tracking system may be necessary to obviate periodic adjustment.

The dither-based system resembles in many respects the track following mechanism of C-Format v.t.rs. A sinusoidal drive is fed to the tracking servo, Fig.14, causing a radial oscillation of spot position of about ±50nm. This results in modulation of the envelope of the readout signal, which can be synchronously detected to obtain the sense of the error. The dither can be produced by vibrating a mirror in the light path, which enables a high frequency to be used, or by oscillating the whole pickup at lower frequency.

It is interesting to compare different designs of laser pickup. In the Philips laser head (Fig.15) the dual-prism focus method is used, which combines the output of two split photosensors to produce the focus error. The focus amplifier drives the objective lens which is mounted on a parallel motion

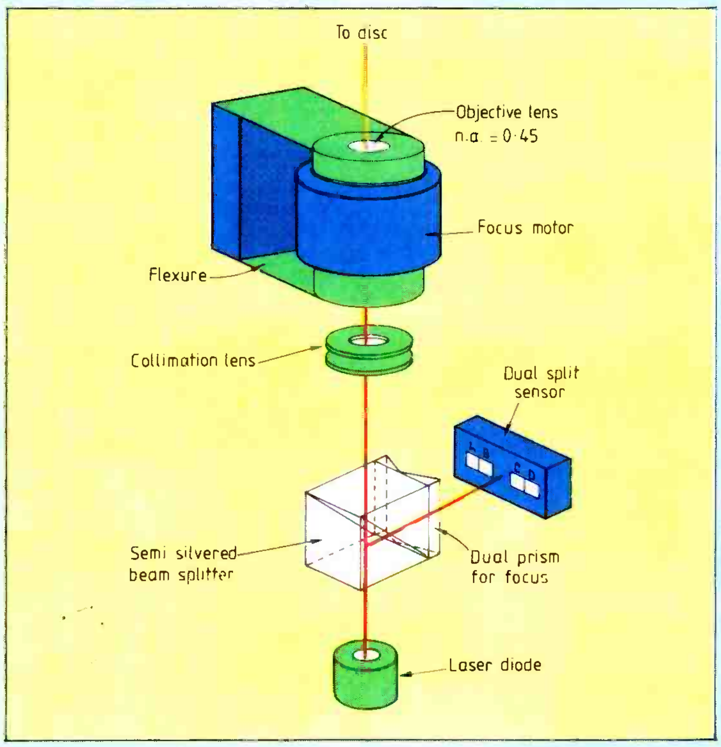


Fig.11 Knife-edge method may have a capture range of 1mm, whereas the astigmatic (cylindrical lens) may have a range of only 40μm, requiring a focus-search mechanism.

Fig.12. Three-spot method of producing tracking error compares amplitude of side spot signals. Side spots are produced by a diffraction grating and require their own sensors.

Fig.13. Split-sensor method of producing tracking error focuses image of spot onto sensor. One side of spot will have more modulation when off-track.

Fig.14. Dither applied to readout spot modulates the readout envelope, to enable a tracking error signal to be derived.

Fig.15. In the Philips laser head, focus error is derived by the dual prism method, using split sensors. Focus error (A+D)−(B+C) drives focus motor which moves objective lens on parallel action flexure. Radial differential tracking error is derived from split sensor (A+B)−(C+D). Tracking error drives entire pickup on radial arm driven by moving coil.

formed by two flexural arms. Capture range of the focus system is sufficient to accommodate normal tolerances without assistance. A radial differential tracking signal is extracted from the sensors as shown in the figure.

Additionally a dither frequency of 600Hz produces modulation which is synchronously rectified to produce a drift-free tracking error signal. Both errors are combined to drive the tracking system. As only a single spot is used, the pickup is relatively insensitive to angular errors and a rotary positioner can be used, driven by a moving coil. The assembly is statically balanced for good resistance to lateral shock.

In the Sony laser head, used in consumer players, Fig.16, the cylindrical lens focus method is adopted, requiring a four quadrant sensor. As this method has a small capture range, a focus-search mechanism is necessary so that when a disc is loaded the objective lens is ramped up and down while the focus circuit looks for a zero-crossing in the focus error. The three-spot method is used for tracking; the necessary diffraction grating can be seen adjacent to the laser diode.

Tracking error is derived from side spot sensors (E − F). Because the side-spot system is sensitive to angular errors, a parallel-tracking laser head is essential. Cost-effective linear motion is obtained by using a rack and pinion drive for slow coarse movements, and a laterally moving lens in the light path for rapid fine movements, and a laterally moving lens in the light path for rapid fine movements.

The same lens is moved up and down for focusing by the so-called two-axis device, which is a dual moving-coil type of mechanism. Unfortunately the two-axis device is not statically balanced in many players, making them more shock sensitive than necessary, though the problem was overcome in laser heads designed for portable players.

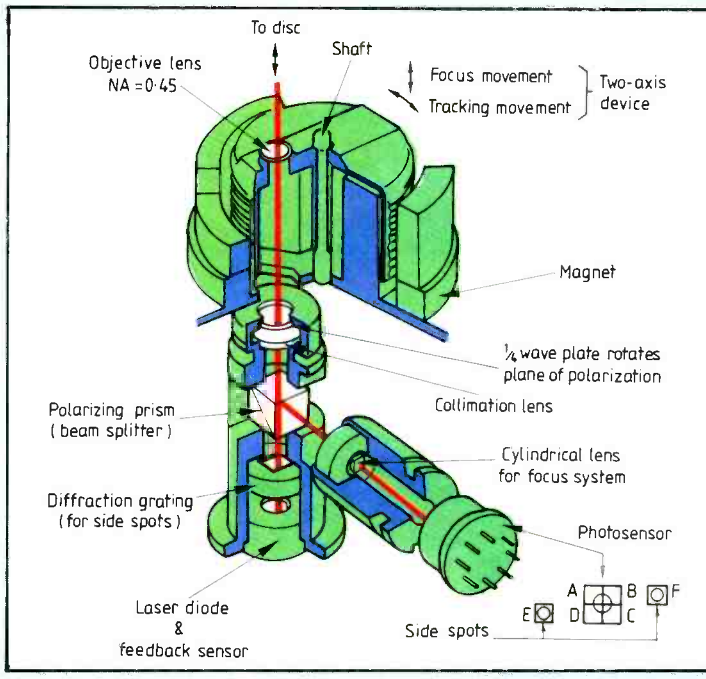


Fig.16. **The Sony laser head uses a four-quadrant sensor and two extra sensors (E,F) for the side spots. Tracking error (E−F) and focus error (A+C)−(B+D) drive the two-axis device.**

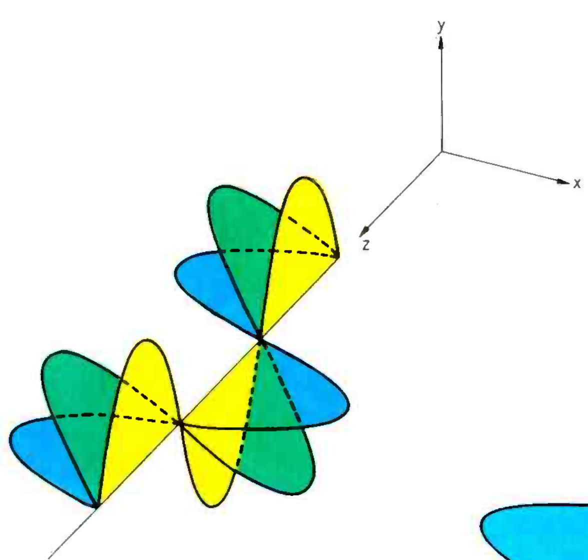
Background note on optical polarization

Polarization. In natural light, the electric field component is in many planes. Light is said to be polarized when the electric field direction is constrained. The wave can be considered as two orthogonal components. When these are in phase, the polarization is said to be linear. Where there is a phase shift between components, the polarization is said to be elliptical, with special cases at ±90° known as circular polarization.

To create polarized light, anisotropic materials are generally necessary. Polaroid material, invented by Edwin Land, vinyl which is made anisotropic by stretching whilst hot. Oriented long-chain molecules form a structure that is rendered conductive by soaking in iodine. The transmission axis is perpendicular to the direction of stretching, since electric fields parallel to the long chains are absorbed.

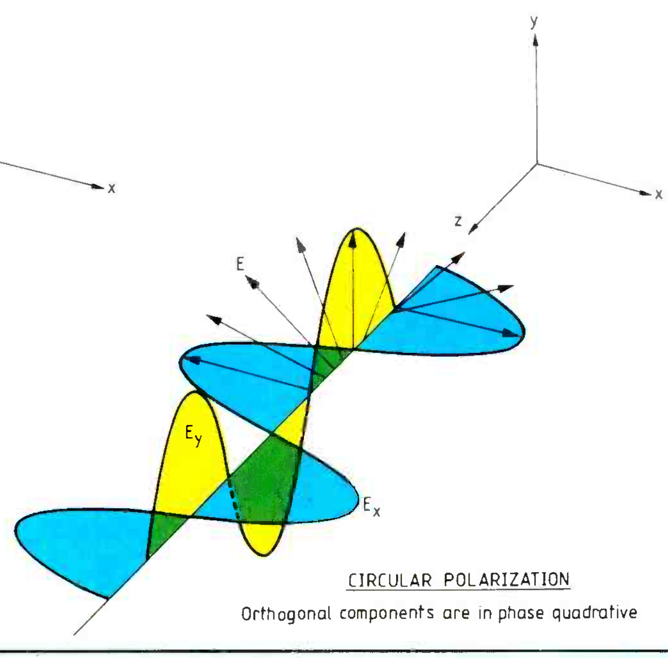
A material whose refractive index is anisotropic is said to be birefringent. If a linearly polarized wavefront enters such a medium the two orthogonal components propagate at different velocities, causing a relative phase difference proportional to distance. Where the thickness of the material is such that a 90° phase difference is caused, the device is a quarter-wave plate. Where the plane of polarization of the incident light is at 45° to the axes of greatest and least refractive index, the two orthogonal components will be equal in magnitude, and the result will be circular polarization.

Similarly, incident circularly-polarized light will be returned to the linear state. Thus linearly-polarized light which has passed through a quarter-wave plate and been reflected back again will be linearly polarized but in a plane at right angles to that of the incident light. This principle can be used in conjunction with a polarizing prism that passes light in one plane but reflects light in the other plane.



LINEAR POLARIZATION

Orthogonal components are in phase



CIRCULAR POLARIZATION

Orthogonal components are in phase quadrative

Variable-speed video playback

By
J.R. Watkinson, B.Sc., M.Sc.
Ampex (G.B.) Ltd.

The series concludes with a discussion of digital filtering

The type of digital filter used in TBCs is the equivalent of the analogue delay-line comb filter. The entire approachh to TBC design is that delay is easy to achieve in the digital domain, and this applies equally to the delays in the filters.

The operation of an analogue filter will be examined first, since this will be used as an analogy in the description of the digital filter.

Reference to Fig. 9(a) shows that an input signal enters an operational amplifier both direct and via an analogue delay. The phase difference between the ends of the delay is a function of the input frequency, and is given by:

$$\frac{\text{delay period}}{\text{signal period}} \times 360°$$

The op-amp output is the vector sum of the two inputs:

$$\tfrac{1}{2}V_{in} + \tfrac{1}{2}V_{in} \sin \theta$$

where θ is the phase angle between the inputs. When the delay period exceeds the signal period, the phase difference given by the first expression will exceed 360°, and clearly subtracting 360° or multiples thereof does not change the vector sum. There will thus be a series of signal periods all of which have the same gain. The frequency response becomes repetitive, hence the term 'comb filter'. Figure 9(b) shows several frequencies, all of which suffer complete cancellation due to effective inversion by the delay, and Fig. 9(c) shows frequencies which give unity gain because the delay is an integer multiple of the signal period. Figure 9(d) shows the overall frequency response, which has a rectified cosine shape. Note that the peak spacing is at the reciprocal of the delay period.

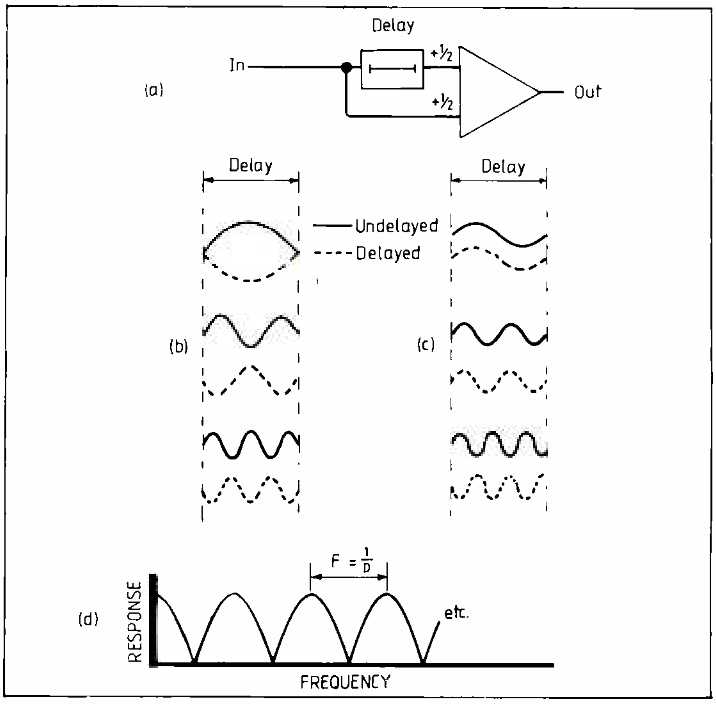
A sharper response peak can be achieved by using two delays, as in Fig. 10(a). The op-amp now has three inputs. Figure 10(b) shows the situation where a frequency which suffers 180° shift in each delay is applied. Since the twice delayed signal and the input signal will add, they must receive half as much gain as the signal from the centre tap. The op-amp thus has input gains of $+\frac{1}{4}$, $-\frac{1}{2}$ and $+\frac{1}{4}$. The frequency response shown in Fig. 10(d) is a cosinusoid, in which the peak spacing is the same as for Fig. 9.

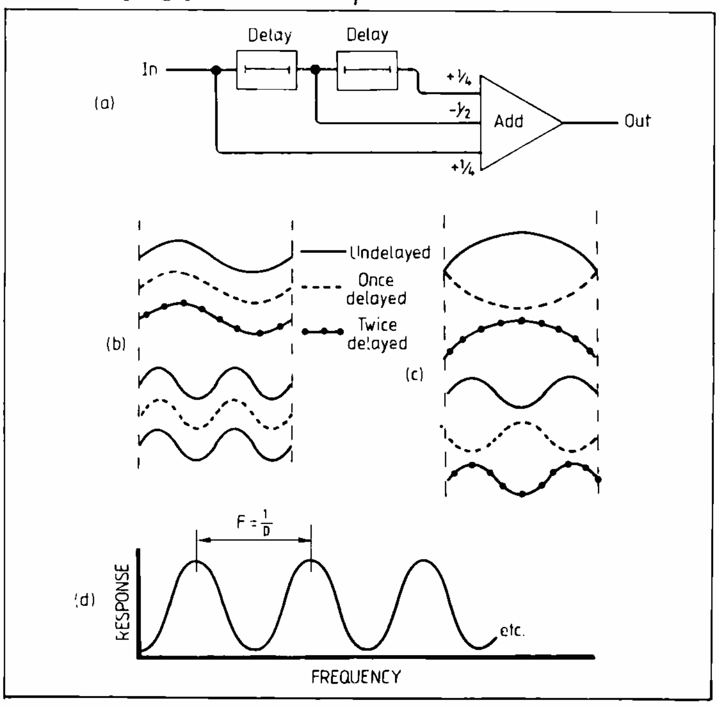
Figure 11 shows a relative of the two-delay filter of Fig. 10. The difference is that the weights and phases of the inputs are all the same at $+\frac{1}{3}$. When the input frequency suffers a phase shift of 120° there will be complete cancellation. The system acts as a comb filter with the response shown in Fig. 11(b), where the first null is at one third of the reciprocal of the delay.

Transferring to the digital domain, signal voltage is represented by a binary number, delay is achieved using latches, and a full adder performs the function of the op-amp. Figure 12 shows the digital equivalent of Fig. 10. The constraint in this kind of digital filter is that the delay periods available are all integer multiples of the sampling period. As the

Fig.9. Simple comb filter at (a) has delay in one input of adder. At some frequencies, (b) delay causes cancellation, whereas at others (c) delayed and undelayed signals are in phase. Frequency response shown at (d).

Fig.10. Two-delay comb filter at (a). In (b) certain frequencies suffer 360° shift in one delay, but since once-delayed signal has twice the weighthing, there is cancellation. At (c) is 180° resultant phase shift in one delay, removed by inverting input, permitting unity gain. Response at (d) is cosinusoid.





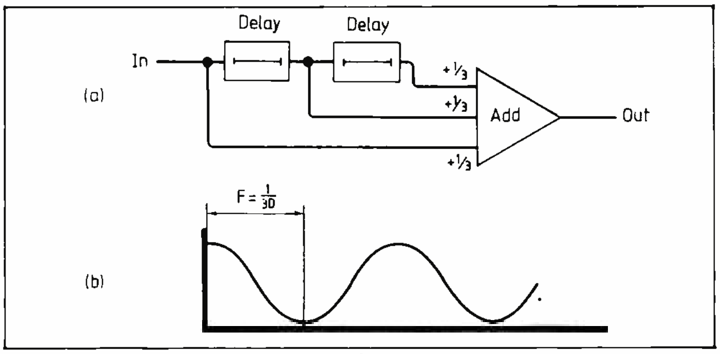


Fig.11. **Comb filter working on 120°delays to give cancellation. Response at (b). Nulls are 1/3D, 2/3D, etc.**

Fig.12. **Digital Y/C separation at 4 × F_{sc} uses pairs of latches to give 180° phase shift at subcarrier frequency. Binary adders and dividers give weighting of +¼, −½, +¼ to three samples. Chroma output is subtracted from the input to give luminance. Compare with analogue filter of Fig.10. There is only one response peak at F_{sc}, since Nyquist limit for 4×F_{sc} sampling is reached at 2×F_{sc}.**

delay period is intimately related to the frequency response, the desired response and the sampling rate largely determine the filter configuration. It is also important to note that there is an upper frequency response set by the Nyquist limit at half the sampling rate, so that only a few teeth of the comb will be visible.

Y/C separation requires selective response around subcarrier frequency, and sampling rate will be 3× or 4× subcarrier. Figures 10 and 12 show filters where a phase shift of 180° is necessary at the null frequency. 180° of phase shift in the digital domain is conveniently achieved by a delay of two samples at 4×F_{sc} sample rate, and this configuration would be used for a TBC working at that rate. Figure 11 showed a filter which needed a delay of 120° at the null frequency, which corresponds to a single sample period at 3× F_{SC}. Figure 13 shows a digital filter for a 3× F_{Sc} TBC. Since division by three is difficult in binary, a close approximation is given by multiplying by 85 (64+ + 16× + 4× + 1×) and dividing by 256 (eight-bit shift).

The 4 × F_{sc} filter of Fig.12 has a gain peak at subcarrier frequency, and the output will be chroma. To obtain luminance, chroma samples are simply subtracted from input samples. The 3 × F_{sc} filter of Fig.13 has a gain null at subcarrier, and the output will be luminance. In this case chroma is obtained by subtracting the filter output from the input samples. In each case separate sample streams of luminance and chrominance result.

Owing to V-switch it is necessary to store two lines of chroma, but only one of luminance, and this storage can be ram or shift registers. During a dropout, samples from the luminance memory and the appropriate chroma memory are selected instead of input samples. A dropout during the burst will leave the luminance intact, but will destroy the chroma for the entire line. This is usually referred to as chroma dropout, and is dealt with by using 2H previous chroma for the entire line, in conjunction with the current luminance.

Figure 14 shows the 3 × F_{sc} DOC of the Ampex TBC-2. Input data are Y/C separated and the chroma is subject to a 1H delay before being combined with the luminance once more. This has the effect of adding previous line chroma to current luminance. The composite signal then suffers a further 1H delay, making the output the requisite 1H prior luminance with 2H prior chroma. The elegant position of the Y/C adder eliminates the need for a separate 1H Y delay. During dropout, the multiplexer selects memory data instead of input data, and these data are also recirculated to the memory inputs to prevent bad data entering the system. This DOC precedes the main memory and is operated almost directly by the v.t.r. r.f. level.

At the opposite extreme is the Sony BVT 2000 shown in Fig. 15. Since this unit offers colours in shuttle and Y interpolation during odd/even field mismatch, it is necessarily complex. As luminance interpolation requires a dedicated 1H delay, there are three memories, luminance, +V chroma and −V chroma. This DOC resides after main memory, so that it works at reference timing. The dropouts which it corrects took place several lines earlier owing to the advance of the v.t.r. The TBC must store for each line of video additional data which records where any dro-

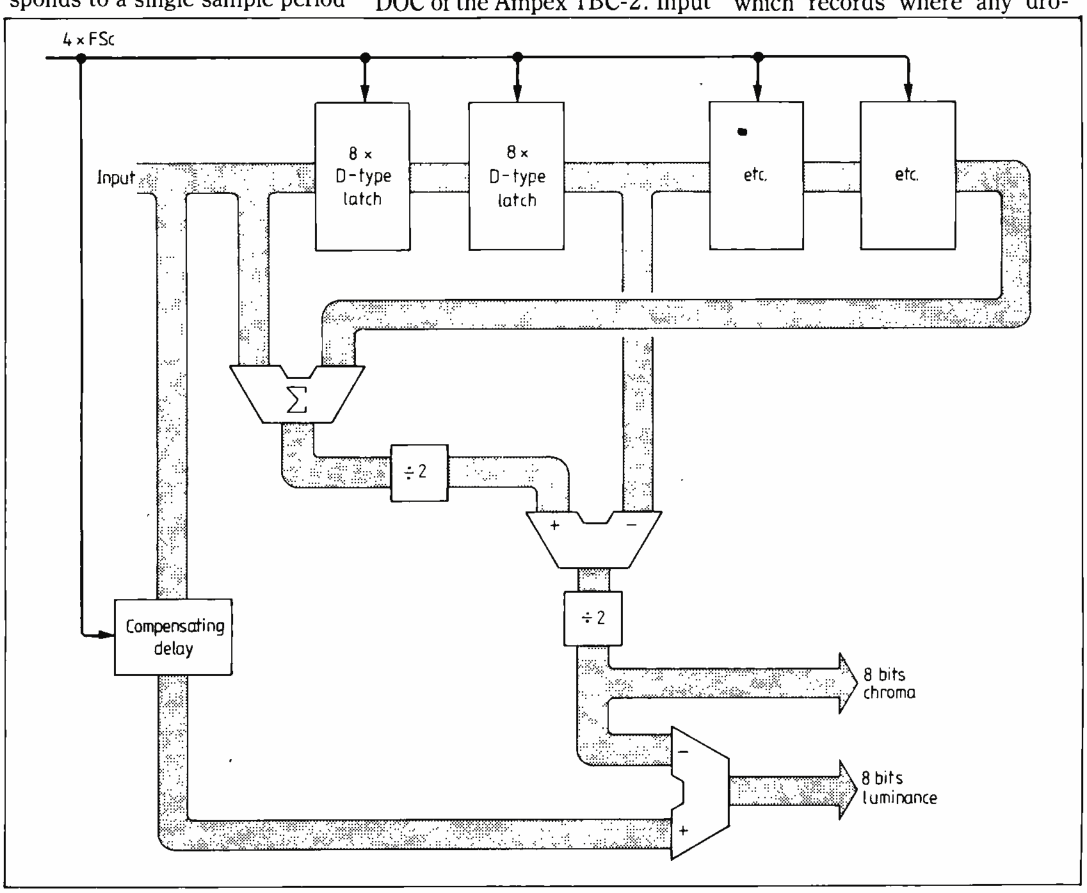
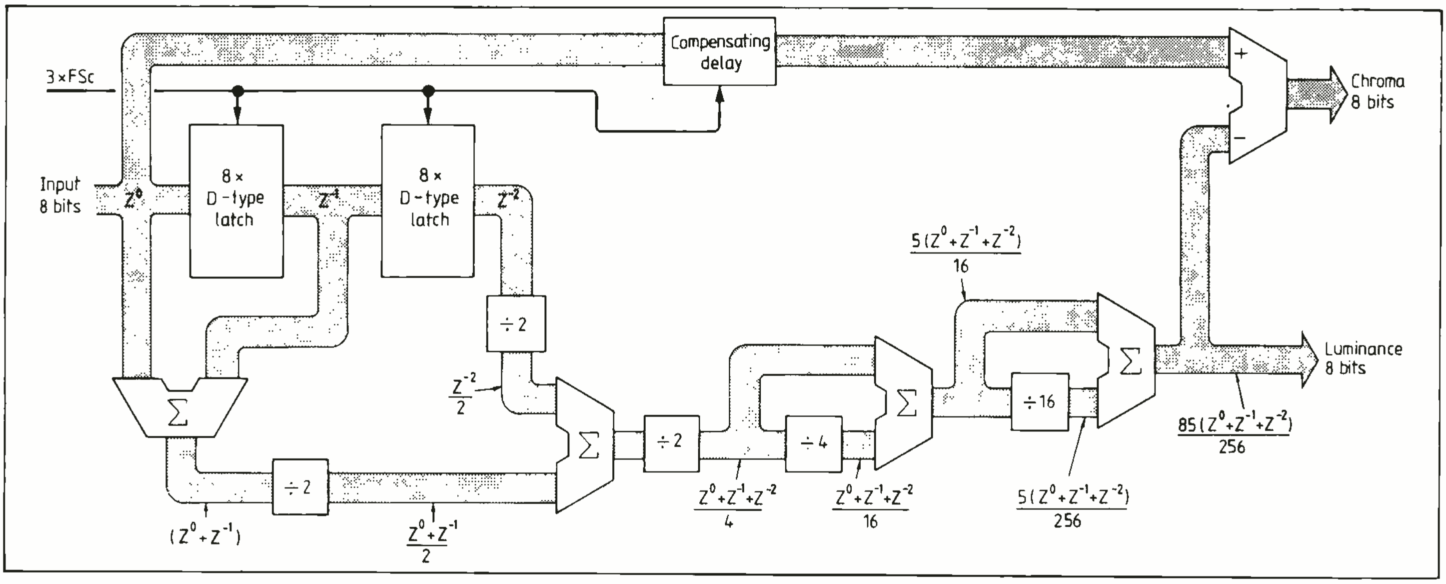


Fig.15. Opposite page **BVT-2000 DOC incorporates luminance interpolation for second field synthesis. Plus and minus V chroma memories are selected alternately at 7.8kHz. During long dropouts in shuttle, plus/minus control inverts chroma every two lines (3.9kHz). Dropout inhibits writing the delays, preventing corrupt data entering the system.**



pouts occurred. This is the function of the Y DO memory. Similarly burst dropouts are remembered in the C DO (Chroma Dropout) memory.

Normal dropout compensation consists of selecting 2H previous chroma for the entire line, and 1H prior luminance at the points determined by the Y DO memory. In shuttle, the head may jump within the field, causing a long dropout as the head crosses the guard band. In this case, the data from before the dropout are repeated until valid video from the new track resumes. Owing to the PAL four line sequence, the chroma must be taken on alternate lines from the +V and −V memories, (7.8kHz) and every pair of lines, chroma must be inverted by subtracting it from luminance instead of adding (3.9kHz).

During interpolation, the Y ADD signal will cause 1H prior luminance and current luminance to be averaged by adding and dividing by two. Chroma with the appropriate V-sense is then added. Since Y interpolation depends on spatial alignment of samples on adjacent lines in a field, the BVT 2000 uses phase alternate line encoding (see Part 2) to overcome the 3.9kHz rate burst inversion relative to H sync.

The memory system of this unit thus has five separate elements: video, luminance dropout position, chroma dropout status, chroma inversion status and velocity error.

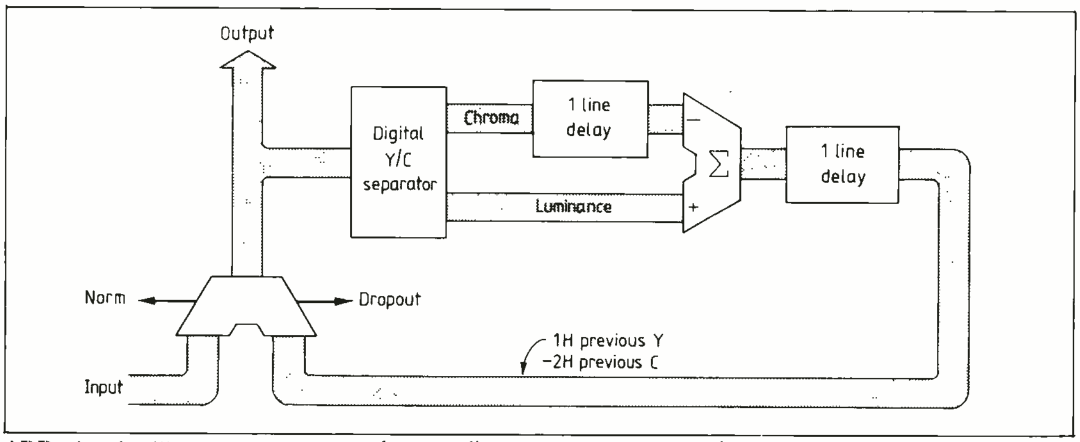
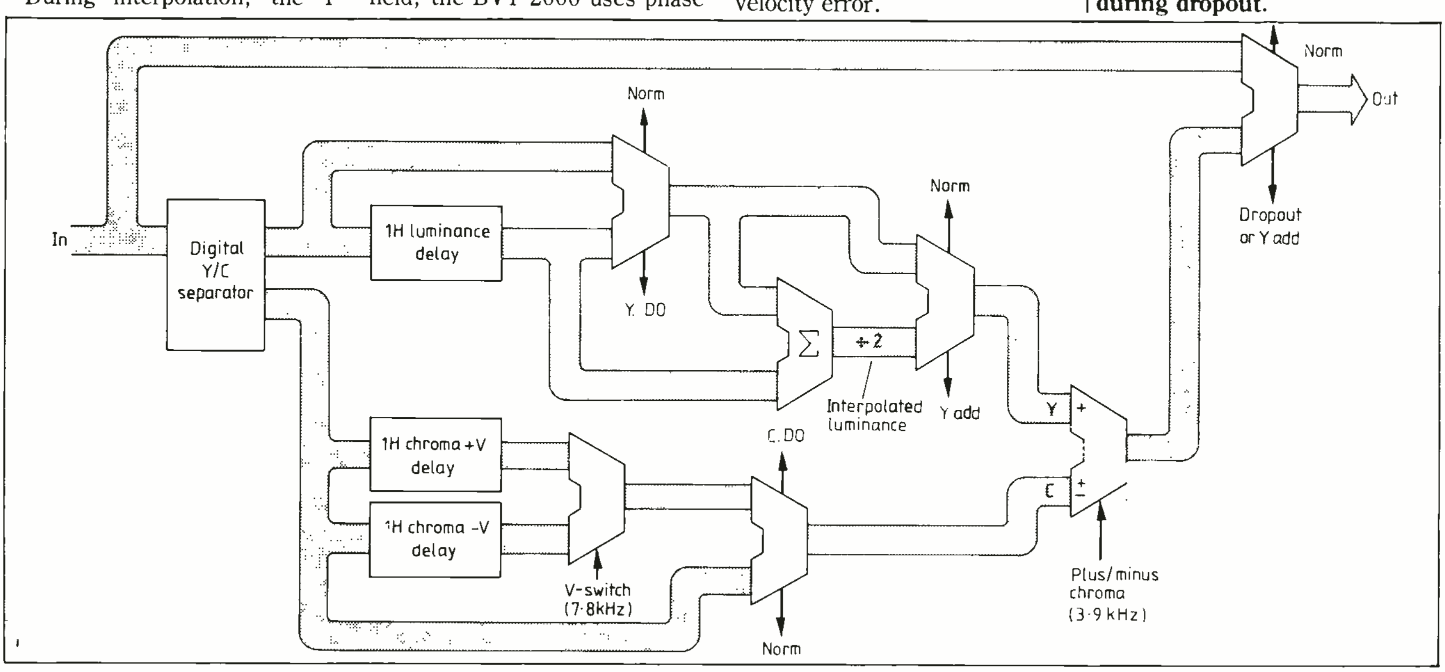


Fig.13. 3 × F_{sc} Y/C seperation approximates closely to divide by 3 of Fig.11.

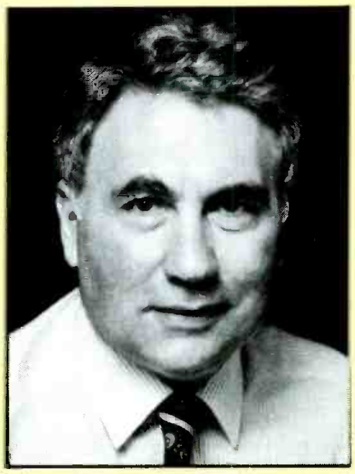
Fig.14. DOC of TBC−2 saves 1H of memory by combining Y and C after first chroma delayy. Input MUX switches to previous line information during dropout.



Choosing quartz crystals

These complex components are seldom properly understood — even by those who specify them

by Gordon Hulyer



Gordon Hulyer is quality assurance manager at Cathodeon Crystals in Linton, Cambridge. He is active on both British and international standards committees for piezoelectic devices.

Raw material and finished product — a group of glass-holder quartz crystals.

There are two aspects of quartz crystals used as frequency controllers which are opposite yet equally valid. One is that they are essentially simple components with only two terminals; that simplicity has ensured their continued and expanding use since they were first used for radio more than 40 years ago. The other is that they are complex components, seldom properly understood even by those who specify them for use in electronic circuits.

It is this second aspect that this article seeks to expound in the interests of users, because failure to specify the correct type of unit for a specific task can result in unnecessary cost as well as failure in performance. For example, it pays to be very specific about the temperature range within which the unit will operate. Failure to do so may result in a crystal exhibiting unwelcome errors in service.

Furthermore, the most important development of quartz crystals in recent years has been the improvement in long-term stability or ageing properties, as a result of improved cleaning and encapsulation techniques, so it is important to make the right choice in relation to this, among many other parameters.

Because quartz crystals are piezoelectric devices, relying on mechanical motion to generate electrical properties, they are susceptible to mechanical as well as electrical problems. Thus stiction (static friction) manifests itself, in electrical terms, as a variation in crystal impedance with drive level; and as with mechanical stiction, the impedance characteristic has hysteresis. For this reason, it is extremely difficult to specify a quartz crystal in such a way that it will operate reliably in an unspecified semiconductor circuit — particularly a circuit designed for low power consumption, as this is usually associated with a situation where the crystal is being driven at a low drive level, i.e. in the region of maximum stiction.

The crystal

Need for care in specifying crystal units arises from the methods employed to manufacture them. In fact a specification will effectively determine how the unit is or has been made, and with the now widespread use of integrated circuis instead of discrete components it has become even more important to exercise care.

Each crystal unit is cut from the mother crystal at a precise angle in relation to the crystallographic axis; this angle — usually the "AT angle" — is chosen in relation to Young's modulus of the material, the piezoelectric coupling, and the acoustic velocity, in such a way as to produce a crystal which, in its performance, will be as nearly independent of temperature as possible. After cutting, the crystals are individually sorted into several grades, and then all are lapped to within a half light-band of flatness. Electrodes subsequently deposited on the opposite faces of the crystal serve not only as electrical contacts but also finalise the frequency of the unit: by precise, automatic deposition of the thin gold or silver electrode the physical mass of the unit can be adjusted to give the desired frequency.

The required operating temperature range and frequency tolerance will therefore determine

What is a quartz crystal?

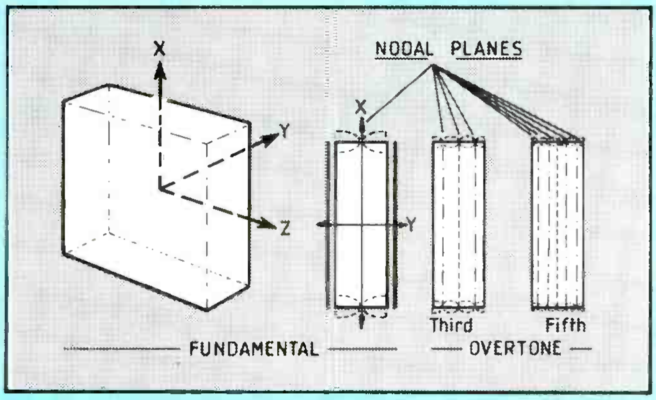
A quartz crystal is cut from a bar of manufactured quartz. It is cut very precisely in relation to the crystallographic axis of the crystal and is formed into a thin disc, rather like an optical lens. Two electrodes are secured to it, one on each side, by vacuum deposition of silver, gold or aluminium.

When a voltage is applied to the electrodes the crystal changes its shape due to its piezoelectric properties, thus causing a stress to be applied to the crystal. If this stress is varied by reversing the applied voltage, the crystal will be subjected to an alternating stress and will tend to vibrate at its natural frequency. Thus resonance is initiated. The frequency of resonance is so precise with quartz crystals that they can serve as frequency determining devices, and they are considerably more precise than a tuning fork because of the high purity of the quartz material.

A quartz crystal may operate in its fundamental mode — generally up to 30MHz — or at the third, fifth, etc., overtones, as shown below. The mode of vibration is in thickness shear, so the critical dimension controlling the frequency is in "Y", i.e. the thickness of the plate. The vibrations are shown extending to the edge of the plate, but in practice the plate is designed to confine the vibrations to the centre, in the area of the exciting electrodes.

Strictly speaking, this unit is a resonator. When it has been encapsulated — in one of several possible ways — it then becomes what is generally known as a "quartz crystal". If the quartz crystal is then built into a appropriate electronic circuit it becomes a quartz crystal oscillator, i.e. a complete frequency controlling system.

Relevant crystal theory is summarized on page 54. For those who wish to study the relevant standards, refer to British Standard 5069, for standard outline and pin connections of quartz crystal units, and to those listed on page 54.



how the crystal plate is cut in relation to the crystallographic axis of the raw material. Its geometric shape and diameter are determined by the parameters L, C_1, R, and C_0 amongst others (see section headed "Parameters").

The crystal electrode material, its method of deposition, and mass are all determined by what is specified by the user. In the event of a particular parameter not being specified, it will almost certainly mean that the unit supplied may not necessarily be the one needed. It will have been made by one of the manufacturer's standard methods, which may or may not match the user's requirements.

Holders

Crystal holders are of four types, and are universally known by their names: solder seal, resistance weld, cold weld, and glass.

Solder-seal holders, the least expensive, suffer from poor long-term ageing performance as it is impossible during manufacture to completely eliminate the flux residue. Also it is extremely difficult to achieve the low level of leaks required for good long-term performance. They should therefore be considered only when there is nothing of equivalent dimensions available in one of the other types.

Resistance-weld holders are currenly the most popular form of encapsulation. They are a distinct improvement on solder seal holders, but they require local heating during the welding operation and are therefore not as reliable as cold-weld or glass holders. Except where ultra-high long-term stability is required, resistance-weld holders can be used for all applications. Typical uses are for microprocessors, data communication modems, pageing systems, mobile and portable radio, and military communications. The resistance-weld method gives a good clean construction at relatively low cost.

Cold-weld holders are more expensive, but they give an improvement in long-term ageing compared with resistance-weld units, and a significant improvement over solder seal. The encapsulation is achieved by heatless welding of the can and base — a very high pressure being applied over a localized area to cause the two surfaces (usually copper) to flow together to form a homogeneous bond. The process is carried out in a vacuum or in nitrogen. There is thus neither flux residue nor local heating of any significance. The two surfaces, however, must be free of contamination and oxidation, and this is usually ensured by depositing a thin layer of nickel place on each surface so that the nickel ruptures during sealing. For applications similar to those for resistance-weld holders, cold-weld holders may therefore be preferred if price constraint is not a major factor.

Glass holders are 'a must' for applications where ageing is of paramount importance. The base and envelope are sealed together by radio-frequency heat melting the two surfaces so that they fuse together. By means of a ring of Kovar (a nickel-iron alloy having the same coefficient of expansion as glass), the heat is concentrated in the contact area, and the whole process is carried out under vacuum after de-gassing at about 500°C to remove any organic matter. The main applications for glass holders are frequency standards, satellite navigation, measuring instruments, microwave beacons, and synthesizers.

Parameters

There are at least ten parameters affecting the choice of a quartz crystal unit. The properties of a quartz crystal can be represented by an equivalent circuit consisting of an inductor L, capacitance C_1, resistance R, shunted by a second capacitance C_0, as shown on page 54. Capacitance C_L is an external load capacitance specified, if required, by the user.

These four parameters are constant and independent of frequency and amplitude changes, providing the crystal unit is operated in the correct way. The parameters L, C_1 and R are termed the "motional parameters" of the unit; f_s is the series mode, f_p the parallel mode.

A manufacturer or supplier needs to know, in addition to the nominal operating frequency, the following, which significantly affect the design criteria:

- frequency accuracy (calibration or adjustment tolerance)
- frequency stability with temperature
- frequency stability with time (ageing).

These first three parameters constitute the 'accuracy' of the crystal. They should be selected with care as unnecessary over-specifying only serves to make the crystal more expensive. Typical values for the four types of holder are given in Table 1. Other

Pretty, but seldom used nowadays in the manufacture of crystal units, except in very low frequency applications: yield is much higher with synthetic quartz.

important parameters are
- operating temperature range
- maximum resonant resistance (e.s.r.) (R)
- motional inductance L or motional capacitance C_1
- parallel capacitance C_0
- power dissipation (drive level)
- unwanted responses
- holder style
- load capacitance (C_L)
- environmental factors.

The choice of holder is determined mainly by (1) the long-term stability required, (2) environmental factors, (3) operating frequency (blank diameter), and (4) the price the user is prepared to pay. If the crystal is to be used in a potentially hostile environment, e.g. guided missile and satellite applications, it is important to consult the manufacturer as a ruggedized mounting can be chosen to suit the particular application.

Applications

Table 2 gives typical application in order of cost, starting with the most expensive, set against certain general parameters and other features.

From a manufacturing point of view, the lower unit costs are associated with the larger volumes of production. It is not practicable to correlate the four types of holders directly with this list, though the glass holders would normally only be used for the upper group of applications and some of the second group. It is advisable to consider resistance-weld holders for all other applications.

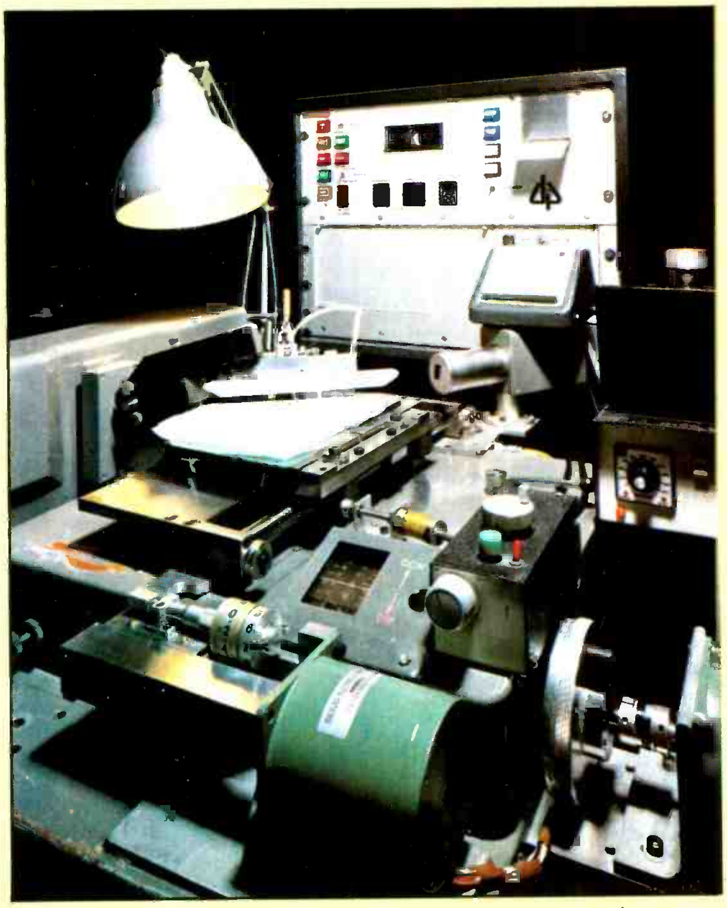
Whenever conditions permit it is always advisable to discuss your application with the manufacturer; experience in other areas could be extremely beneficial when considering your particular needs.

Crystal oscillators

It is possible to produce R C or L C oscillators which have a stability of 0.1% under ideal conditions, but this is unlikely to be sufficient if the "Rule of 10" is followed, i.e. over-specify to a factor of 10, or even 100, to be sure of the required reliability and integrity. Thus a desired accuracy of 0.1% becomes ideally a requirement for a frequency source with an accuracy of 0.001%, or 10ppm.

Even the simplest of crystal oscillators will achieve an overall accuracy of 100ppm for all reasons (setting accuracy, temperature, ageing, etc.). Such devices therefore provide a cost-effective solution to the less stringent electronic requirements.

These "clock oscillators" are available in various outlines to suit situations where either height or area (as on p.c.bs) is limited. A survey of models commercially available has shown that they have accuracies in the



Setting accuracies of ±0.1 minutes of arc prior to cutting are needed in positioning quartz to achieve the required performance.

Table 1. 'Accuracy' of crystals comprises three parameters

	Solder seal	Res. weld	Cold weld	Glass
Adjustment tolerance, ppm	±15	±10	±7½	±5
Frequency/temperature tolerance,				
ppm at −10°C to +60°C	±15	±10	±10	±10
ppm at −40°C to +90°C	±40	±30	±30	±30
Ageing at 85°C, ppm/annum	±10-15	±3-5	±2	±1-2

These values are dependent on other factors, particularly frequency.

Table 2. Quartz crystal applications against features

(Increasing cost ↑ / Increasing volume ↓)

Applications	Features
Frequency standards Satellite navigation Measuring instruments Microwave beacons High-resolution radar Airborne radar Missile control	Excellent long-term stability Good quality factor Frequency precision Vibration immunity Radiation hardened
Military communications Base stations Synthesizers Instrumentation Navigation aids Airborne radio Radar Satellite tv	Good stability Custom frequencies Clean spectrum Low noise Local supply Auditable quality
Mobile and portable radio Pageing systems Security alarms Automotive electronics Mainframe computers Rescue beacons	Rugged Custom frequencies Wide temperature range Rapid delivery
Television sets Microprocessors Microcomputers Data communication modems "Timing" crystals	Low price Standard frequencies Adequate performance High volume

Table 3. Stability of four main types of crystal oscillator

	Accuracy in ppm	Remarks
Clock oscillators	50 to 2000	Low cost Logic compatible
Simple package	5 to 100	Standard crystal oscillator Tuneable to frequency
Temperature compensated	0.2 to 5	Low power consumption Instant warm-up Modest cost
Oven controlled	0.001 to 1	High precision Long warm-up High power consumption Expense rises rapidly with stability

The clock oscillator is the basic crystal oscillator. A distinction is drawn between simple-package and clock oscillators, as clock oscillators often do not incorporate any means of frequency adjustment.

range 50 to 1000ppm (0.005 to 0.1%).

For more demanding applications, crystal oscillators which are temperature compensated or oven controlled are recommended. Table 3 shows the stability of the four main types of crystal oscillator.

Simple packaged oscillators (SPXO) are the least complex. Some have a remote frequency control capability, i.e. they incorporate a variable capacitance diode in the frequency circuitry, and are called voltage-controlled cyrstal oscillators (VCXO). They are more susceptible, in frequency control, to variations in power supply voltage, but the user can add extra voltage immunity.

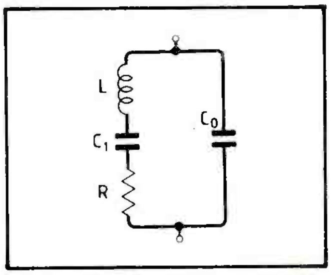
Temperture-compensated oscillators (TCXO) are characterized by a temperature-dependent reactance in the frequency control loop, designed to compensate for variations of frequency with temperature. They are expensive because the reactance has to be synthesized to make it complementary to the cubic-shaped dependence of the AT-cut crystal, and this has to be optimized for each crystal.

Oven-compensated oscillators (OCXO) achieve stabilities of 1pp 10^{10} per day be means of extremely precise temperature control using a built-in double oven and vacuum flask, together with careful circuit design. These crystal oscillators are used as "secondary standards". For most applications, however, a single-oven design is adequate, giving stabilities of 0.1ppm in respect of temperature variations.

The physical dimensions of the space available for the crystal oscillator may also have a bearing on the choice. The height or area may be restricted; in either case there will be a specific unit which is suitable.

CRYSTAL THEORY

EQUIVALENT CIRCUIT



L — Dynamic or motional inductance (mH)
C_1 — Dynamic or motional capacitance (fF)
R — Equivalent series resistance (ohms)
C_o — Parallel or static capacitance (pF)

Note 1. L, C_1 & R are not true electrical components. They are apparent values of inductance, capacitance and resistance which serve to model the mechanical/piezoelectric performance of the vibrating crystal in the region of resonance.
2. Units shown in brackets are those normally used for AT-cut crystals.

CIRCUIT EQUATIONS — basic crystal

Series resonant frequency

$$f_s = \frac{1}{2\pi\sqrt{L C_1}} \quad \text{(MHz)}$$

Parallel resonant frequency

$$f_p = \frac{1}{2\pi\sqrt{L C}} \text{ where } C = \frac{C_1 C_o}{C_1 + C_o}$$

In practice, an allowance usually has to be made for 'strays' (C_{L2} opposite).

Quality factor

$$Q = \frac{2\pi f_s L}{R} = \frac{1}{2\pi f_s C_1 R}$$

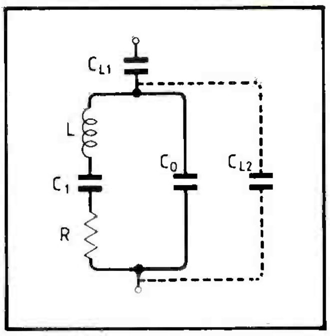
Capacitance ratio

$$r = \frac{C_o}{C_1}$$

Figure of merit

$$M = \frac{Q}{r} = \frac{1}{2\pi f_s C_o R}$$

CIRCUIT EQUATIONS — with external load



Frequency deviation from resonance

$$D = \frac{C_1 \times 10^6}{2(C_o + C_L)} \quad \text{(ppm)}$$

Note 1. Series capacitance (C_L) shifts frequency upward.
2. Parallel capacitance (C_{L2}) shifts frequency downward.
3. Deviation (D) from resonance (f_s or f_p) is the same but of opposite sign if $C_{L1} = C_{L2}$.
4. The effect of a trimmer may be readily assessed by calculating D & D' for C_L & C_L' and subtracting.
5. Units are correct for C_1, C_o and C_L in pico farads. Also below

Pulling sensitivity

$$S = \frac{-C_1 \times 10^{-6}}{2(C_o + C_L)^2} \quad \text{(ppm/pF)}$$

Apparent series resistance (with C_{L1})

$$R_e = R\left(1 + \frac{C_o}{C_{L1}}\right)^2 \quad \text{(ohms)}$$

Parallel impedance (with C_{L2})

$$R_p = \frac{1}{R\,[\,2\pi f_s (C_o + C_{L2})\,]^2} \quad (\text{k}\Omega)$$

Further reading

Virgil E. Bottom. Introduction to Quartz Crystal Unit Design. Van Nostrand. 1982.

Marvin E. Frerking. Crystal Oscillator Design and Temperature Compensation. Van Nostrand, 1970.

Benjamin Parzen: Design of Crystal and other Harmonic Oscillators. Wiley, 1983.

Ballato. A. Resonance in Piezoelectric Vibrators, *Proc IEEE* vol 5. Jan 1970, pp.150-151.

Holbeche & Allen: The Influence of Series Reactance on Quartz Crystal Resonators. *Proc IEE* vol 130, part G no.4, August 1983, pp.145-152

International standards

IEC 122: Quartz crystal units for frequency control and selection.
IEC 122-1 (1976): Standard values and test conditions.
IEC 122-2 (1969): Guide to the use of quartz oscillator crystals.
IEC 283 (1968): Methods for the measurement of frequency and equivalent resistance of unwanted resonances of filter crystal units.
IEC 302 (1969): Standard definitions and methods of measurement of piezoelectric vibrators operating over the frequency range up to 30 MHz.
IEC 444 (1973): Basic method for the measurement of resonance frequency and equivalent series resistance of quartz crystal units by zero phase technique in a pi-network.
444-2 (1980): Phase offset method for measurement of motional capacitance of quartz crystal units.
BS 9610 (1982): Quartz crystal units of assessed quality: generic data and methods of test.

Thick amorphous metals

Amorphous metal alloys can have interesting properties, such as hardness combined with ductility, magnetic softness and very high corrosion resistance. Until recently they could only be produced in strips of less than 0.05mm thick but much thicker nickel-titanium and nickel-zirconium compounds have now been produced using a technique known as rapid diffusion.

To create amorphous metals, extremely rapid cooling from the molten state is required to ensure that a crystalline structure has no time to form during solidification. Current techniques involve spraying the melt onto a cooled rotating copper drum but to achieve a sufficiently high cooling rate the resulting layers must not be more than 0.05mm thick. Rapid diffusion, however, has been used to produce strips of up to 1mm thick and even tubes.

This new technique involves rolling together alternate, 25μm-thick layers of nickel and zirconium. Subsequent annealing for around 150 hours at between 300 and 350°C causes the nickel atoms to diffuse into the zirconium layers. At these temperatures, the zirconium atoms are practically immobile and an amorphous structure stable up to about 500°C is formed.

Sampled-data servos — a new analysis

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

Sampling and aliasing are explained in this second part of Dr Taub's analysis

One can regard a sampled-data signal as being formed by taking the corresponding continuous signal and multiplying it by a sampling waveform which consists of impulses occurring at regular intervals, see Fig.2 (February issue). Such a waveform is shown in Fig.5 and because of its shape is sometimes called a 'comb function.' Each impulse in the waveform is considered to have infinitessimal duration and infinite magnitude, but its integral with respect to time is finite.

The sampling process

The literature on the subject generally takes the integral as being unity, so that each impulse becomes what is known as a Dirac function, see section 4.2 of ref.5. However, the mathematical expressions become simpler if one takes the integral as being equal to the sampling interval T, and this is what is done here*. There is nothing against this provided that one does it consistently, and that the corresponding change is made when converting a sampled-data signal back to continuous form (part 3).

We can thus say that the sampling waveform consists of Dirac pulses of weight T ocurring every T seconds. In Fig.5 and other diagrams showing sampled-data waveforms, the height of each impulse shown should be taken as representing its integral with respect to time.

In many cases, something very close to the sampling process described above actually takes place: that is to say, a continuous signal is gated with a sampling waveform consisting of very narrow pulses. In other cases, such as the one quoted in part 1, no continuous signal exists; nevertheless, the sampled-data signal is the same as if the continuous signal had existed and the sampling process had taken place.

Representation of trignometric functions by exponentials

Throughout this paper, trignometric functions will be represented by their exponential equivalents. As a reminder, the relationships between the two are

$$\cos\theta = \frac{1}{2}\left(e^{j\theta} + e^{-j\theta}\right)$$

$$\sin\theta = \frac{1}{j2}\left(e^{j\theta} - e^{-j\theta}\right) \qquad \ldots 2.1$$

* To help relate the theory as presented here with the general literature on the subject, the principal expressions for a sampling-impulse weight of unity are given in the Appendix.

Spectrum of the sampling waveform

The sampling waveform is periodic and can therefore be expressed as a Fourier series. The fundamental frequency is the sampling frequency f_s = 1/T and the corresponding angular frequency is $\omega_s = 2\pi/T$ (The term 'frequency' used in this paper will often relate to ω rather than f, but this will be clear from the context).

Using the exponential form of the Fourier series (Section 3.2 in ref.5) the sampling waveform p(t) can be expressed as

$$p(t) = \sum_{m=-\infty}^{\infty}\left[\frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} p(t)e^{-jm\omega_s t}\,dt\right]e^{jm\omega_s t} \qquad \ldots 2.2$$

Between the integration limits —T/2 and + T/2, p(t) consists of a single Dirac pulse of weight T occurring at t = 0, i.e.

$$p(t) = T\delta(t), \quad -\frac{T}{2} < t < \frac{T}{2}$$

where δ(t) represents the Dirac pulse. Equation 2.2 therefore simplifies to

$$p(t) = \sum_{m=-\infty}^{\infty}\left[\int_{-\frac{T}{2}}^{\frac{T}{2}} \delta(t)e^{-jm\omega_s t}\,dt\right]e^{jm\omega_s t}$$

From the definition of the Dirac pulse, δ(t) is zero everywhere except at t=0, and so it is only at t=0 that the integrand in the above expression can have a finite value. $e^{-jm\omega_s t}$ can therefore be taken as constant at its t=0 value, i.e. as 1, and brought outside the integral sign. This gives

$$p(t) = \sum_{m=-\infty}^{\infty}\left[\int_{-\frac{T}{2}}^{\frac{T}{2}} \delta(t)\,dt\right]e^{jm\omega_s t}$$

from the definition of the Dirac pulse, the integral in the above expression is 1, and so

$$p(t) = \sum_{m=-\infty}^{\infty} e^{jm\omega_s t} \qquad \ldots 2.3$$

The term in this summation corresponding to m = 0 can be looked on as a constant vector lying along the real axis, while those corresponding to positive and negative values of m represent counter-clockwise and clockwise-ratating vectors respectively. All these vectors have unit magnitude, and at t = 0 they all lie along the real axis, i.e. they have zero phase angle. They can thus be represented in the form of a line spectrum as shown in Fig 6.

Another way of representing p(t) is in terms of trignometric functions. The line at ω = 0, corresponding to m = 0, represents a d.c. component of unit magnitude. From equation 2.1, the lines at ω_s and $-\omega_s$, corresponding to m = ±1, represent the term 2 cos ω_st; those at $2\omega_s$ and $-2\omega_s$ (m = ±2) represent 2 cos $2\omega_s$t, and so on. Therefore equation 2.3 can be expressed as

$$p(t) = 1 + 2\sum_{m=1}^{\infty} \cos m\omega_s t \qquad \ldots 2.4$$

Spectrum of sampled cosine wave

The cosine wave that is to be sampled is given by

$$q(t) = Q\cos(\omega_0 t + \Phi_0)$$

or, using the equivalent exponential form of equation 2.1,

$$q(t) = \frac{Q}{2}\left(e^{j(\omega_0 t + \Phi_0)} + e^{-j(\omega_0 t + \Phi_0)}\right)$$

$$= \frac{Q}{2}\left(e^{j\Phi_0}e^{j\omega_0 t} + e^{-j\Phi_0}e^{-j\omega_0 t}\right) \qquad \ldots 2.5$$

The spectrum of q(t) thus consists of two components, both of magnitude Q/2. One occurs at ω = ω_0 and has a phase angle φ_0, and the second at ω = ω_0 with a phase angle $-\varphi_0$. That is to say, the component at $-\omega_0$ is the

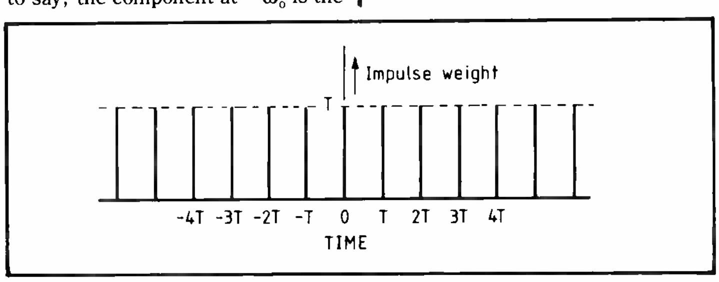


Fig. 5. **Sampling waveform consists of impulses of weight T occuring every T seconds.**

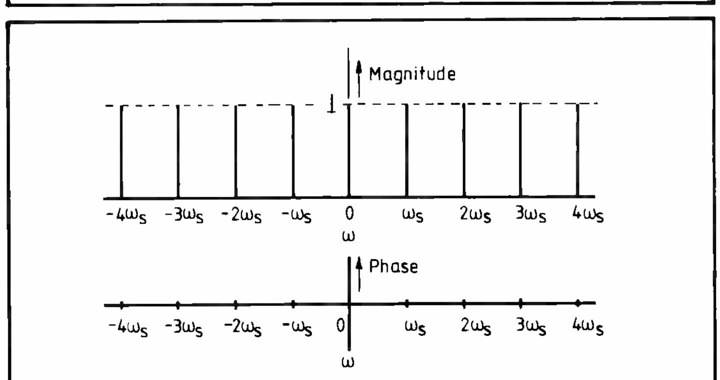


Fig. 6. **Frequency spectrum of the sampling waveform. All the components have an amplitude of 1 and a phase angle of Φ**

complex conjugate of the component at ω_o. The spectrum is shown in Fig.7.

The effect of sampling is to multiply q(t) by the sampling waveform p(t), i.e. to multiply equation 2.5 by 2.3.

The product, v(t), is

$$v(t) = \frac{Q}{2}\left[e^{j\phi_o} e^{j\omega_o t} \sum_{m=-\infty}^{\infty} e^{jm\omega_s t} + e^{-j\phi_o} e^{-j\omega_o t} \sum_{m=-\infty}^{\infty} e^{jm\omega_s t}\right]$$

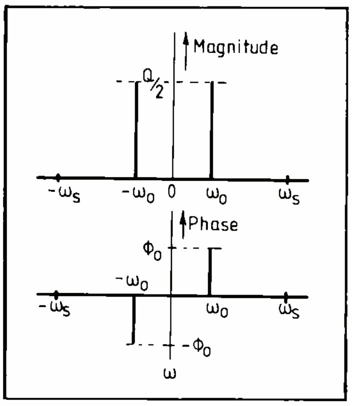


Fig. 7. Frequency spectrum of cosine wave Q cos $(\omega_o t + \varphi_o)$. The components at $+\omega_o$ and $-\omega_o$ have the same amplitude but opposite phase angles.

$$= \frac{Q}{2}\left[e^{j\phi_o} \sum_{m=-\infty}^{\infty} e^{j(m\omega_s+\omega_o)t} + e^{-j\phi_o} \sum_{m=-\infty}^{\infty} e^{j(m\omega_s-\omega_o)t}\right] \quad \ldots 2.6$$

The spectrum representing this equation (Fig.8) consists of an infinite set of components at $\omega = m\omega_s + \omega_o$, all of phase angle φ_o, and another set at $\omega = m\omega_s - \omega_o$, all of phase angle $-\varphi_o$. The magnitude of every component is Q/2.

The effect of sampling has thus been to cause each of the spectral components of q(t) to be repeated indefinitely at intervals of ω_s.

Aliasing

Figures 7 and 8 were drawn showing ω_o as being less than $\omega_s/2$, but the equation for v(t) is true no matter what the value of ω_o. It is important therefore, to see what happens to the spectrum as ω_o increases. Referring to Fig. 7 as ω_o increases, the lines at $\omega = \omega_o$ representing magnitude and phase move to the right, and those at $\omega = -\omega_o$ move to the left. The effect of sampling is to cause all these lines to be repeated at intervals of ω_s, and so transferring attention to Fig. 8, all the lines at $m\omega_s + \omega_o$ will move to the right, and all those at $m\omega_s - \omega_o$ will move to the left.

When ω_o passes the value $\omega_s/2$, all the right-moving lines and left-moving lines pass each other, and so while ω_o is in the range $\omega_s/2$ to ω_s, the sampled-data spectrum appears as in Fig.9. The point to note is that this is the same as would be produced if q(t) had and angular frequency of $\omega_s - \omega_o$ and a phase angle of $-\varphi_o$.

As ω_o passes the value of ω_s, a second crossing of the right-moving and left moving lines takes place, so that for ω_o between ω_s and $3\omega_s/2$ the spectrum is as shown in Fig.10. This is seen to be exactly the same as Fig.8, so that within this range of ω_o, the sampled-data spectrum is indistinguishable from what would be produced if q(t) had an angular frequency $\omega_o - \omega_s$ and its phase angle were unchanged at φ_o. As ω_o continues to increase, further crossings of the right-moving and left-moving lines take place, causing the above two spectra to repeat alternately.

Thus when one encounters a spectrum of the type shown in Fig. 8, there is no way of telling whether it arose from sampling Q cos $(\omega_o t + \varphi_o)$, Q cos $[(m\omega_s + \omega_o)t + \varphi_o]$ or Q cos $[(m\omega_s - \omega_o)t - \varphi_o]$, where m is any positive integer. Equally well, it could have resulted from sampling a combination of these frequencies with appropriate amplitudes and phase angles. This phenomenon of the sampled version of one frequency looking exactly like that of another, is known as aliasing.

To complete the picture, we examine what happens when ω_o is an odd multiple of $\omega_s/2$ i.e. $(m + 1/2)\,\omega_s$, and when is an integral multiple of ω_s.

When $\omega_o = (m + 1/2)\,\omega_s$ every spectral component with a phase angle $+\varphi_o$ will coincide with one whose phase is $-\varphi_o$. As they are equal in magnitude, the effect of adding them is to add the real parts and cancel the imaginary parts, giving the spectrum shown in Fig. 11. A similar combining of spectral components takes place when $\omega_o = m\omega_s$, and the resulting spectrum, shown in Fig. 12, is the same as would be produced by sampling a d.c. signal of magnitude Q cos φ_o.

Gain of sampled-data signal processor

A sampled-data signal processor accepts a sampled-data signal at its imput and produces the same type of signal at its output. Suppose that the input is the sampled version of Q_o cos $(\omega_o t + \varphi_o)$ or any of the frequencies and phase angles giving the same spectrum, shown in Fig.8. Then provided that the processor is linear, the output will have a similar spectrum, the components recurring at the same values of ω, though of course their magnitudes and phases will be different. Let the output components have a magnitude $Q_1/2$ and phase $\pm\varphi_1$ as shown in Fig. 13. then the gain at all

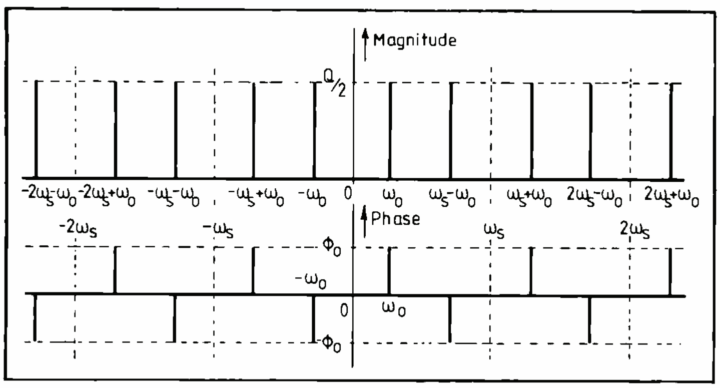


Fig. 8. Spectrum of the sampled cosine wave. The effect of sampling is to cause the two components to be repeated indefinitely at intervals of ω_s.

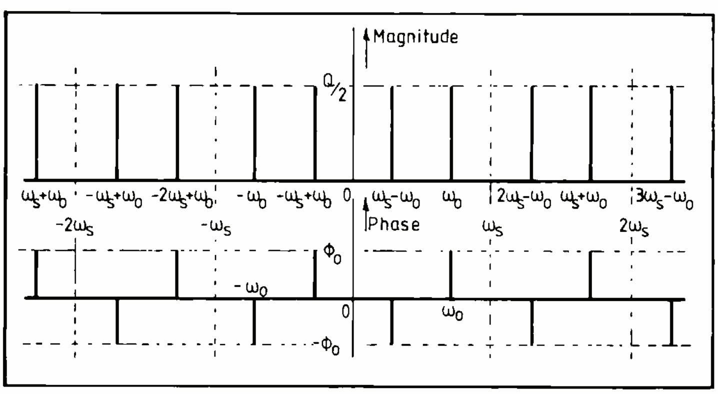


Fig. 9. When ω_o lies between $\omega_s/2$ and ω_s (ie: cosine-wave frequency between 1 and 2 times the Nyquist frequency) the spectrum is exactly the same as if we had sampled Q cos $[(\omega_s - \omega_o)t - \varphi_o]$.

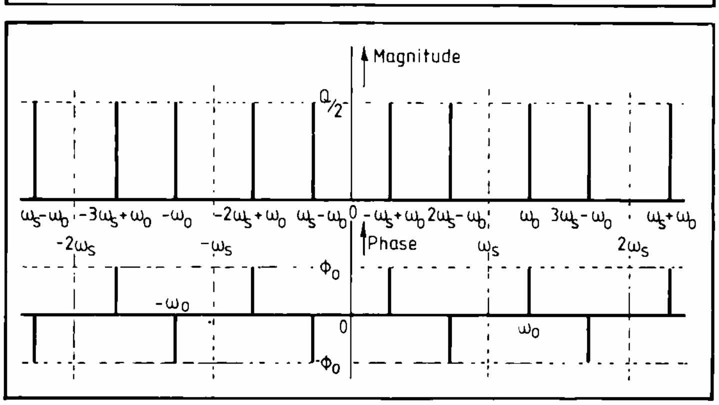


Fig. 10. For ω_o between ω_s and $2\omega_s/3$ the spectrum is the same as if we had sampled Q cos $[(\omega_o - \omega_s)t + \varphi_o]$.

the values of ω represented by $m\omega_s + \omega_0$ (m any positive of negative integer) will be

$$H[j(m\omega_s + \omega_0)] = \frac{\frac{Q_1}{2} e^{j\Phi_1}}{\frac{Q_0}{2} e^{j\Phi_0}} = \frac{Q_1}{Q_0} e^{j(\Phi_1 - \Phi_0)}$$

and at all values of ω represented by $m\omega_s - \omega_0$, it will be

$$H[j(m\omega_s - \omega_0)] = \frac{\frac{Q_1}{2} e^{-j\Phi_1}}{\frac{Q_0}{2} e^{-j\Phi_0}} = \frac{Q_1}{Q_0} e^{-j(\Phi_1 - \Phi_0)}$$

This equation draws attention to two important properties concerning the gain of a sampled-data signal processor. The first is that the magnitude and phase are periodic, repeating at intervals of ω_s; the second is that between $\omega_s/2$ and ω_s the magnitude characteristic is the laterally-reversed form of that between 0 and $\omega_s/2$, and the phase characteristic is laterally-reversed and of opposite sign. Thus if the gain over the range 0 to $\omega_s/2$ is known, it is known everywhere.

A typical sampled-data gain characteristic is shown in Fig. 14.

APPENDIX

Effect of using unit impulses in sampling waveform

To keep the mathematical expressions as simple as possible, it has been assumed in the main text of this paper and in the programs, that the sampling waveform consists of impulses of weight T (part 2), and that on conversion back from a sampled-data signal to a continuous signal. the output immediately following a sample of weight T has unit value (part 3). In practically all the published literature, however, sampling is assumed to be done with unit-weight impulses. Therefore to help relate the material presented here to other publications, the principal equations for unit-weight sampling pulses are given in this Appendix. The equations are numbered as in the main body of the text but with the prefix U to indicate unit-weight impulses.

Sampling waveform:

$$p(t) = \frac{1}{T} \sum_{m=-\infty}^{\infty} e^{jm\omega_s t} \qquad \ldots U2.3$$

$$= \frac{1}{T}\left[1 + 2\sum_{m=1}^{\infty} \cos m\omega_s t\right] \ldots U2.4$$

$$v(t) = \frac{Q}{2T}\left[e^{j\Phi} \sum_{m=-\infty}^{\infty} e^{j(m\omega_s + \omega_0)t} + e^{-j\Phi_0} \sum_{m=-\infty}^{\infty} e^{j(m\omega_s - \omega_0)t}\right] \qquad \ldots U2.6$$

REFERENCES

1. J.J. Distefano, A.R. Stubberud and I.J. Williams. 'Feedback and Control Systems' (Schaum's Outline Series, McGraw-Hill, New York, 1976).
2. M. Healey. 'Principles of automatic control', (Hodder and Stoughton, London, 1975).
3. M.K. Haynes. 'Magnetic recording techniques for buried servos'. *IEEE Transactions on Magnetics*, Vol. MAG 17, 1981 pp 2730-4.
4. N.H. Hansen. 'Head-positioning system using buried servo'. *ibid* pp 2735-8.
5. P.A. Lynn. 'Introduction to the analysis and processing of signals' (Macmillan, London, 1973).
6. B.C. Kuo. 'Analysis and synthesis of sampled-data control systems' (Prentice-Hall, Englewood Cliffs, NJ, 1963)
7. A.M. Tropper. 'Matrix theory for electrical engineering students' (Harrap, London, 1962).
8. S. Goldman. 'Transformation calculus and electrical transients', (Prentice-Hall, New York, 1949).
9. D.M. Taub. 'Programs for computing sampled-data servo performance', IBM Technical Report no.12.199, (IBM United Kingdom Laboratories, Hursley, May 1982).

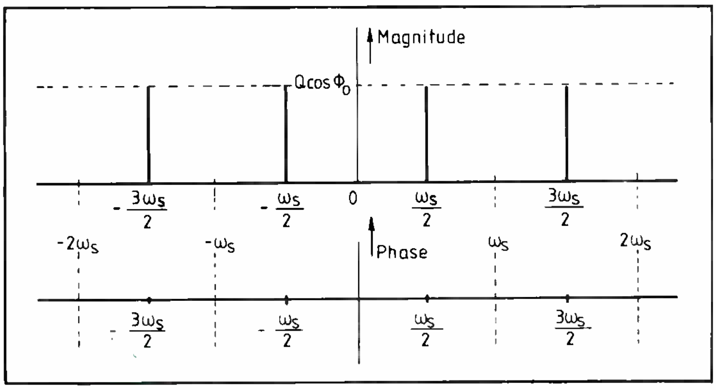


Fig. 11. **When ω_0 is 1, 3, 5, 7, etc times $\omega_s/2$ all components have an amplitude Q cos φ_0 and zero phase angle.**

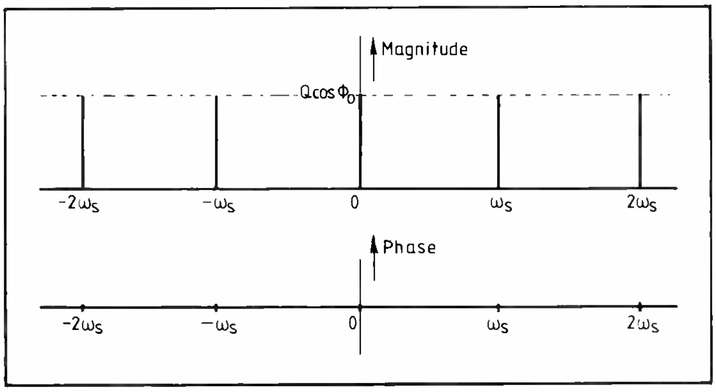


Fig. 12. **When ω_0 is 2, 4, 6, 8 etc times $\omega_s/2$ the spectrum is the same as if we had sampled a d.c. signal of amplitude Q cos φ_0.**

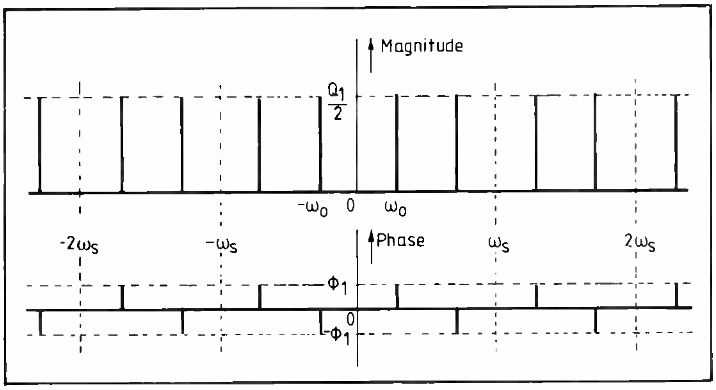


Fig. 13. **The output spectrum of a sampled-data signal processor has the same repetitive nature as the input spectrum.**

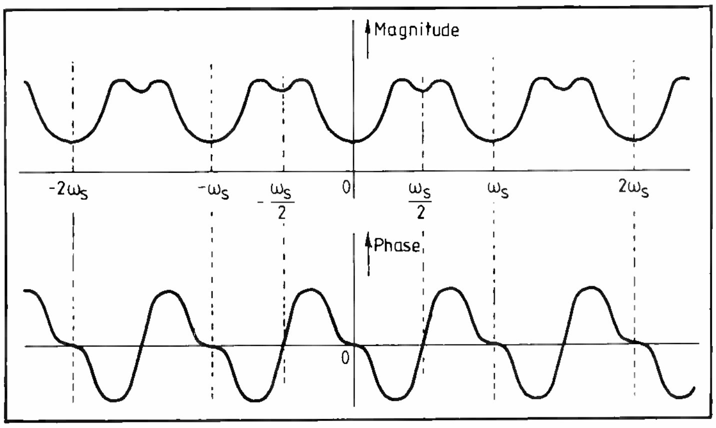
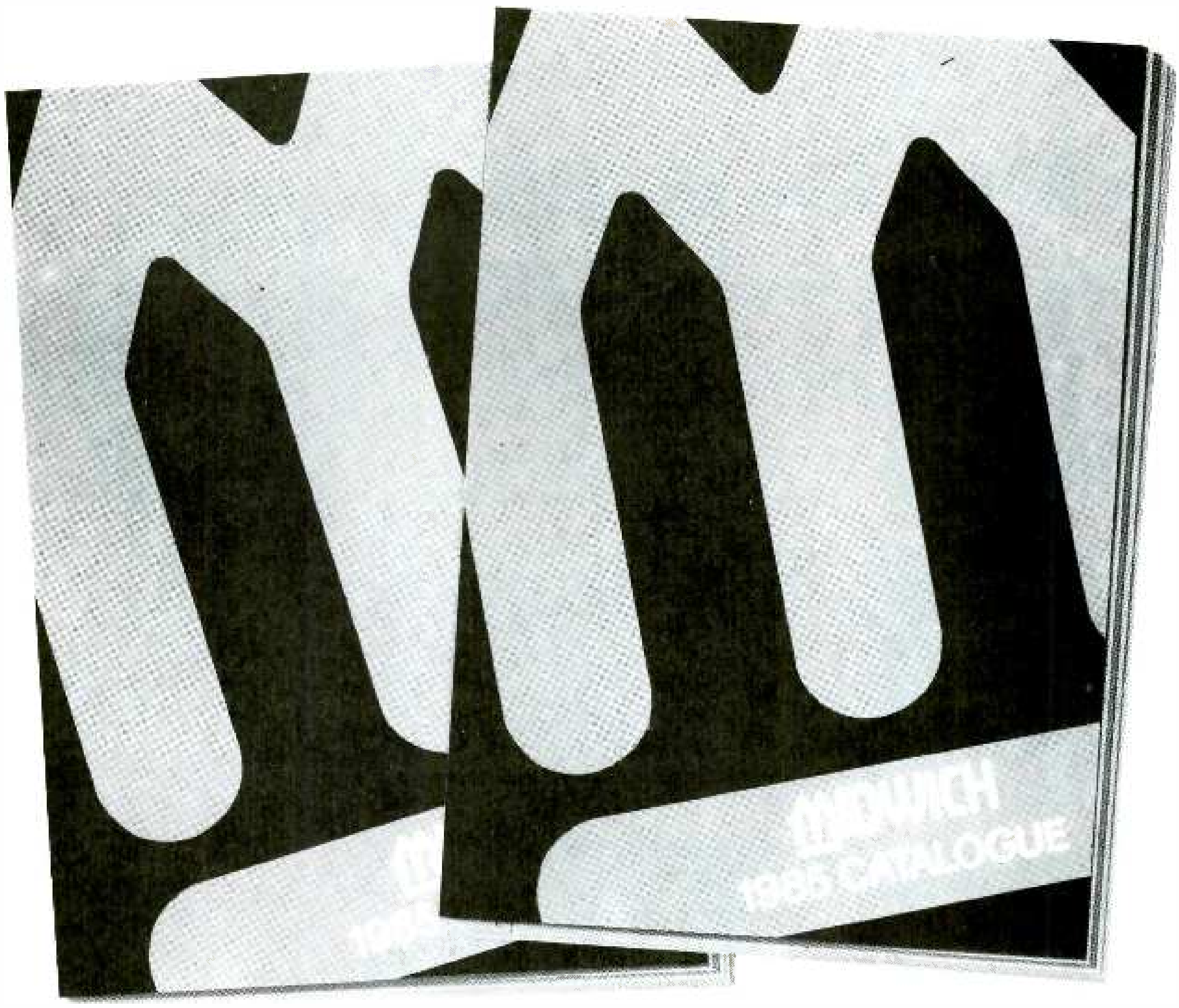


Fig. 14. **Typical sampled-data gain characteristic showing its repetitive nature.**



IT WON'T COST YOU A PENNY.

BEING WITHOUT ONE COULD COST YOU DEARLY.

The 1985 Midwich catalogue is now available, absolutely free.

It's the most comprehensive catalogue yet, containing many of the latest and very best computer components on the market, at highly competitive Midwich prices and a service that is second to none.

Which means it will provide your organisation with a vital source of information including numerous technical specifications and pin-out diagrams.

Fill in the coupon and send for your copy today.

You'll soon discover why no organisation can afford to be without one.

Reply to Dept EWW5 Midwich Computer Company Limited
Gilray Road, Diss, Norfolk IP22 3EU

Name ______

Organisation/Company ______

Position ______

Address ______

______ Postcode ______

Tel. No. ______

MIDWICH
COMPUTER COMPANY LIMITED

CIRCLE 12 FOR FURTHER DETAILS.

Thin-lines?

Sir Donald Maitland, introducing the 130-page report of the Independent Commission for Worldwide Telecommunications Development, of which he was chairman, showed how the gap in telecommunications facilities in industrial countries and those in developing countries is widening rather than narrowing, and is now grossly unbalanced. He said: "There are more telephones in Tokyo than in the whole of Africa. Three-quarters of the 600 million telephones in the world are concentrated in just nine countries. Half the world's population live in countries with less than one telephone for every 100 persons. With certain exceptions the services in developing countries are poor or indifferent and in more remote areas there is no service at all." Some African countries have less than one telephone per thousand of the population compared with 500 in London which is by no means top of the table.

The report identifies the problem, shows how good telecommunications can become the future trade routes of the world and proposes the setting up of a new "Centre for Telecommunications Development (CTD)" under the aegis of the ITU among its 59 recommendations. Less happily, if one digs into the report, one discovers why it will prove extremely difficult to reverse the processes by which those rich in telecommunications get richer, the poor get ever poorer. Poor countries have to beg or borrow the hard currency for such capital-intensive projects; aid tends to go to what are regarded as higher-priority projects and tend to restrict choice of systems to specific exporting countries; revenues from the system are in local "soft" currencies; advanced digital technology requires software expertise often not available locally; modern telecommunications economics favour high-capacity broadband all-digital systems, whereas the most urgent requirement is often for thin-line links to community telephones in the interior.

When I drew Sir Donald's attention to the clear disparity in the comments received by the Commission from Third World administrators/operators and the advice tended by manufacturing countries, he insisted that the way ahead must be digital rather than analogue, making full use of satellite communications rather than less ambitious "alternative technology" or older electromagnetic systems.

The Commission's 59 recommendations fall into four main groups: encouraging national and international organizations to give higher priority to investment in telecommunication; encouraging the upgrading and expansion of existing networks; methods of financing the required investment of some $12 billion/year; and recommendations aimed at making the ITU more effective.

The Commission was set up as a result of ITU's Plenipotentiary Conference, Nairobi 1982 and had a remit to identify and recommend methods, including novel ones, for stimulating telecommunication development in the developing world. In practice the report is stronger at identifying the problems than finding easy or novel ways of overcoming them. Sir Donald is convinced there is no single remedy, novel or otherwise. The ITU Administrative Council may establish the CTD at its meeting in July, but it will be many years, if ever, before the gross unbalance seems likely to be reversed and everybody is within reach of a telephone.

Cold crash

The loss of a tall television antenna-support mast is a serious matter at any time, but even more so when the cause is not immediately obvious. The history of tubular steel masts, as contrasted with triangular lattice masts or concrete towers, has been chequered. In the UK, a three-year-old 1265 ft tabular mast at Emley Moor collapsed in cold weather in March 1969, ascribed to a combination of assymetrical icing of the guy wires and oscillation of the mast due to vortex shedding at relatively low wind speeds. This led to the installation of counter weights to dampen oscillation on the Winter Hill and Belmont masts of basically similar design. Earlier a tubular mast at Waltham collapsed during construction. Ground subsidence at the Mendip site at one stage caused concern.

In mid-January, Westdeutscher Rundfunk suffered the loss of a 977 ft (298m) tubular steel mast in the Teutoburger forest for reasons that are by no means clear. The mast, completed in 1970, comprised 2.2m-diameter sections formed from 9mm-thick sheet steel bolted together in 5m sections for the first 230m, then thinning to 1.5m diameter.

It fell at 6.26 a.m. after a calm but cold night in temperatures around −20°C following a week in which temperatures had not risen above −15°C. Although such a long cold period is unusual in this region, similar masts in higher sites in other parts of West Germany are subject to more severe conditions. Two guy cables and four cable-to-tower connections apparently gave way but neither wind nor ice loading seem to have been the cause; subsidence or ground movement has not been ruled out, but it remains a mystery why the 15-year-old mast collapsed in circumstances apparently linked with an extended period of sub-zero temperatures.

Phone in-flight

With cellular mobile/portable radio, pay-phones on some British Rail intercity trains, cordless telephones, radio-pagers capable of displaying 90 character messages, submerged fibre-optic cables and more and more satellite circuits it may seem that, in some countries, the ability to talk to anyone, anywhere, anytime is fast approaching. The snag is that the usable electromagnetic spectrum is finite and can be rendered ineffective by overcrowding.

The FCC has recently ruled that pay phones in civil aircraft are in the nature of a luxury for the privileged few and have refused to allocate frequencies around 900 MHz specifically for this purpose, requested by Airfone Inc. to expand its present experimental service (in 22 aircraft) to more than 300 aircraft operated by 26 American airlines. The system provides direct links to ground rather than via satellite.

The use of satellites to upgrade aviation communications, navigation and air traffic control as part of the proposed National Airspace Plan is not arousing much enthusiasm from the Federal Aviation Administration who oppose the adoption of unproven technology in an all-embracing system and are currently up-grading its a.t.c. computers, secondary radar data subsystem (Mode S) and installing microwave landing systems at the rate of about 100 airports a year.

Sound archives

There is a well-founded belief that those of us who live in London make less use of its facilities than visitors. It was only recently that I discovered the British Library National Sound Archive at 29 Exhibition Road, London SW7 (01-589 6603) with its remarkable free listening service available by appointment on weekdays. The NSA (formerly British Institute of Recorded Sound) now holds nearly half a million discs and 35,000 hours of recorded tape. Its collection reflects recorded sound from early wax discs to digital compact discs, plus recordings of many BBC broadcasts. While the emphasis is on music (Western art music, international music, jazz, pop etc.) there are also specialist areas such as wildlife sounds, drama and spoken music. Recordings are supplemented by printed catalogues, discographics, periodicals, reference books etc., which can be consulted without prior appointment. It also runs information and transcription services, including the supply of tape copies of deleted commercial recordings to companies and organizations, provided they have copyright clearances.

TV in 1881?

Whether or not you agree with Herb Brodkin's dictum that "Television is busily destroying the world" the current series of 13 hour-long programmes produced by Granada is certainly attempting to show how the medium has captured the world. The second programme "The Race for Television" attempts to trace the early history up to 1945 during which technology had not then been overwhelmed by the power of the programmes. This episode will have been transmitted by the time these notes appear.

According to the synopsis, it traces Baird's sad history, from his early days to his eventual defeat by the rival electronic system and I suspect treats his story rather more sympathetically than did Professor J.D. McGee in his "Rutherford Memorial Lecture" delivered at Christchurch, New Zealand in October 1982 and published recently in *Proc. R. Soc. Lond.* A393 pp193-214 (1984).

Prof. McGee, who, with W. Tedham, was responsible for electronic camera development at Hayes from January 1932, considers that the first demonstration of "real television" was that given by Ayrton and Perry at the Royal Society of Arts, London in 1881 using two oscillating mirrors and modulating a light beam passing through a Kerr cell, though limited by mechanical inertia of the moving parts. Ayrton & Perry however postulated the minimum requirements for worthwhile television as 15 pictures per second, and 100 lines of 100 pixels per line — significantly more than Baird was able to achieve 45 years later.

Of the later mechanical systems, McGee considers they were doomed to failure for reasons that Campbell Swinton repeatedly emphasised, adding: "Of course there could be no objection to experimenters exploring the possibilities of mechanically-based methods, but what was inexcusable was the propaganda and political pressure exerted to have the mechanical system adopted by the broadcasting tv system. Anyone who saw the quality of the pictures then (as I did) would have had to be incredibly naive to accept the system as being worthwhile for a public broadcasting service."

Amateur Radio

Cable e.m.c.

The cabling of UK cities, seen euphorically by some as the first step to a broadband electronic grid, has receded almost out of sight. It is now clear that the high-tech., 30-channel, star-switched interactive systems planned to give wideband channels into and out of millions of homes has stalled, perhaps for decades. The newly formed Cable Authority has made it clear that applicants for the franchises being offered this year will not be rejected if they offer something less ambitious.

Yet the Electrical Research Association has just completed a major study that underlines the need for high technical standards if the many problems of electromagnetic compatibility (e.m.c.) with cable systems are to be avoided.

ERA Report No 84-0059 (£135 to non-members, £99 members) investigates r.f. leakage into and out of both tree-and-branch and switched star cable systems. The report confirms that two components stand out as having significantly more effect on e.m.c. performance than others: the tap-off units and the safety isolators.

ERA concludes that whilst radiated emissions from the systems examined might not cause unacceptable interference (though experience at Milton Keynes and in the USA must surely lead to some doubts), the immunity to external fields required substantial improvement to avoid interference, particularly from amateur and mobile radio transmitters. But with the present commercial doubts on cable, it will be surprising if the stringent technical standards called for by ERA are engineered into all systems.

GaAs fets on 144 MHz

For several years there has been increasing use by radio amateurs of high-gain, low-noise pre-amplifiers based on the use of gallium arsenide field effect transistors not only on microwaves but also on the 144 MHz v.h.f. band. These devices tend to be more expensive than even the best performance on the higher-frequency bands. Unfortunately they are easily destroyed by transient voltages unless care is taken in the switching sequences when used as mast-head amplifiers in conjunction with transmitters and are more vulnerable than silicon devices to static electricity during construction.

A number of American amateurs have recently been strongly advocating the use of GaAs devices on 144 MHz, partly on the basis of "wide dynamic range," despite doubts expressed in the UK whether this is achieved with conventional circuitry. Third-order intermodulation distortion intercept points appear to be more likely to be in the region of OdBm than the 10-12dBm often claimed. Noise performance around 1dB, achievable with good silicon devices, is often the highest usable sensitivity due to external noise levels on 144 MHz.

An exception to the general rule, permitting an input third order intercept of 10dBm and output intercept of 23dBm, with a noise figure of under 1dB, has shown to be achievable with an MGF1202 device on 144 MHz by the use of "noiseless" non-dissipative negative feedback. This is generally regarded as suitable only for high-cost amplifiers for professional applications but Chris Bartram, G4DGU of muTek has been marketing a switched pre-amplifier of this type (Model GFBA 144e) with the feedback adding only about 0.15dB to the noise figure but almost 10Db to the intercept point.

But without non-dissipative feedback there is little evidence that these devices live up to the myth of wide dynamic range.

Fortunately for 12 GHz dbs receivers, for which GaAs devices are virtually essential, dynamic range is of little consequence since the signals from geostationary dbs transmissions tend to show only a moderate spread of signal strenths, with fading limited to conditions of very heavy rain, wet snow and some variation of polarization during hail storms.

In brief

The British Amateur Radio Teleprinter Group now has a s.s.b. a meeting point for amateurs interested in any aspect of data communications, including r.t.t.y., Amtor and "packet radio." BARTG transmits an r.t.t.y. news bulletin on 3.5, 14 and 144 MHz at various times on Sundays. Information on these and other BARTG services is available in leaflet form ("BARTG and the Eighties" and "BARTG and data communications") available free (large S.A.E.) from John Beedie, GW6MOK, PO Box 3, Llandeile, Dyfed, Wales (telephone 0558 822286).

Slow-scan television at low-cost is possible using home computers though not all the software being offered for this application is entirely successful or as flexible as it might be. Dutch amateurs are setting up an amateur-television repeater (input 1252.5 MHz output 1285.5 MHz) at Soest in central Holland with 40W peak erp and horizontal polarization. A 1.3 GHz a tv repeater is also planned for Crawley, Sussex expected to cover North Sussex and Surrey as GB3CT. The repeater has been built for £150.

The possible standardization of 134 MHz as the nominal centre frequency of home DBS receivers, with a 30 MHz passband (110 to 149 MHz) is causing some anxiety to the many thousands of 144 MHz users who fear e.m.c. problems due to direct break-through. Tests carried out by the DTI show that harmful interference can be avoided but the margins are narrow and would be lost unless the indoor units, cable connectors, etc., provide a degree of isolation unusual in consumer equipment.

Even if British manufacturers follow DTI recommendations and, for example, use fully screened metal enclosures for the indoor units, it would be difficult to ensure compliance of imported equipment.

Kelso Amateur Radio Society is organising a 2nd Anglo-Scottish rally at Kelso's Tait Hall on Sunday, May 5. Other rallies include: March 24 White Rose Rally, University of Leeds (details G4NDU);

Pat Hawker, G3VA.

CIRCLE 18 FOR FURTHER DETAILS.

CIRCLE 69 FOR FURTHER DETAILS.

Radar and television – interchange and spin-off

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

Continuing the survey of British invention and innovation in electronics, with a look at the benefits of radar and television research.

On February 26th 1935, a response at a range of about eight miles was received from an aircraft flying through 50-metre beamed radiation from the BBC (World) transmitting station at Daventry[1]. In less than four months (on June 16th, 1935), the first British radar installation was in operation at Orfordness on the Suffolk coast, providing cover which enabled "... an aircraft to be followed for more than 40 miles".

There is no need to stress the vital nature of these "momentous events of 1935", as A.P. Rowe has called them. They were to continue with, if anything, increased speed. Thus operationally acceptable height measurement and determination of azimuth (bearing) was developed within a matter of months; and by March 13th 1936, the new Bawdsey (Felixstowe) station "... successfully located... an aircraft flying at 1500 feet at a distance of 75 miles".

The achievements had the sure foundations on which the unequalled expansion of British radar was based. Following those already quoted, salient points in this expansion were:

- completion of the first CH (Chain Home) "Floodlight" stations for operational capability by August 1937
- completion of the 20 station chain to cover the entire eastern approaches to Britain before the beginning of World War II on September 3rd 1939
- 'One and a half metre' CHL (Chain Home Low) – rotating beam – stations against low fliers developed, installed and brought into operation by the end of September 1939.

The CHL stations supplemented, and worked in conjunction with the main CH stations; and from the beginning of 1940 were joined by a succession of GCI (ground-controlled interception) stations also working on $1\frac{1}{2}$ metres. These were followed rapidly by 'ten-centimetre' wavelength installations embodying the cavity magnetron – radar's master invention.

This impetus was repeated in the other sectors of British radar. Thus the wide range of airborne systems, which gained enormously when the cavity magnetron was introduced, were produced on time scales quite comparable with the remarkable ones already quoted. Similar results were achieved with the various Naval radar systems evolved by ASE (Admiralty Signal Establish ment); and with the systems developed by the associated research establishments for the Army and the other services.

An immediate example is afforded by the short-wave transmitting valves developed by HM Signal School (later ASE) and suitable for high power pulse working, and which were employed in the 'Main Chain' stations coming under the aegis of TRE (Telecommunications Research Establishment). Valves for high (peak) power operation at $1\frac{1}{2}$ metres were produced by industry to meet the crucial installation programmes for the CHL and GCI stations.

In a sense the whole country was involved with radar which had become almost a way of life for a significant proportion of its population, both service and civilian; and it may even be said that the United Kingdom had become a national-scale 'cluster' (see Article 1 in this series, *EWW* March 1985).

This group of propositions may seem extravagant; but illustrations will be used not only to give substance to them, but also because of their importance for today. First of all, only a brief mention has been made of TRE – its work is accurately documented – in 'Science at War' (ref. 1) and by A.P. Rowe (ref. 2); and its unique position in the mainstream of World War II radar development is well known. The full value and extent of this mainstream work can be seen in the account already given of the remarkable project time successes achieved from Daventry and Orfordness onwards. However, it is in connection with the way that 'thinking was kept right' that is of the utmost importance here. This can be seen in its fundamental form with the Daventry test.

The position at Daventry is probably best highlighted by saying that if this experiment had failed or – much more likely – had been misinterpreted, then the appearance of radar in Great Britain could have been delayed indefinitely, certainly beyond the danger point of 1939. That the experiment was successful can be ascribed to two main causes. The first was the technical quality of the equipment itself and correspondingly of the thinking that lay behind it; and the second was the penetration shown in the observation of the displayed signals, and particularly of their analytical interpretation.

It must be remembered that this was a completely new world where even the basic principle of '... getting enough (reflected radio energy) back from the aircraft' was in doubt; and where it

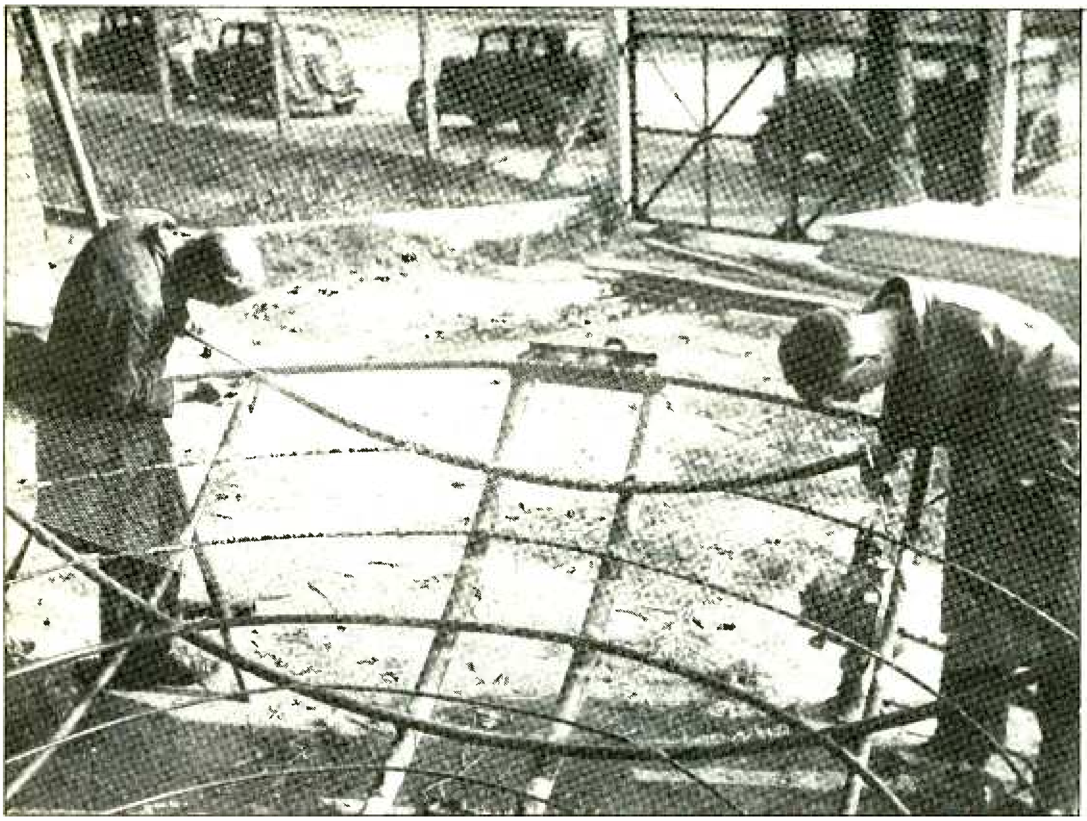


Fig. 1. **Paraboloid Aerial Reflector for Television Radio Link under Construction.**

might not be possible to anticipate all the unforeseens. That they were anticipated, and all false trails avoided, was to give the solid base for the breakthrough expansion which followed, and represents in many ways the culmination of work which had begun at the Radio Research Station, Slough with Watson Watt as Superintendent. Here, amongst a wide variety of research activities, notably on radio propagation, classical work was carried out on cathode-ray tube measurement and other techniques[3].

One aspect of the c.r.t. work is of particular interest in this instance. This was an installation set up to enable two observers, widely separated at the ends of a 550km base line (Slough — Leuchars in Scotland), to determine the direction of arrival of atmospherics by means of cathode-ray direction-finders. A continuous watch was maintained over a selected period, and on "Now" from the 'control' observer passed over the permanent line between the two stations, simultaneous readings of screen trace bearing being 'written down serially' by an assistant at Slough, listening in parallel on the line. The individual atmospheric source 'fix' was then determined from the intersection; and this is probably one of the first examples of a well-engineered operational scheme for such (radio) direction finding. It was typical in that it embodied many of the basic techniques which were to be adopted for radar, and which incidentally, employed 'filtered' data-reduction methods.

As indicated — and as will be appreciated — this 'hands-on' process, some of it almost automatic, was to be a feature of the radar expansion of World War II, and was to continue as spin-off after it.

A particularly apposite illustration of how spin-off could develop comes from the early days of operational radar. When the original group of three stations became available, difficulty was found in reconciling the plots of aircraft obtained from the three sites with their different radio (physical) characteristics and variation between observers (cf. the 'base line' atmospherics method). The problems of correlating aircraft tracks and reporting them *quickly* were tackled by setting up 'filter rooms', the first of these being at Bawdsey; and the second — the derivation of corrected plots and their transfer to standard 'grid' form — by the development of a converter. This converter, which became inevitably known as the 'fruit machine', was a digital computer with electromechanical logic based on automatic telephone practice and demanding automatic-exchange type maintenance.

The success of this system and of those who operated it, may be judged by the remark made by Air Marshal Dowding on seeing the converter that "... it would not be long before the scientists replaced the Commander-in-Chief of Fighter Command by a gadget!" (ref. 2). It is valuable to reflect that this remark, possibly with the replacement of 'gadget' by 'gimmick', would be just as likely to be made in similar circumstances today.

Apart from its technical interest, this incident is one further example of experience and know-how built up during World War II still being relevant, and in many respects, up to date at the present time. This can be taken further in the broadening of the statement made in the first article that the basic technology of that time does not have to be rediscovered, i.e. that the very expensive process of clearing the obscure problems that can be expected in the early stages of a project does not have to be carried out, or at least can be greatly reduced. (In an extreme case, as already indicated, these initial problems can be so intractable that this particular line of development has to be abandoned despite its being likely to succeed in the end.

Television – the build up of technology

High technology, defined as 'advanced engineering permeated by electronics' came to the British *public* "... (with) the inauguration of the television outside-broadcast service in May, 1937 for the Coronation" (ref. 4)

This outside broadcast, outstanding in its success, was even more noteworthy for the organisation and speed of technical achievement which lay behind it. Typical of this speed was the installation of the special low-loss — balanced pair — 'television cable' for video transmission, which was carried out by the Post Office well within a year of its being authorised by the Television Advisory Committee. Active collaboration by the Post Office continued with the development by the BBC of entirely new techniques and equipment to enable video signals to be transmitted over ordinary telephone cable pairs (ref. 5). Facilities provided by the Engineering Department of the PO London Telecommunications Region made it possible to install the repeater equipment in exchanges with, perhaps, only one route-mile of separation between them.

This solution to the problem of bringing the OB signals to the permanent television cable for onward transmission was much more practicable (and cheaper) than the alternatives of a radio link or a special wideband cable, for the built-up areas being covered. Also by the use of existing telephone cable network, it was possible for circuits to be provided within a matter of a few hours; which was a significant advantage both in terms of engineering and of programme service availability.

This pioneering work, a model of engineering R & D, will be described later in this article mainly with regard to the major advance that it represented in television technology; but also as an illustration of how a 'climate of technical confidence' can be created.

It may be noted that an earlier article by S.H. Padel, concerning the principles underlying this work appeared in *World Radio* for August 12, 1938, i.e. in the same year as a foundation paper by MacNamara and Birkinshaw was published on the London Television Service (*Journal of the IEE* December 1938).

This paper was, in fact, a description of the World's first high-definition television service with its 45MHz transmitter at Alexandra Palace in North London covering the large concentration of population in London itself and in surrounding areas including the Thames Valley. Thus an appreciable number of people in Great Britain were brought into contact with modern — albeit black and white — television some years before the outbreak of World War II in 1939.

Before this, low-bandwidth television had been broadcast to cover much the same region on a service basis. Programmes on the Baird 30-line system were transmitted from the BBC station at Brookman's Park during the early 1930s; and although the results were crude in comparison with those achieved later in the decade, they provided information — obtainable in no other way — on possibilities of applying these low-bandwidth techniques in other fields and working by analogy from them.

As will be seen, these possibilities were indeed taken up much later; examples which will be described in subsequent articles include the tv-based 'Independent Check' instrumentation of aerospace and suggestions made for crisis control ("big-system" automation and telemetry, in this series).

This question of how and when to take advantage of earlier or analogous work forms part of the final discussion in this article. However, in the meantime, it is possible to throw more light on the 30-line tv case by examining the results that could be obtained under the right conditions.

With the Nipkow disc and modulated neon light source of the receivers that were commercially available, the picture, usually described as being of postage-stamp size, was not really acceptable. On the mirror-drum monitors used in Broadcasting House, London, at the time (programmes from Studio BB), the picture was of elongated postcard size, the line structure — with vertical scanning — was coarse, while the difficulty of synchronising the rotating drum resulted in some wander. Nevertheless, full-length pictures of individuals were quite recognisable, i.e. specific 'data' was being transmitted over a low-bandwidth circuit, while the effects of faulty synchronisation could be assesed.

This was an interim stage to be followed by cathode-ray tube sets produced by enthusiasts within the range of Brookman's Park. The received pictures, although afterglow was present, were of sufficient quality to show, amongst other things, that such systems could be applied successfully to the transmission of the detail required, for example, instrument dial readings. Also this was being done under conditions which it would be difficult to set up now, including that of restricted bandwidth.

Reverting to the BBC system for sending television signals over ordinary telephone cables, one can best illustrate the extent of this achievement by quoting S.N. Watson who has used the words "technical audacity" to describe A.R.A. Rendall's action in putting up this project. Dr Rendall's concept of taking balanced-line working to its ultimate limit, and countering the 'impossibly high' losses of the cable at video frequencies (30dB/km at 2MHz) by specially developed equalisers and amplifiers was soon shown to be highly successful. In its final form the BBC system had provided four OB line links by September 1938, while this had been expanded to eighty for the next twelve months ending September 1939 (ref. 4).

The equipment is shown schematically in Fig. 2 and, in addition to the video equalisers and amplifiers, included special phantom (rejector) and balanced-to-unbalanced repeating coils; and made possible the transmission of surprisingly high quality pictures over circuits with 2MHz attenuation values lying between 60 and 70dB (refs 4 and 5).

It is worthy of note that this was a 'small team' project, with six engineers as a maximum involved in the R & D work- and that the climate of confidence it generated has, in effect, continued to be of value up to the present time. Thus the basic principles established by the original BBC work provided as a minimum this climate for embarking upon a project in water-supply monitoring which broke new ground. This was a remote control scheme for the East Anglian Water Company with surveillance television signals sent over an 8km length of telephone cable (refs 6 and 7).

Direct interchange between television and radar can be seen in the way in which a technique evolved in the field for adjusting phase equalisation was eventually developed to become a pulse-testing method for use in radar.

One of the main forms of phase distortion encountered with BBC telephone-cable video was once described as 'pseudo-ringing' which appeared as a short duration spurious signal on vertical edges in the picture. Correction of this phase distortion could be carried out most easily when a 'flagpole' type of signal source could be brought into the picture. It was in fact a flagpole at Earl's Court which became more than familiar during pre-transmission testing when it provided the well-defined short video pulse required.

Much later on, these ideas were recalled during the development of a special video display system for a magnetron-based type of radar set. The response to pulses was all-important in this system and it was realised that a simple method of testing this existed in the 'magnetron pulse' monitoring signal which was available to be fed into the video input for viewing on a waveform display. Not only did this enable

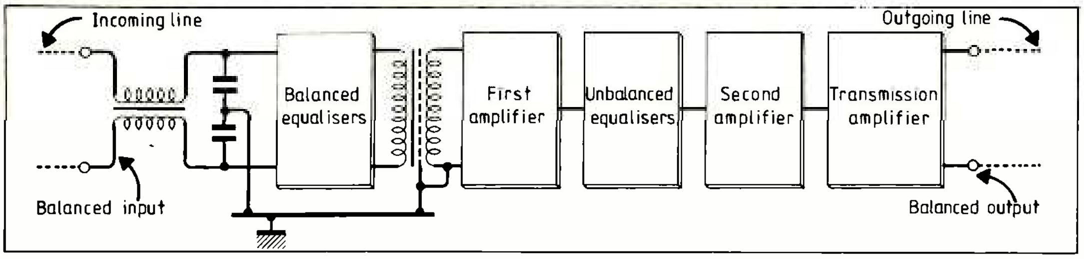


Fig.2. **Video Repeater for Telephone Cable**

actual pulse response to be observed, but also provided an indirect method of determining frequency response.

This account is given in some detail to show how the 'innovative know-how' of the original television technique was, as it were, passed on to another area of technology — that of radar. It is relevant to note that this process was continued later with a further transfer to yet another field — telemetry.

Innovative know-how has been adopted to cover that combination of original thinking and informed practical ability which so often is found to lie at the root of successful and economical engineering development. The example chosen to illustrate how smooth transfer from radar to television could be achieved is that of the design and manufacture of a directional aerial system for a television radio link which was being developed for the 4-500MHz band. The production of this aerial system soon turned into a project in its own right. It had become clear that the cost of development by a firm new to the field would be prohibitive. However, it had become equally clear that the techniques evolved for radar (system) working at the same order of frequency could be used as a basis for the television case.

Thus with the paraboloid (dish) reflectors required for the directional aerials it proved possible to evolve a method of construction that was both economical and technically acceptable. Briefly, the primary technical (radio) requirement was for the surface of the dish to be maintained within close tolerances as near as possible to those of an equivalent optical reflector; while for narrow-beam aerials for point-to-point working, it was vital for the dish — and the radiating element in it — to be held rigidly on their line-of-sight axis.

Full recognition must be made of the success achieved in meeting these requirements, particularly the way in which the fitters evolved techniques of their own to keep the reflecting mesh (chicken wire) surface to the requisite close tolerances on its tubular steel supporting framework. This was of low-cost construction made of standard electrical conduit with a robust secondary framework of high-grade 'steam' tube forming the rigid supporting structure required. As will be gathered from the photograph, brazing was used extensively; an air-acetylene flame being adopted on the basis of radar experience which had shown that a satisfactory joint was made at temperatures which did not cause mechanical distortion. It is perhaps superfluous to note that these craftsmen, with their innovative know-how, came from the pool which has existed for many decades in the 'super cluster' of London and the Thames Valley.

The overall picture

As has been shown, and in terms of the pre-war period up to 1939, development in Britain of both radar and television technology took place on much the same time scale: The fundamental radar equipment was carried out at Daventry in 1935, and 30-line television was being broadcast by the BBC in the early 1930s. The first three CH stations — forming a basic chain — were completed by August 1937, the historic television outside broadcast of the Coronation was made in the BBC high-definition service earlier in that year.

In both of these areas, work was essentially at R & D level during this period and carried out largely with the 'small-team' approach. In 1939 the position changed with unprecendented speed when the full radar expansion was set in motion, and the build-up of resources, both human and material, began. At the same time, the television service was shut down, not to be resumed until the end of the war.

The point to be stressed here was the far-reaching changeover which took the form of bringing-together of many people with diverse technical experience produced a national-scale cluster of remarkable strength, as noted earlier. (The shut-down of the BBC television service was not all loss in that it released a number of engineers, already familiar with basic techniques, for the radar programme.)

As will have been realised from the examples already given, full advantage was taken of the breadth of experience that had become available, particularly as it affected constructive liaison with industry; and, above all, the various aspects of systems engineering which arise when electronics meets the outside world.

The view has tended to develop over the years in the UK that modern technology is so advanced and is changing so rapidly that each new departure in it is a matter for specialists. Nevertheless it is suggested that although the opportunities for gaining wide-ranging experience in the UK may be more restricted than they were, say, 5-10 years ago; there is still a major requirement for technologists at all levels who know enough of more than one field of engineering to be able to exercise managerial or control over, for example, the interface problems which arise almost as a matter of course with complex systems engineering. An even more important managerial function, perhaps seen at its best in the programme of expansion of British radar, is that of coordinating and directing the R & D work for such complex systems, and in relation to the other organisations working on the project.

This does not mean that specialists have made other than a major contribution to engineering R & D in the United Kingdom. This aspect will be brought out in later articles, as for instance with the intervention and development of the cavity magnetron, and the achievements of British universities.

In conclusion, it is suggested that although the British capability for the management of R & D is far from being lost, more emphasis might be given to the acquistion of all-round engineering capability, and particularly in the electronics context.

One of the main arts in running a complex project is to know when to take advantage of analogous work which one has carried out in the past, even in a separate but associated field; and it is in this fund of experience and again know-how, that much of the hidden strength of the country lies.

References

1. Crowther, J.G. and Whiddington, R: Science at War, His Majesty's Stationery Office, London 1947
2. Rowe, A.P.: One Story of Radar, The University Press, Cambridge 1948
3. Watson Watt, R.A., Herd, J.F. and Bainbridge-Bell, L.H.: Applications of the Cathode Ray Oscillograph in Radio Research, His Majesty's Stationery Office, London, 1933
4. Rantzen, H.B, Rendall, A.R.A. and Watson, S.N.: Land-line technique for television outside broadcasts, *BBC Quarterly*, Vol.2 no.3, October 1947
5. Padel, S.H.: Television Transmission by Telephone Cable, *World Radio*,(1) April 28, 1939 and (2) May 5, 1939
6. Layzell, M.C.: Closed circuit television link via telemetry cable, *Water & Water Engng.*, June 1969.
7. Young, R.E., Industrial telemetry, some recent supervisory and control schemes, *Wireless World*, Vol. 77 no.1, January 1970

CIRCLE 48 FOR FURTHER DETAILS.

CIRCLE 47 FOR FURTHER DETAILS.

CIRCLE 17 FOR FURTHER DETAILS.

PREAMPLIFIER DESIGN

I thank Mr Armstrong for his continuing interest in my approach to preamplifier design. I also note that he has not yet seen fit to make any objective measurements with which to back up his claims. While Mr Armstrong seems to think that it is a little insensitive of me to draw attention to this, it is the kind of gross tactic that one must get used to if joining in the rough and tumble of the correspondence columns. Being a professional audio designer, I have my reputation (such as it is) to consider, and people who try to demonstrate that I don't know what I'm doing by quoting myth rather than fact can expect little mercy.

To continue playing Bacon to Mr Armstrong's Artistotle, I append below the test setup for trying to wring distortion out of electrolytic capacitors. The oscillator/distortion analyser used is a Sound Technology 1710A, which still has a reasonable claim to be the state of the art in distortion measurement. The minimum t.h.d. levels measurable scross most of the audio bandwidth are of the order of 0.0012% on my example. Starting at 1kHz and an oscillator level of +20dBm (7.75V r.m.s., the largest signal level you could expect to meet in an op-amp audio system) no additional t.h.d. is detectable until the frequency is reduced to 30Hz, when about 0.003% third harmonic is produced. This increases to about 0.05% at 10Hz, the lowest frequency the Sound Tech will provide.

It may appear at this point as if all I have done is prove myself wrong, but this is not so. As I said in my first reply, the use of unbiased electrolytics to pass audio assumes that the voltage across the capacitor in the reverse direction never exceeds about a volt. If it does, then you have a significant signal loss occurring, and you have, accidentally or deliberately, made a high-pass filter of most dubious accuracy due to the wide tolerance of electrolytic capacitors. Not very nice.

This is why in the test set-up distortion occurs at about 30Hz with the values shown; it is at this point that the peak voltage across the capacitor reaches 1.4V, which appears to be when depolarisation occurs in practice. Naturally distortion results as the capacitor dielectric film starts to come undone. Measurements with different values of R & C confirm that the signal voltage across the capacitor is the crucial factor in the onset of distortion. The moral is simply; don't let your electrolytics experience any significant signal voltages across them in the audio band. Use them as coupling capacitors rather than filter elements.

I must confess that I am still a little unsure about exactly what Mr Armstrong means by dielectric absorption in this context, and so I don't feel I should comment. I hope that he will enlighten me.

I resist the temptation here to go on about undue attention to connectors. While gold-plated or gold-flashed connectors are normally considered to have a higher ultimate reliability, especially in hostile environments, it should be obvious that the audio world, and the wider one of electronics, contains thousands and millions of non-gold contacts working quite happily. The effects of a sudden lapse into rectification would be so audibly dire that it would be immediately obvious. Spending money on gold fittings for the hifi may have an emotional appeal, (it costs so much it *must* be better) but not really a logical one.

Finally, the hoary old argument about what people do to the music before it gets to you, i.e. shove it through electrolytics and non-noble connectors from noon till night-time. Just because arguments are old, it doesn't mean they're wrong. If it was necessary to build mixing-desks and tape machines as if they were satellites then it would be done; but it isn't. The professional audio market is a highly competitive one, and customers want machinery to do the job properly, and no messing with hifi fashions. If Mr Armstrong really wants to worry about a quality bottle-neck he might do worse than consider the analogue tape-machine, still in use in most studios throughout the land.

D.R.G. Self
London E.3.

BAIRD TELEVISION

I was indeed interested on reading in the January 1985 issue, under "Communications Commentary" the paragraph on Swinton and Baird.

I do not know if you are aware that in the *Royal Television Society Journal* over the past year there has been considerable correspondence on whether Baird was the "inventor" of television or not. I joined the Scophony Company in 1930 as the first engineer there to work on the inventions of G.W. Walton. The success of that company was quite considerable, in that in 1935 we were demonstrating high definition optical mechanical pictures on large screen and in 1937 at various cinemas, including the Odeon Theatre in Leicester Square, on an 18ft. screen.

I met Baird many times in those early days and at no time did we feel that his company had anything specific to offer, in that the Nipkov disc was so well-known and the work of Jenkins in America in the early part of the century was also well published; in fact I do have a book published by Jenkins in 1925.

Without wishing to enter into this "who did what" saga, I enclose photocopies of a tv system devised by a Frenchman called Dussauds which apparently was demonstrated in the great Paris Exhibition in 1900. There are one or two technical inaccuracies in the reprint but the whole system is quite feasible and probably did work, not with a complete figure but certainly a head such as Baird demonstrated. The extract comes from a book entitled Victorian Inventions. The synchronisation of his system compared to Baird's solid drive shaft is interesting as he used clockwork to drive the Nipkow discs and clockwork mechanism for accurate timekeeping was known and devised in the 17th century — some major town hall clocks built in those early days are still running.

In my many years associated with television in the pre-war days, with radar during the war, and my gas detection company post-war, I have always found that looking backwards at the inventive genius of people in the latter part of the last century and the early part of this exercises the mind to invent again with all the devices which have become available in those very few years.

Joshua Sieger
Poole
Dorset

LIGHTNING STRIKE

A point might be added to the interesting article in the October issue Lightning Strike. Conductors carrying large currents will experience a shearing force at any bends; this can be seen by drawing a vector diagram of the currents at a bend. It is therefore good practice to keep lightning conductors as straight as possible, and make necessary bends very gradual.

J. Schmelzer
Albuquerque
New Mexico
USA

SOE

It was kind of Pat Hawker to mention my name in his "Here & There" column (*E & WW*, Dec., 1984). But I have to report that he has mis-remembered a telephone conversation I had with him last year. Bill Hudson, our first SOE agent in Jugoslavia, landed in Montenegro in 1941. I did not join SOE until May 1943 — and, after a hectic apprenticeship in Cairo, was sent to Tito's G.H.Q. in charge of Signals at our Mission there from December 1943 until May 1945.

Partly in connection with the BBC-tv films on SOE, I was trying to establish just what Hudson's radio problems had been. (Tragically, he was out of contact for many months.) He could remember only that his main set had been called a "MK III"; he did not know where it had originally come from; it was mains only; it was in a stout wooden box; and it weighed around 80-100lb. (Just the job for the mountains of Montenegro, on foot).

Hudson was given this monster by British Intelligence in Malta. Pat Hawker could not confirm precisely what configuration this particular Mk

III would have been in. So G3EUR produced for the BBC, at almost no notice, a "mock-up" of the Mk III in its familiar HRO configuration. This was rushed to Jugoslavia for the BBC's filming — but, as so often happens on these occasions, appeared in the final version of the film only in very long shot, and only for a second or two.

Hudson's radio operator (as I learned only after the war) was Sgt Veljko Dragičević of the Royal Jugoslav Army in Egypt, detailed to accompany two Jugoslav officers sent in by SOE along with Hudson. These two officers were evidently intending to join the Royalist General Mihailović. Hudson had a wider brief — to contact *all* resistance groups. In the event, they met first the Montenegrin Partisans, who took them on to Tito's GHQ — then in Serbia, at Užice. At this point, Sgt Dragičević, having seen the Partisans in action, volunteered to joint them. Hudson (who had a high regard for Dragičević) felt he could not object. Tito — in dire need of both operators and sets — welcomed the new volunteer, but insisted that the Mk. III be returned to Hudson for his onward journey to Mihailović's HQ.

When I arrived at Tito's GHQ in December 1943, Tito's Chief Signals Officer, in charge of a rather effective W/T network covering the whole country, not to mention a link with Moscow, was none other than Major Veljko Dragičević. We became good friends — but ironically no-one in our Mission, or in SOE, then knew that Veljko was in fact one of SOE's most valuable contributions to Tito's successful war effort! Veljko, for his part, never told me his story — thinking, no doubt, that I must certainly have known all about it, but had been too polite to refer to what we might have regarded as his "desertion" from Bill Hudson's mission.

Sadly, Veljko was killed during the German airborne landing on Tito's GHQ in May 1944. Otherwise, he would no doubt have been only too pleased to tell us the full story of Hudson's notorious "MK. III".

By the time I went to Tito's GHQ, G3EUR and his colleagues in SOE were already in production with their classic "No. 3, Mk. II", or "B 2", "War Station" behind the Pyramids (known as "M E 8") — with its 40 RCA ET 4332s at 250 watts; AR 88s to match; and rhombics galore. So we were no longer dependent on the (for our purposes) altogether less satisfactory Intelligence network and equipment.

Soon after Fitzroy Maclean took over our contacts with Tito, his Mission formally ceased to be a part of SOE This explains why the BBC decided to bring their SOE film on Jugoslavia to an abrupt end with Maclean's arrival. What the BBC did *not* mention was the fact that all Maclean's communications, and all the apparatus of air supply drops (including the laborious business of drawing up "G 1098" lists of authorised equipment for "Partisan Guerilla Corps, Division, Brigade and GHQ Signal Detachments", and getting the stuff from British and US Signals Depots from all round the Mediterranean) remained the exclusive responsibility of SOE until the end of the war. And it turned out that Army and RAF Signals Units were generally not able to cope effectively with the guerilla-style communications which were required in and around the Adriatic in the closing stages of the war by Marine Commandos and others.

However (with the honourable exception of F2WL's "Secret Warfare", on the French Resistance experience) the remarkable story of SOE Signals continues to elude the historians. As one of them noted at the end of the war, after going through SOE's (still secret) archives, this part of the SOE story "can be told adequately only by technicians, to experts. . .". Yet even Major-General Nalder's magisterial "History of British Army Signals in the Second World War" makes no mention of the crucial role of Royal Signals personnel in SOE — or of SOE's sets, beyond a passing reference to "miniature components" not available to the Army in 1942, although they had proved "very successful in suitcase sets made for special operations".

If any of your readers have any experience of SOE Signals activities, or personalities, in Cairo, Bari, or the Balkans generally, I should be very glad to hear from them.

H.W. King
Oban
Argyll

ELECTROMAGNETIC ENERGY TRANSFER

I would like to reply to letters in the January issue following my article in September and October of 1984.

I regret that I cannot comment on P.J. Ratcliffe, since I see no reason for mixing e-m and entropy. Have they been mixed up together before, I wonder?

Ouida Dogg (sic) compares Galileo's travails with mine. Certainly the scandalous, unprofessional behaviour of the Establishment (in my case officials of the I.E.E., Inst. Phys. etc.) closely parallels that of the Church in Galileo's case, except that the Church and its supporters at least bothered to supply some philosophical justification for what they did to Galileo. Disclosure of my research has been delayed for more than ten expensive years. There is no point in giving names, because every single member of the scientific establishment behaved irresponsibly in my case. As Oliver Heaviside wrote;

"If you have got anything new, in substance or in method, and want to propagate it rapidly, you need not expect anything but hindrance from the old practitioner — even though he sat at the feet of Faraday. Beetles could do that. . . But only give him plenty of rope, and when [as now in my case] the new views have become fasionably current, he may find it worth his while to adopt them, though, perhaps, in somewhat sneaking manner, not unmixed with bluster, and make believe he knew all about it when he was a little boy!" — See I. Catt et al., Digital Electronic Design vol 2, p323, pub. C.A.M. Publishing.

Ivor Catt
St. Albans
Herts.

The NPL definition of the ampere is bad science purely because of the difficulty in getting infinitely long conductors. If we are to imagine them as the definition requires, we must make sure that they are a fair extrapolation of the finite shorted line. Chris Parton (December, 1984) gets into a tangle as he unwinds his reels of wire to infinity because he assumes they are initially quiescent. Why not extend the forward and backward wave system of the finite case to infinity along with the conductors? If you must speculate how this could be set up in a finite time from a quiescent state, why not allow a distributed e.m.f. instead of applying it at one point?

On the subject of transmission lines, Ivor Catt, who provoked this discussion, should get his car seen to if, as he says, it suffers from an energy dance at the speed of light. Wot no dielectric insulation? I hate to think what reflections will build up when the conductors touch.

Finally I was intrigued to learn from Mr O'Reilly that open lines are 'always terminated by free space with an approximate impedance of 377 ohms'. This should be of considerable interest to transmitter designers, especially at e.l.f., where they have great difficulty in getting anything radiated at all. But now all they have to do is install a 377 ohm feeder to the outside where it is cut off cleanly. The r.f. will run up the line and obligingly launch itself into free space unhampered by any aerial. Since this effect is independent of frequency, or even geometry, it must be explanation of another phenomenon which has always puzzled me: the fact that my batteries always go flat during storage. Obviously they are being shunted by free space. It would also explain the well-known standby consumption of mains sockets, amounting to 153 watts, if they are not properly switched off at the wall, a fact well appreciated by builders in these energy conscious days, when it comes to specifying the number of sockets in a room. This effect was, in fact, first brought to public attention by James Thurber, whose aunt lived in dread of electricity leaking out and getting around the house.

D.H. Potter
Axminster
Devon

Vehicle location in mines and metros

by D.J.R. Martin BSc, PhD, FInstP, FIERE

Leaky-feeder systems providing radio communication for mines and underground railways may be simply adapted to indicate positions of trains and other vehicles

Underground environments such as mines and tunnels commonly present two requirements with regard to the men and vehicles that may be travelling within them. In the first place there is usually a communication requirement: miners may need to keep in touch with a surface base either simply for their own safety or so that they may be diverted to attend to problems where their particular skills are urgently required; vehicles in the same mines, often manriding trains carrying over a hundred men, may need continuous radio contact to comply with safety regulations.

Secondly, there is an increasing need for a close automatic check on the movements of those same vehicles and perhaps even of individuals. In mining, where track circuit signalling is rarely used, the position of a locomotive can be in serious and dangerous doubt to a central despatcher; and given the nature of a mine it is not unknown for the driver himself to be insufficiently certain or even confused. In the corresponding metro case, modern signalling methods remove all dangerous uncertainties; and yet there is also evidence of a need for an independent and perhaps closer check on the situation, or even of a less expensive method.

In the underground world, mobile communication is almost entirely through leaky-feeder propagation of v.h.f. radio signals, to overcome the severe limitations on natural propagation in such conditions. As its name implies, a leaky feeder is a type of transmission line that has deliberately been made to be imperfect, so that the internal field extends for a distance of a wavelength or more outside the feeder itself and so allows communication with mobiles in the vicinity; a very common type is a coaxial cable in which the outer braided screen has been applied with a loose weave. Repeater amplifiers are inserted in the feeder to restore the losses periodically. This is the basis of the communication systems with which most mines and metro systems are now equipped [1, 2].

But, because of the propagation difficulties, the use of radar as generally known is impracticable in these circumstances, and the same consideration has precluded the development of any form of radio direction finding or distance measurement. As the need for position monitoring by radio means has become apparent, therefore, proposed solutions have centred on the installation of wayside beacons or interrogators operating in similar manner to the 'bus beacons' in increasing use. Such systems, of course, give a very precise indication of the passing of the beacon, but the information still has usually to be relayed to a central control point; this can be done by a normal leaky-feeder radiocommunication link from the vehicle or by fixed lines from the wayside points. The devices may be considered expensive, and perhaps a maintenance liability, where fairly close or frequent updatings on the position are required. There is also the factor that if the position information is lost it cannot be retrieved until the vehicle next passes a wayside point.

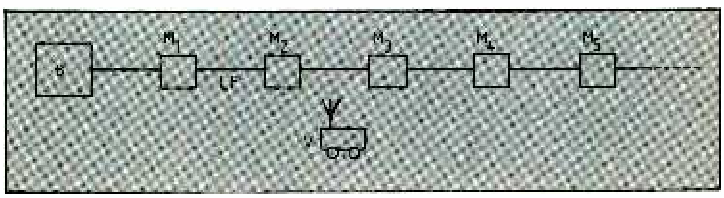
The proposal to be described allows the position of the vehicle or personal set to be established purely by reference to the signals being transmitted through the leaky-feeder system itself. There are no wayside beacons or interrogators to be installed, and the position can be redetermined at any time if stored information is lost.

New location principle

The basis of the location principle is that a radio signal being transmitted from base to a mobile or personal set (or in the opposite direction) can be systematically modified during its passage through the leaky-feeder system in such a way that the location of the mobile set can be deduced from the total extent of the modification observed in the received signal.

The operation may be followed by reference to Fig. 1, which is adapted from the formal patent specification [3]. Here, B is the fixed base station in communication with a mobile station V through the leakage fields of the feeder LF. The necessary modification to the signal is effected through special 'marker devices' interposed in series with the feeder at suitable intervals and denoted by M1, M2, M3, and so on. Such markers may or may not, as appropriate, be integral with any repeaters that may be present in the system. The modification imparted to the signal may take a number of forms, for

Fig. 1. **Leaky-feeder system with position markers**



example amplitude or phase modulation, but the simplest is probably the introduction of a short interruption or 'notch' in the radio-frequency carrier. Such a simple form of modification is probably not easily removable or reversible by a subsequent marker device, and so in this case the method of determining position amounts to counting the total number of separate notches imparted to the signal as finally received. The position-determining operation is initiated by either the base or mobile station, in introducing the first notch into its own transmission; each marker detecting such notch or series of notches then adds it own contribution to the series.

The marker device might take the simple form shown in Fig. 2, in which INPUT denotes the connection to the incoming leaky feeder from the direction of the base station or preceding marker and OUTPUT denotes the connection to the outgoing leaky feeder and any further markers.

The incoming r.f. signal is rectified by capacitor C_1, diode D_1 and resistor R_1 and then smoothed by choke RFC_1 and capacitor C_2 to produce a steady direct voltage across C_2. Interruptions in the imcoming signal cause corresponding interruptions in this voltage and the resulting pulses are passed through the differentiating circuit comprisiing C_3 and R_2 to the counter circuit IC_1, which determines when the final pulse in a series has been received, and thereupon passes a signal to the timing circuit IC_2.

This in turn initiates the required further interruption in the outgoing signal path, setting its interval and duration. In Fig. 2 this has been shown as though by a mechanical relay RL, though in practice a PIN diode or other solid-state method would probably be used.

Where the signal being coded is originating at a mobile transmitter the arrangement requires some elaboration. In the first place, the signal level in the feeder will be far lower and there will certainly be need for some amplification in advance of the notch detection circuits. But more fundamentally, the number of notches in the incoming signal will no longer be fixed, being itself already dependent on the location of the mobile rather than as before on the position of the marker in the chain, and so a simple counter cannot indicate when the last notch has been received. This can be decided instead by arranging that the additional notch applied by each marker is initially of smaller width than the rest. This will identify it to the following marker within the time duration of a normal notch, whereupon it can be extended to the normal width before addition of the new narrow notch.

In practice, leaky feeder systems more than about a kilometre in length normally incorporate repeaters in the line to compensate for losses. These are usually line-powered.

As shown in Fig. 2, the relay contact RL_1 (or its equivalent solid-state device) will interrupt not only the r.f. signal but also any line-fed d.c. supply. It may be necessary to provide a d.c. bypass in some system arrangements: but in fact the situation as shown can lead to an attractively simplified system, fo the sensing may be carried out on the d.c. supply instead of on the r.f. signal. This does presume that it is the base-station carrier that is being coded, and that the system is powered from a single d.c. supply at the base-station transmitter; and to maintain uniformity between the markers it becomes necessary to replace the initiating interruption of the carrier by an interruption of the d.c. supply.

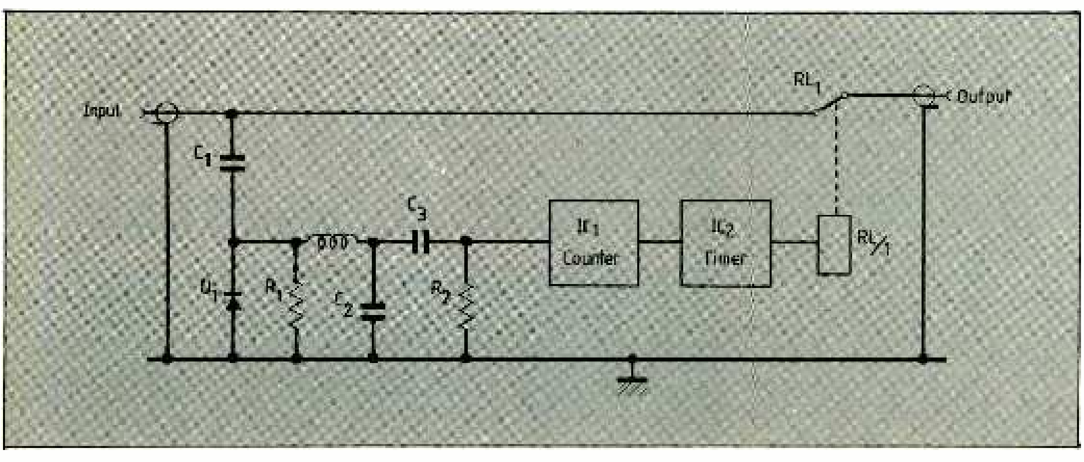
Two-stage coding

If the number of markers in a system is large, either because of the length of the system or because a high resolution of position is being sought, a disadvantage may arise in the resulting long series of notches taking an unacceptable time — perhaps several seconds — for the location process, especially if the frequency of interruptions is limited by bandwidth considerations of the signal. In such cases it is possible to carry out the location process in two stages, with consequent reduction in the total number of interruptions involved.

For example, suppose that a particular system requires the use of 99 markers. In the simple scheme described this would result finally in a series of 100 interruptions, to be counted for any vehicle in the final section. In the improved variation only every 10th marker will respond to a series of fewer than 10 interruptions and add its further interruption; the intervening markers will respond only to trains of notches exceeding 10. Thus, on this interrogation the number of notches received by the mobile will denote only the decade in which it is located. This information is then relayed to the base station, which thereupon initiates a further series of interruptions.

This new intitiation, however, consists of sending not just a single notch but a series of notches corresponding to the number 10 decremented by the number of notches previously counted. As before, every 10th marker will respond by incrementing the number of notches by one. But when the number of notches reaches 10 every subsequent marker will respond. This transition will occur when the previously determined decade is reached. Thus, the number of notches then received in excess of 10 will denote the number of the section within the decade.

Fig. 2. **Skeleton diagram of position marker**



References

1. D.J.R. Martin: Leaky feeder communication in tunnels, *Wireless World*, *88* (1557), pp 70-5, June 1982, and *88*(1558), pp 33-7, July 1982.
2. P. Delogne: Leaky feeders and subsurface radio cummunication, Peter Peregrinus and IEE, 1982, 283 pp.
3. D.J.R. Martin: Vehicle location system, Brit. Pat. Appln No. 8324686

The new logic symbols – 2

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

Since manufacturers' data sheets are already changing gradually to the new standard and more and more of the larger companies will comply, everyone concerned with digital electronics will sooner or later have to come to terms with the new standard.

The reader is here reminded of one important point explained last month. If polarity indicators (triangularly shaped qualifying symbols on inputs and outputs) are employed in a diagram, this means that voltage levels (i.e. high or low) are known for given logic states, so making logic convention irrelevant. (A polarity indicator on an input or output serves to indicate that a low level external to the element corresponds to an internal logic 1-state.) If negation symbols are used on any inputs or outputs, then no polarity indicators should appear on any inputs or outputs, and it is also necessary to define the logic convention (i.e. positive or negative). Since only pure logic is represented internally within a binary logic element, only negation symbols may be used to signify inversion, for here polarity indicators have no place.

In this article a mixture of postive logic convention and usage of polarity indicator diagrams will be found: a positive logic convention may be assumed if polarity indicators are not present.

Dependency notation

The dependency notation allows the relationship between inputs, outputs, or inputs and outputs to be defined without the need for showing all the elements and interconnections involved. The aim is to supplement qualifying symbols (symbols associated with inputs and outputs) in complex elements, not to replace simple elements in their own right. For use of the dependency notation in simple elements makes them more complex, whereas their use in inherently complex symbols provides a simplification. (The logic of this apparent enigma will become clearer later on.)

In order to simplify the following text, the abbreviation 'I/O' is used to represent the phrases: 'input or output' or 'inputs or outputs'.

The dependency notation is accomplished by:

- Labelling the I/O affecting other I/O with a particular symbol denoting the relationship involved followed by an identifying number;
- Labelling each I/O affected by that affecting I/O with that same number. Where the affected I/O already has a label denoting its function this label is prefixed by the dependency notation number.

And, or, negation and interconnection dependency

The label 'G' is used to denote an And dependency. Figure 9 demonstrates this, where the dotted lines on the binary logic element signify that only a portion of a complex element is under consideration. The '1' number label shows a relationship between all of the inputs shown. The 'G' label associated with input b signifies that this input has an And relationship with other I/O having an identical number ('1' in this case). Thus there is a straightforward And relationship between inputs a and b as the equivalent logic diagram alongside shows; in the case of input c, the bar over the label '1' signifies an inversion (i.e. is Anded with the inverse of b).

Figure 10 shows G dependency between an output and an input; output b is Anded with input a (remember we are only considering a part of a more complex symbol). It should always be borne in mind that these internal labels refer to internal logic states; therefore, if there had been an external negation symbol on the output of this symbol — as depicted in Fig. 11 — then it is the internal condition which is Anded with the input, as shown in the equivalent logic diagram, not the inverted external condition. Note that a '1' is used as the general qualifying symbol for a negating (i.e. inverting) element.

A dynamic input is signified by the familiar 'notch' qualifying symbol as shown for input b in part (a) of Fig. 12. The equivalent logic diagram in part (b) of the figure serves to make the point that only input b is a dynamic input in this case: it does not mean that inputs a and b are Anded prior to a dynamic input to the main element; thus a and b in part (a) of the figure are not equivalent to the logic diagram shown in part (c) of the figure. Two (or more) affecting inputs with the same dependency letter and number stand in an Or relationship to one another, as shown in Fig. 13.

The label 'V' is used to denote a conventional Or dependency, as depicted in Fig. 14. In this case, output b is Ored with output a internally, therefore not affecting output a itself, as shown in the equivalent logic diagram.

The label 'N' is used to indicate negate (or exclusive-Or) dependency, as shown in Fig. 15.

Interconnections are simplified in complex elements by use of Z-dependency. The 'Z' label signifies interconnection; thus, the internal state of the output of the element shown in Fig. 16 is interconnected to the shown effective input by nature of the Z-dependency. Note once again how this does not affect the outpu at a.

Set/reset dependency

Set/reset dependency (S/R) is not so easily shown in brief, so we must suffice here to show one example only. Figure 17 depicts an SR bistable (or latch) which has reset (R) overrides on both outputs. As the truth table shows, the logic 1-state at the a input has no effect when a logic 1-state also exists at the b input. (NB. 'nc' in the truth table signifies 'no change'.)

EN inputs and EN dependency

The label 'EN' signifies an enable. Thus the input shown in part (a) of Fig. 18 is an enabling input affecting all outputs. The inverted triangular qualifying symbol shown against the outputs signifies a three-state output. If the enable only affects certain I/O then EN dependency notation is called for, as shown in part (b) of the figure. In the latter case, input a affects input c and outputs d and e, whilst input b only affects output f.

Mode dependency

Mode (M) dependency is one of the more complicated relationships, and an example of this is given in Fig. 19. In such situations, the effect of an affecting I/O on an affected I/O is summarised below, where separate segments of a label are separately considered when separated by oblique strokes:

- If the affecting I/O is at a 1-state then affected I/O are enabled;
- If the affecting I/O is at a 0-state then affected I/O are disabled; sets of labels containing the appropriate dependency number should be ignored.

Figure 19 illustrates various points in connection with mode dependency, and also introduces a labelling method used for indicating a range of dependency numbers, i.e. 0/3 in this example for the M (mode) input. The fractional form of representation indicates modes ranging from 0 to 3; thus the dependency numbers 0, 1, 2 and 3 within such an element must be reserved for mode dependency use.

The bracket around inputs a and b to the element signifies binary grouping. The associated labels of '0' and '1' simply signify bit significance in this instance (they are not dependency numbers); thus the '0' on input a indicates that this is the least-significant bit of the binary grouping, the '1' on input b signifies the next bit significance (and so on with '2', '3', etc, as necessary in cases where there is a larger binary grouping). From this we may assume the following mode identities in accordance with inputs a and b:

INPUTS a	INPUTS b	RESULTANT MODE
0	0	0
0	1	1
1	0	2

Input modes are therefore dependent upon the binary input on a and b. Outputs e, f and g are mode affected outputs since they contain labels in the range 0-3. Let us consider each of these outputs in turn.

Output e has a mode dependency in modes 2 and 3, and in these modes, the label set specifies negation (XOr) dependecy when input c is at a 1-state due to the N4 association; in all other modes output e stands at its normally defined state as if it had no labels.

Output f also has a negation dependency when the mode dependency is operative since this is also dependent upon the N4 affecting input c; when the mode dependency is not operative the output stands at its normally defined state as if it had no labels. Mode dependency exists in the 0 mode, which is equivalent to specifying (1/2/3)4 in the label, i.e. mode dependency exists in all cases except Mode 0, giving an effect in Modes 1, 2 and 3.

Output g has a negation dependency with input c in Mode 2 and an And dependency with input d in Mode 3; in all other modes the output stands at its normally defined state as if it had no labels.

Input h in the only affected input with mode dependency. This input only has an effect on the element in Mode 2, and Mode 2 effectively enables the And relationship specified by G6 between inputs h and j. Another point to note is the commas in the qualifying symbols for inputs h and j. Where commas exist, it implies that the dependency relationships indicated should be applied in the indicated order where each relationship is separ-

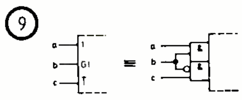


Fig. 9. **G dependency between inputs**

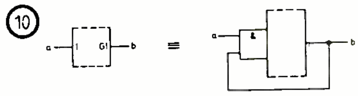


Fig. 10. **G dependency between output and input**

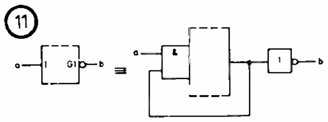


Fig. 11. **G dependency between output and input, showing that it is the internal state of the output which is Anded.**

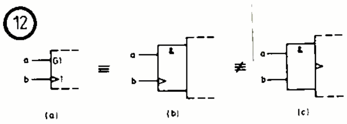


Fig. 12. **G dependency with dynamic input.**

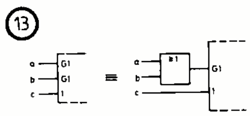


Fig. 13. **Identical affecting inputs are in Or relationship.**

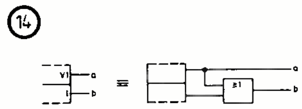


Fig. 14. **V dependency between two outputs.**

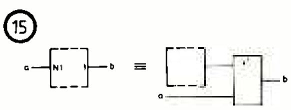


Fig. 15. **N (negate) or XOr dependency.**

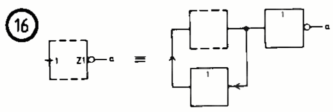


Fig. 16. **Z (interconnection) dependency.**

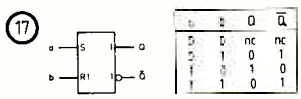


Fig. 17. **S (set) and R(reset) dependency.**

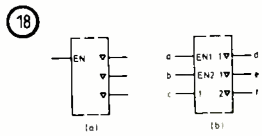


Fig. 18. **Examples of (a) EN input and (b) EN dependency.**

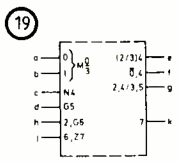


Fig. 19. **M (mode) dependecy.**

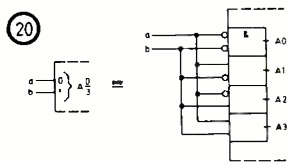


Fig. 20. **A (address) dependency.**

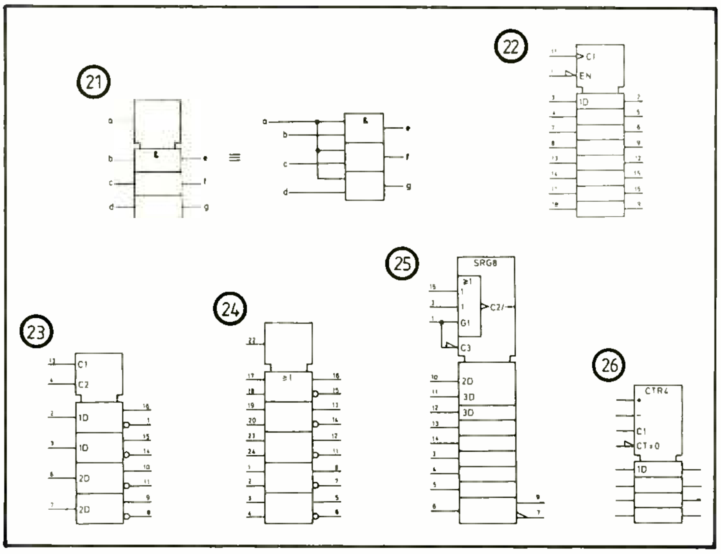


Fig.21. **Common-control box in use.**

Fig.22. **Octal flip-flop with common enable (74LS377)**

Fig.23. **4-bit bistable latch (7475)**

Fig.24. **Quint Or with one common input and complementary outputs.**

Fig.25. **8-bit shift register with parallel load facility (74165)**

Fig.26. **4-stage bidirectional counter with parallel loading and common reset.**

ated by a comma. Thus input h has no effect until Mode 2 is true, after which G6 becomes valid when input h is true, to be Anded with input j, so making the interconnection dependency valid when j is also true; all this — and only all this, results in a 1-state being output at k. Thus the label '6' associates h and j, and the label '7' associates j and k.

Address dependency

Address (A) dependency is relatively easy to understand if mode dependency is understood, for there can be many similarities, as may be seen from Fig. 20. Binary grouping is indicated by the bracket on the inputs, and the fractional qualifying symbol indicates the range 0-3 as it did in the previous example. This time the letter 'A' signifies address dependency within the given range. All this equates to four independent A labels (A0, A1, A2 and A3), as shown in the equivalent logic diagram. A different device might have four separate input lines to achieve the same effect, and in such a case, the input lines would be separately labelled as A0, A1, A2 and A3 respectively.

Shift registers and counters

The previous part of this article indicated how a number of identical elements can be represented in the form of an array. In these early examples there was no inter-relationship between the elements, but if such exists, this is most easily represented by the use of the common control box. This is the 'robot-head' appendage on top of the example array shown in Fig. 21. Any I/O associated with the common control box has an effect on several or all of the elements in the associated array. Input a in Fig. 21, for example, is a common And input to all the elements, as shown in the equivalent logic diagram.

Figure 22 depicts an octal flip-flop with a common enable (EN) input on pin 1 (active when low), and a common dynamic clock input on pin 11. I have intentionally economised by not previously introducing one further dependency input: control (C) dependency, to be seen on the clock input in this case. When an affecting control input is at its internal 1-state then the affected inputs have their normally defined effect on the function of the element. In this case, it may be seen that this facility is used to signify a clocking effect on a D-type input on pin 3. The similar lower elements in the array are also labelled '1D' by implication (see Part 1). Thus input data may be clocked into all eight-bits of the register on the positive-going clock edge at pin 11, providing that the input at pin 1 is low.

A variation on this theme is shown in Fig. 23. In this case, four D-type latches are shown, the upper pair controlled by the input on pin 13, and the lower pair by the input on pin 4. (Note that true and false outputs are shown for each element in this example).

Figure 24 depicts a quint Or array with one common input on pin 22, and complementary outputs.

The common control box

Shift registers and counters are clearly prime examples of binary logic elements which can be efficiently represented by using the common control box. The general qualifying symbols of 'SRG' and 'CTR' signify shift register and counter respectively.

Figure 25 is an 8-bit shift register; this is immediately signified by the 'SRG8' general qualifying symbol within the common control box. The particular device here represented has a parallel (or 'broadside') load facility (the 74165 device). Parallel loading is achieved by taking the input on pin 1 low: in this case, control dependency C3 enables inputs on pins 11 to 14 and 3 to 6. For shifting to occur, C3 must be false, therefore the input on pin 1 must be high (this is the SHIFT/LOAD input). A high on pin 1 makes G1 true, and this combined with either pin 15 or pin 2 high establishes the required conditions for shifting. When this condition occurs, the dynamic input C2 is satisfied to give a right shift (indicated by the right pointing arrow); this corresponds to a top-to-bottom shift with respect to the symbol. Note that the input on pin 10 is a serial input enabled only when shifting. Note also the complementary outputs on the bottom (right-hand) stage.

Figure 26 depicts a 4-stage binary counter, as signified by the 'CTR4' general qualifying symbol. This has separate count up (+) and count down (−) clock inputs to the common control box, a parallel loading facility controlled by the C1 input, and a common reset (CT=0 signifies count=0).

Conclusion

That concludes this brief look at some of the more complex aspects of the new logic symbols.

Next month I conclude this series with a look at the practical application of the new logic symbols and illustrate how they may be applied to give different levels of detail according to needs.

Acknowledgements

The author is greatly indebted to the following:

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

Touch-screen sensor

Computers can be used by the youngest children and the handicapped if the input is not confined to the keyboard. One demonstration of this is the Touchtech 501, an add-on device tailored to fit Microvitec colour monitors. It detects the interruptions in infra-red beams along x and y coordinates and can therefore sense the position of any stylus or finger pointed at the screen and can be used with menu software to enable easy access to the computer. The first software package has been produced by the Government's Microelectronics in Education programme and demonstrates the capabilities of the system. It works specifically with the Acorn/BBC micro plugging into the RS423 serial interface. It has its own on-board processor to decode the i.r. beam pattern and transmits to the host computer at 9600bit/s. Versions for other computers are due later in the year. The device is being marketed first in the educational sector and is expected to sell for about £210 which Microvitec claim is a fraction of the cost of other touch screen devices. Microvitec plc, Futures Way, Bolling Road, Bradford, W Yorks BD4 7TU. EWW207

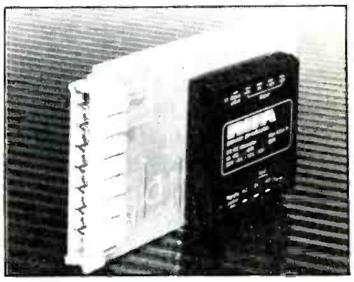
Low-cost disc drives

After considerable investment and research work, Servicon Dynamics have managed to cut the price of 3″ disc drives to very low prices. A single-sided double density is £129.95 and a double headed drive is £199. Both have the same capacity as a 3″ disc may be flipped over and both sides used, but the single headed drive can only access one side at a time while the two record/replay head have access to the full 400K formatted disc capacity.

The units are direct replacements for 5½″ drives and are supplied with cables and a manual suitable for use with the Acorn/BBC micro. The same company has produced a BBC d.f.s. which is compatible with second processors, has auto density/tracking capability, includes a formatter on rom and is claimed to be fully Acorn compatible. They have also announced a disc drive for the Sinclair Spectrum which will be available soon, which have 128K of storage with expansion up to 256K, will incorporate an RS423 interface and will cost under £100. The Crescent range of disc drives is marketed by Servicon Dynamics Ltd, 186 Cirencester Road, Charlton Kings, Cheltenham, Glos GL53 8DZ. EWW216

Single-chip data acquisition

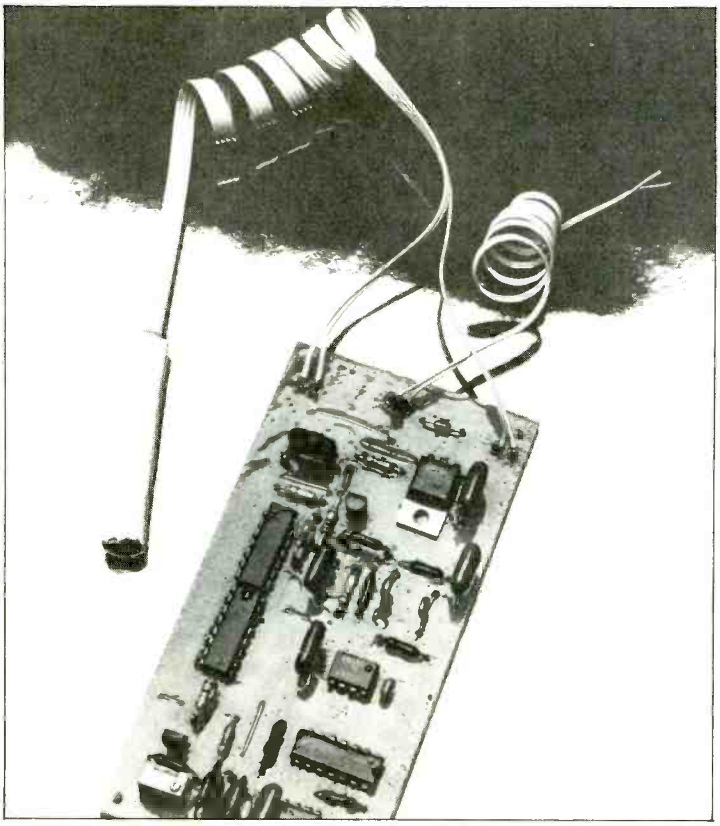
An eight-channel analogue multiplexer, a sample-and-hold circuit and an eight-bit a-to-d converter are all combined into a single chip from Siliconix. The chip gas at 14kHz data rate making it suitable for voice grade communication digitizing. It has a low power consumption of 5mW and may be used in battery-operated equipment. Claimed to have a maximum linearity error of 0.5 l.s.b, the 81520 is safe to use in feedback and control systems. Input voltage range is 3 to 5.5V and it is housed in a 28-pin plastic or ceramic d.i.l. package. Available from Dage (GB) Ltd, Eurosem Division, Rabans Lane, Aylesbury, Bucks HR19 3RG. EWW213



Eprom emulator

8K and 16K eproms may now be emulated for the development of target systems in conjunction with an Acorn/BBC micro. It allows the computer to share a block of memory with a target system. The unit is a p.c.b. with 16K of c.mos ram and a battery back-up. One 28-way connector fits into a 'sideways' rom socket on the computer while another plugs into the rom socket of the target. As a bonus the emulator may be loaded with rom software and used as a sideways ram by the computer. It comes with software to allow for the easy loading and editing of the emulator memory from disc. The software is in fact provided loaded into the emulators memory and may be saved to disc by the user. £95 for the 8K version or £119 for 16K. Benwick Electronics, 5 Church Street, Wimblington, March, Cambs PE15 0E8. EWW214

Fluxgate sensor



Readers may remember a WW project of a fluxgate compass in October, 1982. Now Medical Magnetics have produced a similar system for the detection and measurement of magnetic fields. The complete system consists of a fluxgate transducer element which is sensitive to magnetic fields. It produces a signal voltage at its output terminals when the logitudinal axis is aligned with an ambient magnetic field vector. The output follows a cosine law when the transducer is moved out of alignment with the field. The associated electronics on a small p.c.b. generate a drive signal for the transducer element and processes the output signal. The sensitivity of the transducer is better than 65nT for an output of 1mV. This is to be compared with the ambient magnetic field in the UK of about 20,000nT. this refers to system SA2. SA1 with a longer transducer is even more sensitive at 15nT/mV. Unlike the Hall-effect device, the fluxgate sensor is highly directional and largely independant of ambient temperature. This makes it very suitable for compass applications and for low field-strength magnetic surveys. The low cost of the system (£45 inclusive) makes it available for use in educational work. Medical Magnetics, 19 Norwood Drive, Chester, Cheshire. EWW218

Storage module for oscilloscopes

An add-on digital storage module is designed to capture analogue signals at speeds of up to 10M samples/second. Stored as a 1024 by 6bit data stream the waveform can be displayed on a standard oscilloscope. The 81000 has 12 input sampling frequencies to capture events as fast as 100ns or as slow as 0.5s. It also has selectable input and output voltage ranges. Sumatron Ltd, Hamilton House, 39 Kings Road, Haslemere, Surrey GU27 2QA. EWW215

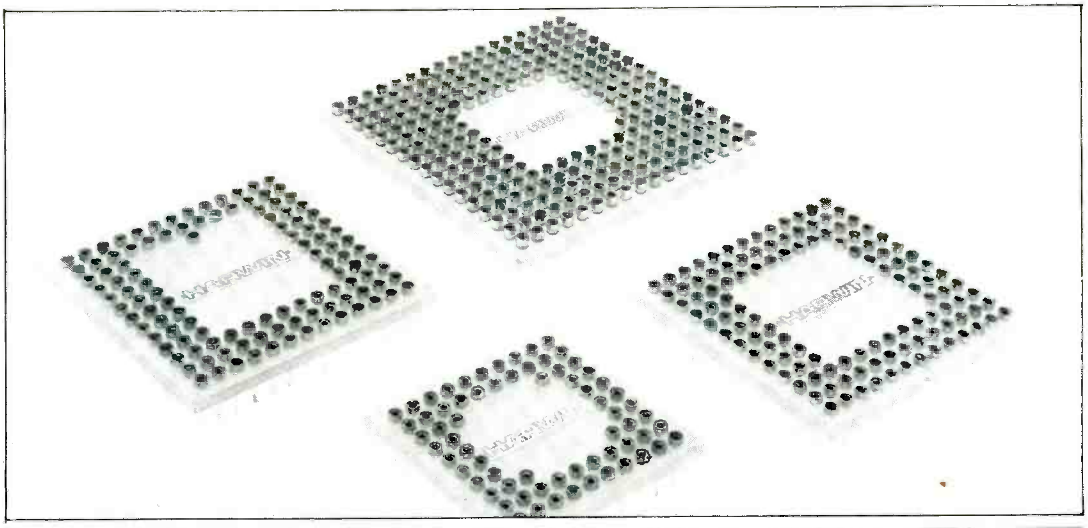
Hard disc controller

A controller for Winchester discs is incorporated in a kit which also includes data handling components. These Intel devices are the iSBC 215, a generic Winchester controller capable of supporting two 5.25in disc drives and make use of Seagate ST412 standard interface. Also included is the iSBC 213 Data seperator kit which can handle data transfer at 5Mbit/s, using m.f.m. A scrambler card matches the controller pin-out with the ST412 interface. The controller is interfaced to the host processor through Multibus memory and can address directly 16Mbytes of system memory. The kit includes enough on-board ram to buffer one full data sector and the system uses this buffer in all data transfers. On-board diagnostics and error checking are provided and an erroneous data burst up to 32 bits long can be detected. The controller has bus connectors for expansion and may be connected to a flexible controller or tape streamer for backup. Available from Rapid Recall Ltd, Denmark Street, High Wycombe, Bucks HP11 2ER. EWW211

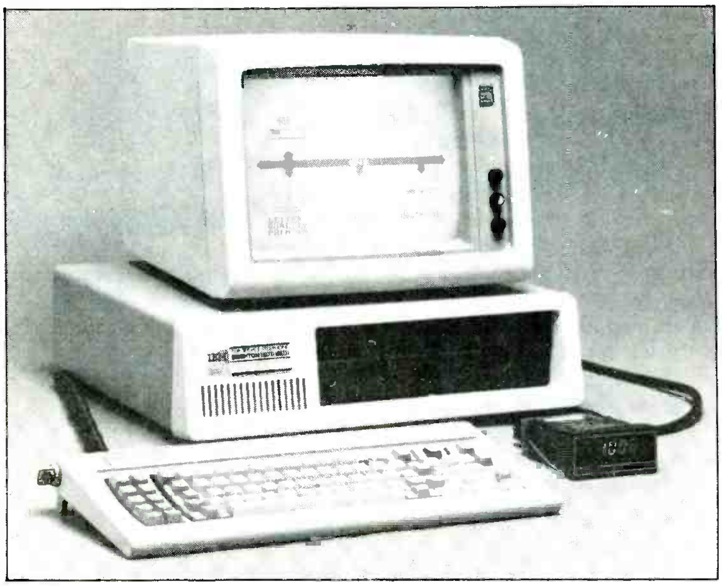
Card mounted converters

The very small size of the Rifa PKA range of d.c./d.c. converters is made possible by having a switching rate of 300kHz. They feature short-circuit protection, soft start, transient protection and low r.f.i, an efficiency of 80% and an m.t.b.f. of 200 years, though how this can be measured is beyond us. Campbell Collins are now mounting them on Eurocards and so provide more flexibility by permitting the voltage adjustment to be mounted on the board. A number of combinations of output voltage are available, from 5V, 12V, ±12V and ±15V; the units are rated at 30W and if high power is required the units may be connected in parallel. Campbell Collins Ltd, 162 High Street, Stevenage, Herts. EWW219

Pin grid sockets made to order



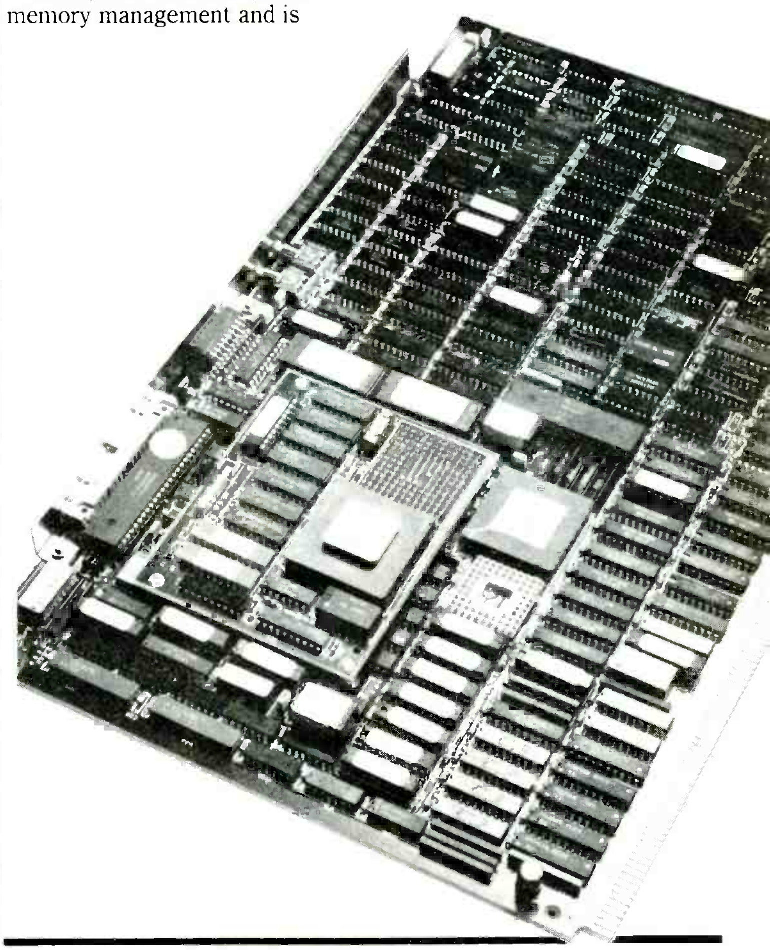
It is now possible for Harwin to make pin grid array sockets to a customer's specification for little extra cost than producing standard d.i.l. configurations. The company has produced for specific customers 97 and 117-way sockets. They feature low insertion force: it is easy to remove the i.cs, and they are therefore suitable for testing components. Harwin Engineers 8A, Fitzherbert Road, Farlington, Portsmouth, Hants PO6 1RT. EWW222



32-Bit development system

An evalution package to aid designers considering the implementation of Motorola's 68020 32-bit processor has been introduced. Benchmark 20, as it is known, consists of a single-board computer based on the processor, with 1Mbyte of d.ram, a four-slot VERSAbus chassis with power supply and built-in firmware to allow benchmarking and code debugging.

The system includes paged memory management and is fully compatible with Motorola's VERSAmodule system, allowing simple implementation of user target systems. It is designed for use with such software development hosts as the VME/10 or EXORmacs and has full capability of data transfer between these systems. New-Tek Distribution, Beadle Trading Estate, Ditton Walk, Cambridge CB5 8QD. EWW220



Rotary switches

Binary-coded decimal or hexadecimal outputs are available from a range of miniature rotary switches. They come in a flat format for screwdriver operation, with knobs for manual control and/or with indicators. The switches are said to be highly reliable with hard gold plated on nickel for the contacts. They are sealed against flux, solder or dust. The pins are arranged in d.i.l. formation for p.c.b. mounting. Maximum contact ratings are 30V switched but 100V can be tolerated when not switching. Maximum switched current is 125mA. Barlec-Richfield Ltd, Foundry Lane, Horsham, W Sussex RH13 5PX. EWW212

Farad capacitors

As electronic apprentices we were taught that the Farad was an unmanageable quantity. Picofarads were o.k. but one Farad would need a capacitor as large as a large block of flats. Not so. National Panasonic have produced Gold Cap electrolytics with up to 3.5F capacitance which are no bigger than ordinary capacitors and may be used instead of battery back-up to preserve the contents of c.mos and n.mos memories during power-downs. Taking its power from the 5V d.c. rail, a 3.3F capacitor will take some 500 hours to discharge into a 1Mohm load and is claimed to have extremely low self-discharge characteristics. Available through Ajax Electronics, Wessex Road, Bourne End, Bucks SL8 5DT. EWW210

16-bit micro for education

A 16-bit microcomputer designed specifically to meet the needs of science and education has been launched by Research Machines Ltd. The RM Nimbus is built around the Intel 80186 8MHz processor and is claimed to be three times as fast as an IBM PC, or roughly the same speed as the IBM PC AT, and yet costs 20% less than a PC or about half the price of an AT, for an equivalent configuration.

The Nimbus computer is supplied in a number of versions with varying amounts of memory, number of disc drives, and network facilities but they all include the MS-DOS operating system, a minimum of 192K memory (including 64K for graphics) high resolution colour graphics, Piconet network and a full range of i/o ports. The range starts with the Nimbus PC1 which has one 3½-in. floppy disc drive for £945. At the top of the range is the Nimbus X10 with one floppy disc drive and a 10Mbit hard disc for £2076. There is also a network server model with a wide selection of packaged software, two floppy drives and MS-NET software for use with the network interface; this is the SPCN2 which costs £2508 to Further and Higher Educational establishments, £400 less to schools. A terminal model, TN, for use with the network has no discs, 320K of ram and costs £898 to F. and H.E. colleges with a £153 reduction to schools.

Optional extras include a floating-point mathematical processor, external 5¼-in disc drive for using proprietary software for other MS-DOS computers, memory can be extended to 1Mbyte. Standard features on all models include printer interface, mouse or joystick interface, two rom cartridge sockets, a softkey socket, music and voice output and power rails together with the built-in network interface.

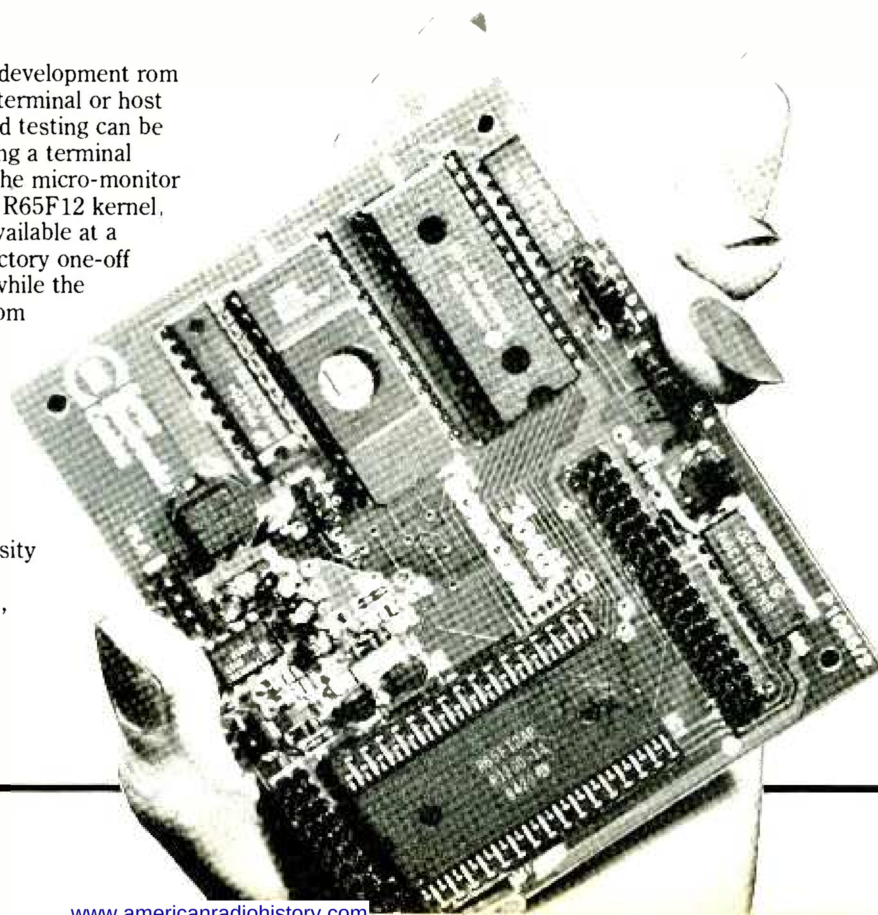
Every model has four expansion sockets inside the casing and any model can be upgraded to the level of other models in the range with additional disc drives, including hard disc. The computer has an emphasis on its graphics capabilities and RML have designed their own v.l.s.i. graphic processor which, according to Mike Fischer, the Managing Director, has been optimised for the emerging software which combines text graphics multiple fonts of typeface and mouse interfacing, all with colour. "By designing our own graphics processing chip, we have been able to achieve five to twenty times the graphics speed of competitive systems at a lower cost."

He also explained that with computer literacy starting younger, there is a growing need for more sophisticated computer power in the secondary school in administration, business studies and in computer-aided design. The company will continue to manufacture and support the 380Z and 480Z 8-bit computers and have further plans for software and peripheral development for these. Research Machines Ltd, Mill Street, Oxford OX2 0BW.
EWW205

Forth in control

Although known to us for their Tiny Basic control boards, Essex Electronic Centre have now produced a Forth micro-control card. Measuring only 80 by 100mm, the board is built around the Rockwell R65F12 single-chip microcomputer which incorporates a 4K Forth kernel. The board may be connected to any RS232C-compatible terminal to provide a Forth computer. The full capability of the processor is utilized to provide 40 input/output lines through ribbon-cable connectors and there are two 28-pin sockets for the provision of ram and/or eprom. An autostart feature makes it easy to use the system in process control and instrumentation applications.

The Essex Forth Microcard can function as its own development system when used in conjunction with the Rockwell RF1 development rom and an RS232 terminal or host computer. Field testing can be carried out using a terminal together with the micro-monitor resident in the R65F12 kernel. The board is available at a special introductory one-off price of £119 while the development rom which, of course, may be re-used for further applications, costs £75.37. Essex Electronics Centre, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.
EWW206



Call in at your 'local' for a CROTECH

LONDON & HOME COUNTIES		
Audio Electronics	London W2	01-724 3564
Henry's	London W2	01-724 0323
Carston Electronics	Teddington	01-943 4477
Kentwood Electronics	Reading	0734-698040
Aughton Instruments	Strood	0634-724751
The Instrument Centre	Dunstable	0582-602739
Maplin Electronics	Benfleet	0702-554155

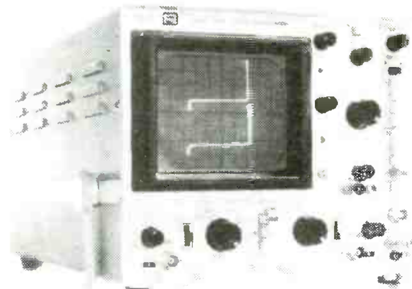
WALES & WEST		
The Instrument Centre	Newport (Gwent)	0633-280566

EAST ANGLIA		
Electronic & Computer Workshop	Chelmsford	0245-262149
Cirkit	Broxbourne	0992-444111

MIDLANDS & NORTH		
Northern Instruments	Leeds	0532-791054
The Instrument Centre	Brierley Hill	0384-293898
Electronic Measurement Services	Manchester	061-273 4653
Radio Telephone Service	Derbyshire	0332-41235

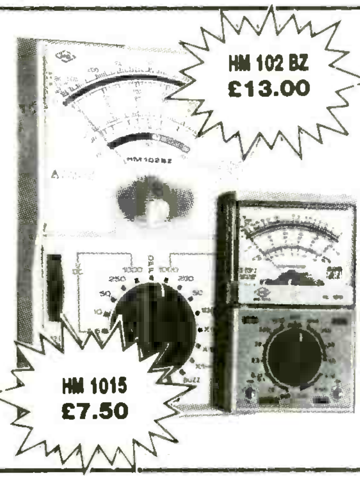
SCOTLAND		
RMR Measurements	Cumbernauld	02367-28170

IRELAND		
Electronic Instrument Brokers (IRL) Ltd.	Dublin	Dublin 857119



Crotech Instruments Limited
2 Stephenson Road, St. Ives, Huntingdon, Cambs. PE17 4WJ
Telephone: (0480) 301818

CIRCLE 59 FOR FURTHER DETAILS.



AFFORDABLE ACCURACY
QUALITY MULTIMETERS FROM ARMON

ANALOGUE

HM-102BZ
10ADC Range, 20KΩ/VDC, Buzzer, Battery Test Scale **£13.00**
19 measuring ranges

HM-102R
Low end voltage & current ranges, Jack for Audio o/p Voltages **£11.00**
20 measuring ranges.

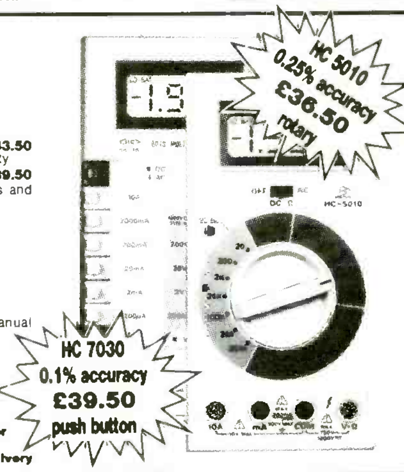
HM-1015
Rugged, Pocket sized meter, for general purpose use **£7.50**
16 measuring ranges
Battery, Test Leads and Manual included with each model.

DIGITAL

HC–6010 0.5% Accuracy, Standard Model **£33.50**
HC–5010T 0.25% Accuracy, TR Test Facility **£39.50**

All models have full functions and ranges and feature:

3½ digit 0.5" LED display
Low battery indication
Auto zero & Auto polarity
ABS Plastic Casing & Tilt Stand
DC AC 10amp Range
Overload Protection on all ranges.
Battery, Spare Fuse, Test Leads and Manual



FULL DETAILS ON APPLICATION FROM:-

ARMON ELECTRONICS LTD

DEPT A HERON HOUSE, 109 WEMBLEY HILL ROAD, WEMBLEY, MIDDLESEX HA9 8AG
TELEPHONE 01-902 4321 TELEX 923985
PLEASE ADD 15% to your order for VAT. P&P Free of charge. Payment by cheque with order
Offer applicable to mainland UK only
Trade enquiries invited
Please allow 28 days for delivery

CIRCLE 41 FOR FURTHER DETAILS.

We test your equipment, not your patience.

Technical Project's new microprocessor-controlled MJS401D, Audio Measurement System is a powerful cure for test frustration, leaving engineers with more time and energy for solving problems. Here's the prescription:

- ***FAST*** Accurate, clear, multi-standard Noise and Level measurement.
- ***FAST*** Totally Automatic THD measurement.
- ***FAST*** 4 Digit Frequency Display.
- ***FAST*** Unique "below noise" crosstalk measurement.
- ***FAST*** ±1.5dB Expanded Scale magnifies variations.
- −107 to +45 dB range to measure any device.
- Linear volts scales too.
- Function interlock recalls settings, speeding repeated measurements.
- "Plug in and go" options, all field installable
- Balanced in and floating out for minimal earth noise.
- Speedy recovery from accidental overload.
- RF and oscillator breakthrough abolished.
- Optional IEEE-488 for automatic testing.

Get your engineers the tool for efficiency – TecPro's MJS401D Audio Measuring System – they deserve the best.

Technical Projects Ltd.
Unit 2, Samuel White's Industrial Estate,
Medina Road, Cowes, Isle of Wight, PO31 7LP, England.
Telephone: (0983) 291553 Telex: 869335 TECPRO G

TecPro Inc.
PO Box 1069, Palatine, Illinois 60078, USA.
Telephone: ... From IL AK HI (312) 359-9240
Telex: 280 502 (PROTON PALTN)

CIRCLE 19 FOR FURTHER DETAILS.

COMPUTER WAREHOUSE

1000's OF BARGAINS FOR CALLERS

THE 'ALADDIN'S' CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

RECHARGEABLE BATTERIES

Dry Fit Maintenance FREE by Sonnenschein. A300 07191315 12v 3 AH same as **RS 591-770 NEW £13.95** A300 07191202 6-0-6 1.8 AH same as **RS 591-382 EX EQUIP £4.99** Miniature PCB mount 3.6v 100 Mah as **RS 591-477 NEW £1.00 SAFT VR2C** 1.2v "C" size **NICADS** in 18 cell ex equipment pack. Good condition – easily split to single cells £10.50 + pp £1.90

HOT LINE DATA BASE
DISTEL©

THE **ORIGINAL FREE OF CHARGE** dial up data base 1000's of stock items and one off bargains. **ON LINE NOW** – 300 baud, full duplex CCITT tones, 8 bit word, no parity **01-679 1888**

Anderson Jacobson AJ510 VIDEO DISPLAY TERMINAL

Made by one of the USA's largest peripheral manufacturers the AJ510 Professional VDU terminal has too many features to include in space available – just a few are: internal Z80 cpu control, very readable 15" non glare green screen, 24 lines by 80 characters. 128 ASCII character set with lower case and graphics, standard RS232 interface, Cursor addressing, numeric key pad etc. Supplied in good **TESTED** second hand condition with full manual **£225.00** + carr £10.00. Data sheet on request.

EX-STOCK INTEGRATED CIRCUITS

2732 ex equip £3.25. 27128 – 250ns **NEW** £12.00. 6116-200 £4.50, 6116-250 £3.95, 6264LP-150 £22.00. 4164-200 £3.50, 4864-150 £4.00, 4116-300, £1.20, 2114 £1.75. 6800 £2.50, 6821 £1.00, 68A09 £8.00, 68B09 £10.00, 68B09E £14.50, D8085AH-2 £12.00, D8086 £20.00, Z80A £2.99.

MAINS FILTERS

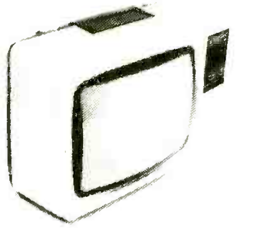
Cure those unnerving hang ups and data glitches caused by mains interference
SD5A As recommended by ZX81 news letter matchbox size up to 1000 watt load **£5.95**
L2127 compact completely cased unit with 3 pin fitted socket Up to 750 watts **£9.99**

COOLING FANS

Keep your hot parts COOL and RELIABLE with our range of **BRAND NEW** professional cooling fans.
ETRI 99XUOI Dim. 92 x 92 x 25 mm Miniature 240 v equipment fan complete with finger guard **£9.95**.
GOULD JB-3AR Dim. 3" x 3" x 2.5" compact very quiet running 240 v operation. **NEW £6.95**
BUHLER 69.11.22. 8-16 v DC micro miniature reversible fan. Uses a brushless servo motor for extremely high air flow, almost silent running and guaranteed 10,000 hr life. Measures only 62 x 62 x 22 mm. Current cost £32.00 **OUR PRICE ONLY £12.95 complete with data.**
MUFFIN-CENTAUR standard 4" x 4" x 1.25" fan supplied tested EX EQUIPMENT 240 v at £6.25 or 110 v at £4.95 or BRAND NEW 240 v at £10.50. 1000's of other fans Ex Stock. Call for Details. Post & Packing on all fans £1.60

A Major company's over production problems, and a special **BULK PURCHASE** enable **TWO** outstanding offers.

COLOUR MONITOR SPECIALS

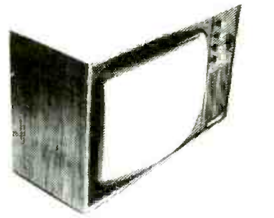


'SYSTEM ALPHA' 14" Multi Input Monitor.

Made in the **UK** by the famous **REDIFFUSION Co.** for their own professional computer system this monitor has all the features to suit your immediate and future monitor requirements. Two types of video input, **RGB** and **PAL** Composite Video, allow direct connection to most makes of micro computers and **VCR's**. An internal speaker and audio amplifier may be connected to your system's output or direct to a VCR machine, giving superior colour and sound quality. Many other features include PIL tube, Matching **BBC** case colour, Major controls on front panel, Separate Contrast and Brightness – even in **RGB** mode, Two types of audio input, Separate Colour and audio controls for Composite Video input, BNC plug for composite input, 15 way 'D' plug for RGB input, modular construction etc. etc.

This must be **ONE OF THE YEAR'S BEST BUYS!!!**

Supplied **BRAND NEW** and **BOXED**, complete with **DATA** and 90 day guarantee. **SUPPLIED BELOW ACTUAL COST – ONLY £149.00** + Carr.



DECCA RGB 80-100 Monitor.

Little or hardly used manufacturer's surplus enables us to offer this special converted **DECCA RGB** Colour Video TV Monitor at a super low price of only **£99.00**, a price for a colour monitor as yet unheard of!! Our own interface, safety modification and special 16" high definition PIL tube, combine with the tried and tested DECCA 80/100 series chassis to give 80 column definition and picture quality found only on monitors costing **3 TIMES OUR PRICE**. In fact, **WE GUARANTEE** you will be delighted with this product, the quality for the price has to be seen to be believed. Supplied complete and ready to plug directo to a **BBC MICRO** computer or any other system with a **TTL RGB** output. Other features include internal audio amp and speaker, Modular construction, auto degaussing 34 H x 24 D, 90 day guarantee. Supplied in **EXCELLENT** condition, **ONLY £99.00** + Carr. Also available **UN-MODIFIED** but complete with MOD DATA. Only £75.00.

Carriage and Insurance on monitors £10.00

BUDGET RANGE VIDEO MONITORS

At a price YOU can afford, our range of **EX EQUIPMENT** video monitors defy competition!! All are for 240v working with standard composite video input. Units are pre tested and set for up to 80 col use on BBC micro. Even where MINOR screen burns MAY exist – normal data displays are unaffected

1000's SOLD TO DATE

12" KGM 320-321, high bandwidth input, will display up to 132 columns x 25 lines Housed in attractive fully enclosed brushed allov case **B/W only *£32.95***
24" KGM large screen black & white monitor fully enclosed in light alloy case Ideal schools, shops, clubs etc ***ONLY £55.00*** Carriage £10.00

DATA MODEMS

Join the communications revolution with our super range of **DATA MODEMS** with prices and types to suit all applications and budgets!!
Most modems are **EX BRITISH TELECOM** and are made to the highest standard for continuous use and reliability. RS232 interfaces are standard to all our modems, so will connect to ANY micro etc. with an RS232 serial interface.

DATEL 2B see **SPECIAL OFFER** centre of this ad.
MODEM 13A, 300 baud. Compact unit only 2" high and same size as telephone base. Standard CCITT tones, CALL mode only Tested with data. ***ONLY £45.00 + PP £4.50.***
MODEM 20-1, 75-1200 baud. Compact unit for use as subscriber end to PRESTEL, MICRONET or TELECOM GOLD. Tested with data ***£39.95 + PP £6.50.***
MODEM 20-2, same as 20-1 but 1200-75 baud ***£99.00.***
TRANSDATA 307A, 300 baud acoustic coupler. Brand new with RS232 interface. **ONLY £49.95**
DACOM DSL2123 Multi Standard Modem, switchable CCITT or USA BELL 103 standard. V21 300-300, V23 75-1200, V23 1200-75 or 1200-1200 half duplex.
Auto answer via MODEM or CPU. CALL or ANSWER modes plus LED status indication Dim 2.5" x 8.5" x 9" **BRAND NEW fully guaranteed *ONLY £268.00 + PP £4.50.***
DATEL 2412 Made by SE LABS for BT this two part unit is for synchronious data links at 1200 or 2400 baud using 2780/3780 protocol. Many features include Auto answer, 2 or 4 wire working etc. etc. **COST OVER £800. *OUR PRICE £185.00.***
DATEL 4800, RACAL MPS4800 high speed good condition ***£285.00 CARR £10.00***

SPECIAL 300 BAUD MODEM OFFER

Another **GIGANTIC** purchase of these **EX BRITISH TELECOM, BRAND NEW** or little used 2B data modems allows US to make the **FINAL REDUCTION**, and for **YOU** to join the exciting world of data communications at an **UNHEARD OF PRICE OF ONLY £29.95**. Made to the highest **POST OFFICE APPROVED** spec at a cost of hundreds of pounds each, the 2B has all the standard requirements for data base, business or hobby communications. All this and more!!

- 300 baud full duplex
- Full remote control
- CCITT tone standards
- Supplied with full data
- Modular construction
- Direct isolated connection
- CALL, ANSWER and AUTO modes
- Standard RS232 serial interace
- Built in test switching
- 240v Mains operation
- 1 year full guarantee
- Just 2 wires to comms. line

NOW ONLY £29.95

Order now – while stocks last. Carriage and Ins. £10.00

SUPER PRINTER SCOOP

SAVE £250

BRAND NEW CENTRONICS 739-2

ONLY £199

The "Do Everything Printer" at a price that will **NEVER** be repeated. Standard **CENTRONICS** parallel interface for direct connection to **BBC, ORIC, DRAGON** etc. Superb print quality with full pin addressable graphics and 4 type fonts plus **HIGH DEFINITION** internal **PROPORTIONAL SPACED MODE** for **WORD PROCESSOR** applications. 80-132 columns, single sheet, sprocket or roll paper handling plus much more. Available **ONLY** from **DISPLAY ELECTRONICS** at the ridiculous price of ***ONLY £199.00*** + VAT Complete with full manual etc. Limited quantity –Hurry while stocks last.
Options. Interface cable (specify) for BBC, ORIC, DRAGON or CENTRONICS 36 way plg £12.50. Spare ribbon £3.50 each BBC graphics screen dump utility program £8.60
Carriage and Ins £10.00 + VAT

HUNDREDS OF PRINTERS EX STOCK FROM £49.00. Call Sales Office for Details.

1 only large **CALCOMP 1036** AO 3 pen drum plotter and offline 915 magtape controller. Good working order. **£2500.00.**

ADD VAT TO ALL PRICES

EX STOCK

DEC CORNER

PDP 1140 System comprising of CPU. 124K memory + MMU 16 line RS232 interface. RP02 40 MB hard disk drive. TU10 9 track 800 BPI Mag tape drive, dual rack system, VT52 VDU etc. etc. Tested and running	***£3750.00***
BA11-MB 3.5" Box, PSU, LTC	£385.00
DH11-AD 16 x RS232 DMA interface	£2100.00
DLV11-J 4 x EIA interface	£310.00
DLVII-E Serial. Modem support	£200.00
DUP11 Sych. Serial data i/o	£650.00
DQ200 Dilog – multi RK controller	***£495.00***
DZ11-B 8 line RS232 mux board	£650.00
KDF11-B M8189 PDP 1123+	£1100.00
LA36 Decwriter EIA or 20 ma loop	£270.00
LAX34-AL LA34 tractor feed	£85.00
MS11-JP Unibus 32 kb Ram	£80.00
MS11-LB Unibus 128 kb Ram	£450.00
MS11-LD Unibus 256 kb Ram	£850.00
MSC4804 Qbus (Equiv MSV11-L) 256 kb	£499.00
PDP11/05 Cpu. Ram, i/o, etc.	£450.00
PDP11/40 Cpu. 124k MMU	£1850.00
RT11 ver. 3B documentation kit	£70.00
RK05-J 2.5 Mb disk drives	£650.00
KL8JA PDP 8 async i/o	£175.00
MI8E PDP 8 Bootstrap option	£75.00
VT50 VDU and Keyboard – current loop	£175.00
VT52 VDU with RS232 interface	***£250.00***

1000's of **EX STOCK** spares for **DEC PDP8, PDP8A, PDP11** systems & peripherals. Call for details. All types of Computer equipment and spares wanted for **PROMPT CASH PAYMENT.**

DISPLAY -ELECTRONICS-

All prices quoted are for U.K. Mainland, paid cash with order in Pounds Sterling PLUS VAT. Minimum order value ***£2.00***. Minimum Credit Card order ***£10.00***. Minimum BONA FIDE account orders from Government Depts., Schools, Universities and established companies ***£20.00***. Where post and packing not indicated please ADD £1.00 + VAT. Warehouse open Mon-Fri 9.30-5.30. Sat 10.30-5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export

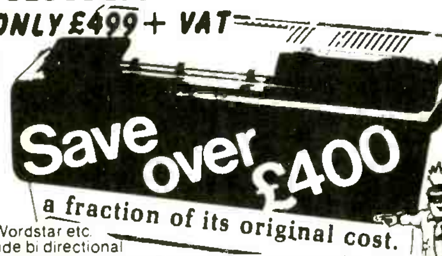
32 Biggin Way, Upper Norwood, London SE19 3XF
Telephone 01-679 4414 Telex 894502 Data 01-679 1888

ERS — PRINTERS — PRINTERS — PRINTERS
PRINTERS — PRINTERS — PRINTERS — PRI

SUPER DEAL? NO — SUPER STEAL!!

The FABULOUS 25CPS TEC Starwriter

BRAND NEW AT ONLY £499 + VAT

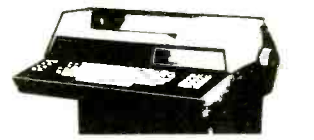


Save over £400

a fraction of its original cost.

Made to the very highest spec the **TEC Starwriter FP1500-25** features a heavy duty die cast chassis and DIABLO type print mechanism giving superb registration and print quality. Micro-processor electronics offer full DIABLO/QUME command compatability and full control via CPM Wordstar etc. Many other features include bi directional printing, switchable 10 or 12 pitch, full width 381 mm paper handling with upto 163 characters per line, friction feed rollers for single sheet or continuous paper, internal buffer, standard RS232 serial interface with handshake. Supplied absolutly **BRAND NEW** with 90 day guarantee and **FREE** daisy wheel and dust cover. Order **NOW** or contact sales office for more information. Optional extras: RS232 data cable **£10.00**. Tech manual **£7.50**. Tractor feed **£140.00**. Spare daisy wheel **£3.00**. Carriage & Ins (UK Mainland) **£10.00**.

GE MODEL 30



A large purchase of these stand alone terminal units offers an EXTREMELY LOW PRICE for a professional printer for direct connection to your micro. The printer has a standard RS232 serial interface with switchable rates of 110, 200 and 300 baud. Upper and lower case characters are printed by a matrix head with character widths up to 132 columns. Unit accepts standard fan fold sprocket fed paper from 4" to 9.5". Many other features such as numeric keypad, electronic keyboard, auto motor on/off and FREE floor stand. Supplied in good S/H working condition – complete with manual **ONLY £95.00 CARRIAGE & INS. £10.00**

GE TERMIPRINTER

A massive purchase of these desk top printer-terminals enables us to offer you these quality 30 cps printers at a **SUPER LOW PRICE** against their original cost of over £1000. Unit comprises of full QWERTY, electronic keyboard and printer mech with print face similar to correspondence quality typewriter. Variable forms tractor unit enables full width – up to 13.5" 120 column paper, upper – lower case, standard RS232 serial interface, internal vertical and horizontal tab settings, standard ribbon adjustable baud rates, quiet operation plus many other features. Supplied complete with manual. Guaranteed working **£130.00** or untested **£85.00**, optional floor stand £12.50 Carr & Ins £10.00

PROFESSIONAL KEYBOARD OFFER

An advantageous purchase of brand new surplus allows a great **QWERTY**, full travel, chassis keyboard offer at fractions of their original costs.
ALPHAMERIC 7204/60 full **ASCII** 60 key, upper, lower + control key, parallel TTL output plus strobe. Dim 12" x 6" +5 & –12 DC. **£39.50.**
DEC LA34 Uncoded keyboard with 67 quality, **GOLD**, normally open switches on standard X, Y matrix. Complete with 3 LED indicators & i/o cable – ideal micro conversions etc. pcb DIM 15" x 4.5" **£24.95** Carriage on keyboards £3.00

EXTEL PRINTERS

EX NEWS SERVICE compact, quality built 50 column matrix printer, type AE11. Unit operates on 5 BIT BAUDOT code from current loop, RS232 or TTL serial interfaces. May be connected direct to micro, or comms receiver via simple filter network to enable printing of most world wide NEWS, TELEX and RTTY services. Supplied in tested second hand condition with 50 and 75 baud xtals, data sheet and large paper roll. **ONLY £49.95.**
Dimensions 15" D x 5" H x 10" W
CARR £6.00 Spare paper rolls £4.50 each

TELETYPE ASR33 I/O TERMINALS

FROM £195 – CAR. + VAT

Fully fledged industry standard ASR33 data terminal. Many features including ASCII keyboard and printer for data I/O auto data detect circuitry. RS232 serial interface. 110 baud, 8 bit paper tape punch and reader for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order.
Options: Floor stand **£12.50** + VAT
KSR33 with 20ma loop interface **£125.00** +
Sound proof enclosure **£25.00** + VAT

66% DISCOUNT

ELECTRONIC COMPONENTS EQUIPMENT

Due to our massive bulk purchasing programme which enables us to bring you the best possible bargains, we have thousands of I.C.s, Transistors, Relays, Caps, P.C.B.s, Sub-assemblies, Switches, etc. etc. surplus to our requirements. Because we don't have sufficient stocks of any one item to include in our ads. we are packing all these items into the *BARGAIN PARCEL OF A LIFETIME*. Thousands of components at giveaway prices! Guaranteed to be worth at least *3 times* what you pay. Unbeatable value!! Sold by weight.

2.5kls **£4.25** + pp £1.25 | 5kls **£5.90** + £1.80
10kls **£10.25** + pp £2.25 | 20 kls **£17.50** + £4.75

20,000 FEET OF ELECTRONIC AND COMPUTER GOODIES
ENGLAND'S LARGEST SURPLUS STORE – SEEING IS BELIEVING!!

D.C. POWER SUPPLY SPECIALS

Experimentors PSU Ex-GPO. All silicon electronics. Outputs give +5v @ 2 amps +12v @ 800 ma –12v @ 800 ma +24v @ 350 ma and 5v floating @ 50 ma. Dim 160 x 120 x 350 mm. All outputs are fully regulated and short circuit proof. Supplied in NEW or little used condition. Complete with circuit. **Only £15.50** +2 £2.50 pp

FARNELL 5 Volt 40 amps. Type number **G6-40A.** This miniature switching PSU measures only 160mm wide 175mm deep and 90mm high, yet delivers a massive 40 amps!! Fully regulated and smoothed with over voltage protection etc. 120 or 240 volts AC input. Supplied **BRAND NEW** and boxed with circuit at a fraction of the current list price. **Only £130.00 + £3.00** carr & ins.

LAMBDA LMCC 5V BRAND NEW 240v AC input with 5 volts DC at 8 to 10 amps fully regulated output. Completely enclosed unit measures only 9" x 4" x 5" **£29.99**

LAMDA LMCC5V 110v AC input with 5 volts DC at 8 to 10 amps fully regulated output. Slightly smoke damaged, hence **ONLY £10.95**

PERIPHERAL SYSTEM SUPPLY. Runs almost any system. Fully cased unit supplied in a brand new or little used condition. Outputs give 5v @ 11 amps "+" 15-17v @ 8 amps "–" 15-17v @ 8 amps and "+" 24v @ 4 amps. All outputs are crowbar protected and the 5 volt output is fully regulated. Fan cooled. Supplied tested with circuit. £55.00 + £8.50 carr.

1000's of other POWER SUPPLIES EX STOCK – CALL SALES OFFICE FOR DETAILS

DUAL DISK DRIVE/ WINCHESTER CASES

Very smart, fully enclosed case unit custom made to accept two full height 5¼" floppy disk drives or two 5¼" winchesters such as the RHODIME RO200 or TANDEM series etc. An internal switched mode PSU supplies all the required voltages to enable you to plug in your drives and go!!
Other features include mains filter, internal cables with standard drive connectors, space for internal PCB, standard fan cut out and mounting, air filter. Overall dimensions 28 cm W x 30 cm D x 19 cm H
ONLY £55.00 + £6.00 CARR.

SEMICONDUCTOR 'GRAB BAGS'

Mixed Semis amazing value contents include transistors, digital, linear, I.C's triacs, diodes, bridge recs., etc. etc. All devices guaranteed brand new full spec. with manufacturer's markings, fully guaranteed. 50+ **£2.95** 100– **£5.15**.
TTL 74 Series A gigantic purchase of an "across the board" range of 74 TTL series I.C's enables us to offer 100+ mixed "mostly TTL" grab bags at a price which two or three chips in the bag would normally cost to buy. Fully guaranteed all I.C's full spec. 100+ **£6.90** 200+ **£12.30** 300+ **£19.50**

NORTH STAR HORIZON

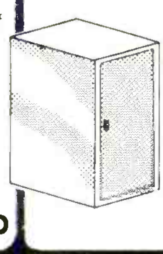
Pro S100 system with dual 5" floppy drives, software, manuals etc. **£850.00** Call sales office for details

ULTRA COMPACT 300 BAUD ACCOUSTIC MODEM — COUPLER

A Major manufacturer's over production and a bulk buy special enables us to offer this **BRAND NEW TRANSDATA 307A** ultra compact, **BT APPROVED**, 300 baud full duplex accoustic modem at a fraction of manufacturer's list price. The unit operates on the standard **CCITT V21** frequencies with **RS232** interface via 25 way 'D' skt.
Combine the adjustable cup system, which fits almost any phone with the benefit of "No jacks or phone cables" and a light weight of only 1.2 Kg and you have a truly portable modem!! Supplied complete with data, 90 day guarantee and ready to use.

ONLY £49.95 + £3.00 pp

PROFESSIONAL 6 FOOT 19" RACK CABINETS



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

LOGICAL KEYBOARD

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

Making a very useful keyboard, ideal for persons unfamiliar with or confused by the standard **QWERTY** layout. All keys generate the equivalent **ASCII** outputs and various control codes shown in data. A 7 bit latched parallel **TTL** output with strobe enables direct connection to any similar micro port etc. Many other features such as internal 240v to 5v PSU, MAINS ON/OFF switch. **Supplied in NEW** or little used condition with data.
ONLY £25.95 Post and packing £4.50

1000's of other EX STOCK items including POWER SUPPLIES, RACKS, RELAYS, TRANSFORMERS, TEST EQUIPMENT, CABLE, CONNECTORS, HARDWARE, MODEMS, TELEPHONES, VARIACS, VDU'S, PRINTERS. POWER SUPPLIES, OPTICS, KEYBOARDS etc. etc. Give us a call for your spare part requirements. Stock changes almost daily.
Don't forget, ALL TYPES and QUANTITIES of electronic surplus purchased for CASH

CIRCLE 76 FOR FURTHER DETAILS.

LOW PRICES

DIGITASK

BUSINESS SYSTEMS LTD

56, MAPLE DRIVE, EAST GRINSTEAD, WEST SUSSEX, RH19 3UR

SERVICE ADVICE

The PC-16 16-bit computer provides PERFECT COMPATIBILITY with the IBM PC/XT range. The motherboard can be supplied in two versions for stereoscopic conveneince. The 'N' version has no memory on board and the 'B' version with space for 64 to 256K RAM. Addition of the Memory Expansion Card provides a further 64 to 512KB of RAM. BASIC FEATURES INCLUDE:

* 8088 CPU operating at 4.77 MHz
* Provision for 8087 co-processor
* Four DMA channels
* Three TIMER channels on board
* 8 EXPANSION SLOTS
* RUNS MS/PC-DOS & CP/M 86
* READS & WRITES IBM-PC format
* Accepts IBM-PC Peripherals
* Up to 256K RAM ON BOARD

SYSTEM—5 PC16 (B/3) — **PRICE £1599** — Main computer employing 'B' board with 128K on board (upgradeable to 256K on board) PLUS Colour/Graphics adaptor providing signal capable of running monochrome displays on RGB output for full colour. Multi I/O card, providing floppy drive controller for two drives, one parallel port, one serial port, one games port with batter backed clock calander. RAM extension card for 512K. Two DS/DD floppy drives. 83-key keyboard. All complete, built & tested in case with power supply together with Concurrent (multiuser, multitasking) CP/M, CCP/M manual, Basic manual and computer operations manual – ready to run!

MOTHERBOARD 'B', 8-slot, 128K **£449**
MOTHERBOARD 'N', 8-slot **£329**
MULTIFUNCTION card with 128K (expandable to 256K) one PLL-port, one SER-port (2nd option) Clock/Calendar with backup **£259**
MONOCHROME adaptor with printer port **£239**
MULTI I/O CARD — one pll, one serial port, one games port, floppy drive controller, clock calender with battery backup **£299**

14in RGB HI-RES MONITOR (640dots × 300 lines) **£389**
12in HI-RES GREEN MON **£89**
64K RAM EXTEND MODULE **£59**
DS/DD FLOPPY DRIVE (500 KB unformatted **£175**
WINCHESTER DRIVE CONTROLLER **£425**
512K RAM BOARD — comes with 128K RAM installed fully IBM compatible **£299**
PC Case **£98**

WINCHESTER DRIVE 12MB complete with controller **£915**
IBM COMPATIBLE KEYBOARD (83 key) **£89**
KEYTRONIC 5150 K/BOARD **£175**
KEYTRONIC 5151 K/BOARD **£210**
SWITCHING POWER SUPPLY **£105**
ADD SERIAL PORT KIT **£23**
FLOPPY DRIVE CONTROLLER **£109**

RAM CHIPS
4164 NEC/MITSUBISHI
64K DRAMSAT £2.35 each

DRIVES — MEGABYTES FOR MICROPOUNDS!

5¼" Half height 500 kB 40/80 .... £119
5¼" Half height 1 MB 40/48 .... £125
5¼" Half height 1.6 MB 40/80 .... £159
5¼" Half height 2 MB 40/80 .... £199
3" Half height 500kB £119
3" Half height 1 MB £125
8" Full size 1.6 MB £309
8" Half size 1.6 MB £282
MR521 Half height 12.75 MB (unformatted) Hard Disk £492
MR522 Half height 26MB (unformatted) Hard Disk £691

All brand new, boxed, with built in controller — standard power requirments. Full documentation and technical details.

Add 15% VAT to all prices given. Remember, VAT is also applicable on carriage at 15%. Terms CWO. DEALER ENQUIRES WELCOME. FOREIGN enquiries if possible by telex please. However, French & German speaking staff at your disposal. MONEY BACK GUARANTEE. SEND £1.00 for our latest catalogue of over 3000 items, computers, peripherals, consumables, robotics, etc etc

TEL: (0342) 313427•24631/2 TLX: 957547

CIRCLE 94 FOR FURTHER DETAILS.

■ COMPONENT PACKS ■

All Brand New except where marked
Price: £1 per pack
Order 12 you get one extra FREE
Please add £1 post if order under £20

1 – 5 13 amp ring main junction boxes
2 – 5 13 amp ring main spur boxes
3 – 25 13 amp fuses for ring mains
4 – 5 surface mounting switches
5 – 3 flush switches intermediate type
6 – 5 in flex line switches
7 – 4 in flex line swithces with neons
8 – 2 80 watt brass cased elements
9 – 2 mains transformers with 6v 1a secondaries
10 – 2 mains transformers with 12v ½a secondaries
11 – 1 extension speaker cabinet for 6½" speaker
12 – 5 octal bases for relays or valves
13 – 12 glass reed switches
14 – 4 OCP 70 photo transistors
15 – 25 assorted gemanium transistors OC45 etc
16 – 4 tape heads, 2 record, 2 erase
17 – 2 ultra sonic transmitters and 2 ditto receivers
18 – 2 15000 mfd computer capacitors
19 – 2 l.d.r. similar ORP 12
20 – 5 diff micro switches
21 – 2 mains interference suppressors
22 – 2 25 watt crossover units
23 – 1 40 watt 3 way crossover unit
24 –250 screws and self tappers
25 – 1 of each wafer switches — 6p 2 way; 4p 3 way; 2p 6 way; 1p 12 way
26 – 2 tape deck counters
27 – 1 6 digit counter 12v
28 – 1 6 digit counter mains voltage
29 – 1 BOAC in flight stereo unit (s.h.)
30 – 2 NICAD battery chargers
31 – 1 key switch with key
32 – 2 humidity switches
33 – 2 aersol cans of ICI Dry Lubricant
34 – 96 × 1 metre length colour-coded wires
35 – 4 battery operated model motors
36 – 2 air spaced 2 gang tuning condensors
37 – 2 solid diaelectric 2 gang tuning condensors
38 – 10 compression trimmers
39 – 1 Long & medium wave tuner kit
40 – 4 × 465 KC IF transformers
41 – 8 rocker switches 10a mains SPST
42 – 6 rocker switches 10a mains SPDT
43 – 5 rocker switches 10a SPDT
44 – 1 rocker switches 10a SPDT
45 – 1 24 hour time switch mains operated
46 – 1 6 hour clockwork time switch
47 – 2 2 lever switches 4 pole changeover up and ditto down
48 – 2 6v operated reed switch relays
49 – 10 neon valves – make good night lights
50 – 2 × 12v DC or 24v AC 4CO relays
51 – 1 × 12v 2C 0 very sensitive relay
52 – 1 × 12v 4C 0 relay
53 – 2 mains operated relays 3 × 8a changeovers (second hand)
54 – 10 rows of 32 gold plated IC sockets (total 320 sockets)
55 – 1 locking mechanism (with 2 keys)
56 – 1 miniature Uniselector with circuit for electric jigsaw puzzle
57 – 5 dolls house switches
58 – 2 telephone handsets
59 – 2 flat solenoids – to make current transformer etc
60 – 5 ferrite rods 4" × 5" – 16" dia
61 – 5 ferrite slab aerials LW & MW
62 – 4 200Ω ear pieces
63 – 1 Mullard Thyristor trigger module
64 – 10 assorted knobs ¼ spindles
65 – 5 diff thermostats

Most items available in quantity at good discounts. Access & Barclay cards welcome

■ N.B. ELECTRONIC SUPPLIES ■
34 America Lane, Haywards Heath, Sussex RH16 3QU
(24hr phone ordering 0444 454563)

CIRCLE 89 FOR FURTHER DETAILS.

IN VIEW OF THE EXTREMELY RAPID CHANGE TAKING PLACE IN THE ELECTRONICS INDUSTRY, LARGE QUANTITIES OF COMPONENTS BECOME REDUNDANT. WE ARE CASH PURCHASERS OF SUCH MATERIALS AND WOULD APPRECIATE A TELEPHONE CALL OR A LIST IF AVAILABLE. WE PAY TOP PRICES AND COLLECT.

R. Henson Ltd.

21 Lodge Lane, N. Finchley, London, N.12. 5 mins. from Tally Ho corner

Telephone 01 445 2713/0749

CIRCLE 45 FOR FURTHER DETAILS.

Toroidal Transformers

as manufacturers we are able to offer a range of quality Toroidal Transformers at highly competitive prices and fast delivery.

Mail Order Price List

15VA **6.92** 30VA **7.18**. 50VA **8.86**. 80VA **9.92**. 120VA **10.59**. 160VA **12.10**. 225VA **13.69**. 300VA **14.77**. 500VA **19.20**. 625VA **22.09**. 750VA **26.17**. 1KVA **38.82**. 1.2KVA **44.06**
price includes p+p & vat.

Available from stock in the following voltages:–6-0-6,9-0-9,12-0-12,15-0-15, 18-0-18,22-0-22, 25-0-25, 30-0-30,35-0-35,40-0-40,45-0-45,50-0-50,110,220,240(max. 10 amp). Primary 240 volt.

Quantity Prices and delivery on request
(we also manufacture conventional E1 type transformers)

AIR LINK

Airlink Transformers.
Unit 6, The Maltings, Station Road, Sawbridgeworth, Herts. Tel: 0279-724425.

CIRCLE 44 FOR FURTHER DETAILS.


Psst.
Did you know that
• the business micro market is worth £620m per year
• almost 80% of business micros are sold through dealers
• only Micro Business magazine reaches those dealers
• if you're launching a new product, it can be advertised on the front cover of Micro Business
So if Micro Business isn't on your media schedule yet, call Ken Walford on 01-661 3139, today.
micro business

Appointments

Advertisements accepted up to 12 noon March 29th for May Issue

DISPLAYED APPOINTMENTS VACANT: £19 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £4.00 per line, minimum £25 (prepayable).
BOX NUMBERS: £5 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 4AS).
PHONE: IAN FAUX, 01 661 3033 (DIRECT LINE)

Cheques and Postal Orders payable to BUSINESS PRESS INTERNATIONAL LTD. and crossed.

ecm

THE BEST APPROACH

£7,000-£30,000 + CAR

★ **Where does your interest lie:** Graphics; CAD; Robotics; Simulation; Image and Signal Processing; Medical; Automation; Avionics; Acoustics; Weapons; Comms; Radar; Opto and Laser?

★ **Experienced in:** VLSI; Microprocessor Hardware or Software; Digital and Analogue circuitry; RF and Microwave techniques?

★ **There are hundreds of opportunities in:** Design; Test; Sales and Service for Engineers and Managers

★ **For free professional guidance:** Call: 0638 742244 (till 8pm most evenings) or write (no stamp needed) to

ELECTRONIC COMPUTER AND MANAGEMENT APPOINTMENTS LIMITED
FREEPOST, The Maltings, Burwell, Cambridge. CB5 8BR.

(1926)

Product Development Engineers

Dolby Laboratories, famous for its audio noise reduction systems, was founded by an engineer. A company that believes in engineers and engineering, we are small enough for individual contributions to be recognised yet well established with the resources to implement and capitalize on innovations.

We are looking for Senior and Junior Engineers, who are probably electronics graduates, to staff a new Product Development Section in the UK. Reporting to the Managing Director, the group will be responsible for translating agreed product 'outlines' into manufacturable units. The emphasis is on creative engineering and design.

Salaries will be competitive.

For more information contact:

Gary Holt,
Dolby Laboratories Inc.,
346 Clapham Road,
London SW9 9AP
01-720 1111

(2537)

Dolby®

SOUND ENGINEER

Applications are invited for the newly-created post of TECHNICAL ASSISTANT to the studio's HEAD OF TECHNICAL SERVICES.

The successful candidate will work in the field of SOUND ENGINEERING for film post-production, and must have a thorough theoretical background in electronics and light electrical engineering. Ability in project management is a priority, involving audio and control systems, planning, specification and installation, with skills at the drawing board and development bench. A working understanding of remedial and routine maintenance is required, and experience with video systems would be an advantage.

The prospects for advancement would be best for an applicant having a good manner and appearance, an even temperament, and the ability to deal with clients, to handle administrative duties and to write clear English. The suggested age range is 28 to 40 years.

In conformity with studio practice, membership of ACTT (the Association of Cinematograph, Television and allied Technicians) would be expected, and due weight would be given to applications from present members. Non-members should be willing to apply for acceptance by this union.

Please forward a full c.v. (quoting ref: ACN/GFL/A) to:—
Personnel Dept., Pinewood Studios, Pinewood Road, Iver, Bucks SL0 0NH.
Tel:Iver (0753) 651700

(2535)

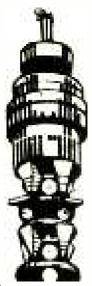
CUT THIS OUT!

Clip this advert and you can stop hunting for your next appointment. We have a wide selection of the best appointments in Digital, Analogue, RF, Microwave, Microprocessor, Computer, Data Comms and Medical Electronics and we're here to serve *your* interests.

Call us now for posts in Design, Test, Sales or Field Service, at all levels from £6,000-£16,000.

Technomark
Engineering & Technical Recruitment

11 Westbourne Grove, London W2. Tel: 01-229 9239.
(1935)



CAPITAL APPOINTMENTS LTD

THE UK's No. 1 ELECTRONICS AGENCY

If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar fields:

Telephone now for our free jobs list
We have vacancies in all areas of the UK
Salaries to £15,000 pa

01 808 3050
(24hours)

CAPITAL APPOINTMENTS LTD
76 WILLOUGHBY LANE, LONDON N17 0SF
(291)

BORED ?

Then change your job!

1) **TEST CALIBRATION ENGINEERS** To work on a variety of micro based instruments and A.T.E. Windsor £12,000+
2) **REMOTE CAMERA EQUIPMENT** Test engineers to work on high speed digital systems to £10,000. Surrey
3) **TECHNICIAN ENGINEER** For maintenance of VAX pdpll and flight simulation systems. Middx. To £11,000
4) **DATA PROCESSING EQUIPMENT** Customer service engineer to work on PDP8 and PDP11's, printers and graphics displays. £12,000 + car. Berks/Bucks.
5) **MARINE SERVICE ENGINEER** To maintain a variety of marine communications and navigation systems. Surrey. To £10,000
6) **DEVELOPMENT/TEST ENGINEER** To design and support a variety of medical systems. £10,000. Berks/ Middx

Hundreds of other Electronic and Computer vacancies to £12,500
Phone or write
Roger Howard, C.Eng., M.I.E.E., M.I.E.R.E.
CLIVEDEN CONSULTANTS
92 The Broadway, Bracknell, Berkshire
Tel: 0344 489489 (1640)

CLIVEDEN

The Queen's University of Belfast
The Computer Centre
HEAD OF HARDWARE SUPPORT AND COMMUNICATIONS DIVISION
£14,136 – £17,706
(under review)

As part of the Senior Management team reporting to the Director of the Computer Centre, the successful applicant will lead a group of seven staff responsible for the Centre's data-communications, hardware development and equipment maintenance programme. The post offers an invigorating opportunity to take over a senior managerial, technical and motivational role in a very active and stimulating University environment.

Applicants, male or female, should preferably be university graduates or equivalent in electrical or electronic engineering; demonstrating a comprehensive, in-depth knowledge and practical experience of data-communications, state-of-the-art hardware, active managerial and technical expertise and a thorough knowledge of the general field of computing.

Salary scale (Universities Other Related Staff Grade III): **£14,137 – £17,706** (under review from 1.4.85), initial placing according to age, experience and qualifications. Assistance with relocation.

Applications, including a full curriculum vitae and the names and addresses of three referees should be sent to the Personnel Officer, The Queen's University of Belfast, Northern Ireland, BT7 1NN, from whom further particulars may be obtained.
(2536)

ELECTRONIC ENGINEERS

FOR MARINE SYSTEMS

Hunting Surveys & Consultants Ltd has vacancies for Electronics Engineers to work on both the theoretical and practical aspects of Marine Survey Instrumentation Systems.

Applicants are required in two areas:-

- Qualified to degree level with a broad electronics experience, having an emphasis on digital circuitry, computing and micro-processing techniques and capable of taking overall responsibility for initial circuit design while working with minimum supervision.
- With not less than 3 years' electronics experience including a broad knowledge of digital circuitry and microprocessing techniques

Candidates (preferred age 23-30) should be physically fit and prepared to undertake periods of operational work in both the North Sea and overseas. In addition to basic salary and staff conditions, generous allowances and leave are granted for work away from base.

If you are bored by routine and seek a real challenge, please send for an application form to:-

Hunting

Personnel Manager
HUNTING SURVEYS & CONSULTANTS LTD
Elstree Way, Borehamwood, Herts WD6 1SB.
(2554)

THE START OF SOMETHING NEW

If you are leaving College and planning a career in modern communications or if your present job lacks interest and challenge ..... why not join us in GCHQ? We are recruiting

RADIO OFFICERS

who are after initial training will become members of an organisation that is in the forefront of communications technology. Government Communications Headquarters can offer you a satisfying and rewarding career in the wide field of communications. Training involves a 32 week course (38 weeks if you come straight from Nautical College) which will fit you for appointment to RADIO OFFICER.

Not only will you find the work as an R O extremely interesting but there are also good prospects for promotion opportunities for overseas travel and a good salary. Add to this the security of working for an important Government Department and you could really have the start of something new.

The basic requirement for the job is 2 years radio operating experience or hold a PMG, MPT or MRGC or be about to obtain a MRGC. Registered disabled people are welcome to apply.

Salaries start at £4,762 at age 19 to £5,755 at age 25 and over during training and then £6,399 at 19 to £8,510 at 25 and over as a Radio Officer. Increments then follow annually to £11,741 inclusive of shift and weekend working allowances.

For full details and application form phone 0242 32912/3 or write to:

GCHQ

The Recruitment Office A/1108
Priors Road
CHELTENHAM
Glos GL52 5AJ
(806)

Appointments

Telecommunications Engineering Technicians

Openings in Servicing and Maintenance
Up to £8,873

Our business is to install and maintain the communications equipment used by the Police and Fire Brigades in England and Wales – some of the latest you will find in operation anywhere.

We have a number of vacancies at our Service Centres in various parts of the country, for Telecommunications Engineering Technicians with practical skills in locating and diagnosing faults in a wide range of equipment from computer-based data transmission to FM and AM radio systems.

The work provides excellent opportunities for extending your technical expertise, with specialised courses and training to keep you up to date on developments and new equipment. There are also opportunities for day release to gain higher qualifications.

Applicants, male or female, must be qualified to at least City & Guilds Intermediate Telecommunications standard and possess a current driving licence. Some travelling will normally be involved. Registered disabled persons can of course apply.

The Home Office is an equal opportunities employer.

Salary will be on a scale £6501 to £8873 a year with generous leave allowance and pension scheme.

Good prospects for promotion.

If you are completing your service, please write for further details and an application form, quoting reference WW/2 to: Miss M Andrews, Home Office, Directorate of Telecommunications, Horseferry House, Dean Ryle Street, London SW1P 2AW

(2526)

Home Office Directorate of Telecommunications

THE UNIVERSITY OF SHEFFIELD
DEPARTMENT OF PSYCHOLOGY

SENIOR EXPERIMENTAL OFFICER

Applications are invited for the above post tenable from 1 April 1985 or as soon as possible thereafter. Candidates should have extensive experience in digital and microprocessor design, and be capable of designing and implementing special purpose equipment for various research projects. Much of the equipment is microprocessor based and software experience would be an advantage. Initial salary in the range £7520 a year to £12,150 a year on Grade 1A for Other Related Staff.

Particulars from the Personnel Department (Academic Staffing), the University, Sheffield S10 2TN to whom applications (6 copies) including the names of three referees, should be sent by 8 April 1985.
Quote ref: R221/BH (2532)

UNIVERSITY OF LIVERPOOL
INSTITUTE OF MEDICAL AND DENTAL BIO-ENGINEERING

TECHNICIAN
GRADE 3 (ELECTRONICS)

To assist with circuit design, construction and maintenance of electronic control equipment in a medical research laboratory. Candidates must possess O.N.C., Intermediate T.E.C., or appropriate equivalent as minimum qualification plus three years experience which should include general workshop skills.

This post is available for two years.

Salary within range £5399 - £6325 per annum.

Application forms may be obtained from the **Registrar, the University, P.O. Box 147, Liverpool, L69 3BX.**

Quote Ref: RV/938/EWW (2487)

BCS LABORATORY DUPUTY HEAD

Due to expansion we have a vacancy for an experienced standards engineer to carry out calibration on DC and LF instrumentation in our laborayory, which is approved by the British Calibration Service.
This position would ideally suit someone in the calibration field wishing to further their career prospects.
Experience in this type of environment is a necessity.

An attractive salary, pension and BUPA benefits will be offered, also relocation expenses where applicable.

Apply in writing giving details of employment to date:

Mr.J.Macalister
DMR Ltd.,
Unit 19
Salisbury Square, Radford,
Nottingham NG7 2AB.

(2528)

We have the following vacancies for engineers to join our young and expanding company based in west London. We are sole UK importers of specialised broadcast equipment and are now designing and manufacturing a range of our own products for the television industry.

SERVICE ENGINEER
We require a service engineer preferably with experience of video equipment or similar area of electronics. The applicant should be able to maintain character generators, time base correctors, vision mixers etc...

TEST ENGINEER
We require an engineer to test, align and fault find on a new range of products designed and manufactured by ourselves. There would be opportunities for involvement in other areas of the production process.

Salaries would be dependent upon experience and qualifications.
Please send CV to the address below.

POLARVIDEO
2-5 Powis Mews, London W11. Telephone 01-727 1111

(2531)

COMMUNICATIONS DESIGN FROM START...

At H.M. Government Communications Centre we're using the very latest ideas in electronics technology to design and develop sophisticated communications systems and installations for special Government needs at home and overseas.

With full technical support facilities on hand, it's an environment where you can see your ideas progress from initial concepts through prototype construction, test and evaluation, to the pre-production phase, with a chance to influence every stage. Working conditions are pleasant, the surroundings are attractive, and the career prospects are excellent.

Ideally we're looking for men and women who have studied electronics or electronics related subjects to degree level or equivalent and have had some experience of design, whether obtained at work or through hobby activities. Appointments will be made as Higher Scientific Officer (£7,435-£10,039) or Scientific Officer (£5,909-£8,153) according to qualifications and experience.

For further details please write to the address given below. It would be particularly helpful if an outline of your personal interests and practical experience could be included.

The Recruitment Officer, HMGCC, Hanslope Park, Buckinghamshire MK19 7BH.

...TO FINISH

(2523)

Satellite Communications

Marconi Space Systems are rapidly developing their Portsmouth Space Centre. As a result of the success of the satellite communications business, a number of posts have been created for Engineers and Technicians at all levels of seniority including Project Manager/Principal level.

There is a full range of engineering facilities concentrated on one site. New facilities include an antenna test range second to none.

We require men and women for the following areas

- **Synthetic Aperture Radar**
- **Radar Systems Analysis**
- **RF/Microwave Systems**
- **Antenna Development**
- **Software/Hardware Development**
- **Mission Analysis**
- **Attitude & Orbital Control**
- **Data Handling**
- **Power Systems**
- **Quality Systems Assurance**
- **Test/EMC/Environmental Engineering**
- **Assembly, Integration and Test**
- **Ground Support Equipment**
- **Electronics Components Acceptance Testing**
- **Electronic Space Parts**

Complete the coupon and send it to Jack Burnie, Marconi Space Systems Ltd, Browns Lane, The Airport, Portsmouth, Hants. PO3 5PH, or telephone him on 0705 674019 quoting ref. BL 28

NAME ____________ QUALIFICATIONS ____________

ADDRESS ____________

EXPERIENCE ____________

TEL. NO. Home ____________ AREA OF INTEREST ____________

Work ____________ BL 28

Marconi
Space Systems

(2527)

The Publishers take all reasonable care to ensure that classified advertisements are genuine, but readers must satisfy themselves that they will be obtaining what they require before entering into transactions, particularly if they involve large sums of money. (2519)

Dont Forget!

for your classified adverts ring

Ian Faux

01 661 3033

Classified

WANTED

SURPLUS

We offer good prices for test equipment, components, redundant computers, PCB's connectors. Immediate settlement.

TIMEBASE
94 Alfriston Gardens
Sholling, Southampton SO2 8FU
Telephone: (0703) 431 323
(1832)

E C COMPONENTS

We buy large and small parcels of surplus I/C, transistors, capacitors and related electronic stock. Immediate settlement.
Tel: 01-208 0766
Telex: 8814998
(2491)

CIRCOLEC
THE COMPLETE ELECTRONIC SERVICE

Artwork, Circuit Design, PCB Assembly, Test & Repair Service, Q.A. Consultancy, Prototypes, Final Assembly. Full PCB Flow Soldering Service.
Quality workmanship by professionals at economic prices.
Please telephone **01-646 5686** for advice or further details.
TAMWORTH MANOR
302-310 COMMONSIDE EAST, MITCHAM
(1391)

STEWART OF READING

110 WYKEHAM ROAD
READING RG6 1PL
TEL NO: 0734 68041

TOP PRICES PAID FOR ALL TYPES OF SURPLUS TEST EQUIPMENT, COMPUTER EQUIPMENT, COMPONENTS etc. ANY QUANTITY. (2616)

WANTED

Test equipment, receivers, valves, transmitters, components, cable and electronic scrap and quantity. Prompt service and cash. Member of A.R.R.A.

M & B RADIO
86 Bishopsgate Street
Leeds LS1 4BB
0532 435649
(9956)

WANTED
SURPLUS ELECTRONIC COMPONENTS AND EQUIPMENT

We also welcome the opportunity to quote for complete factory clearance
B. BAMBER ELECTRONICS
5 STATION ROAD, LITTLEPORT, CAMBS.
Phone: Ely (0353) 860185
(2483)

CASH CASH CASH for surplus electronic components and equipment & also non ferrous metals. Factory clearance no problem. Phone John Turne: 367-6773. (2529)

WANTED

All types of surplus electronic components and equipment.
We specialise in factory clearance.
SGS Electronics,
The Vineyard, Bowley Lane,
Boddenham, Herefordshire
HR1 3LF. Tel (056) 884 532
(2541)

* MICROCOMPUTERS
* PERIPHERALS
* INSTRUMENTATION

For fastest, best CASH offer, phone,
COMPUTER APPRECIATION
Oxford (0865) 55163
Telex 838750
(2492)

TO MANUFACTURERS, WHOLESALERS BULK BUYERS, ETC.
LARGE QUANTITIES OF RADIO, TV AND ELECTRONIC COMPONENTS FOR DISPOSAL

SEMICONDUCTORS, all types, INTEGRATED CIRCUITS, TRANSISTORS, DIODES, RECTIFIERS, THYRISTORS, etc. RESISTORS, C/F, M/F, W/W, etc.
CAPACITORS, SILVER MICA, POLYSTYRENE, C280, C296, DISC CERAMICS, PLATE CERAMICS, etc.
ELECTROLYTIC CONDENSERS, SPEAKERS, CONNECTING WIRE, CABLES, SCREENED WIRE, SCREWS, NUTS, CHOKES, TRANSFORMERS, etc.
ALL AT KNOCKOUT PRICES – Come and pay us a visit ALADDIN'S CAVE
TELEPHONE: 445 0749/445 2713
R. HENSON LTD.
21 Lodge Lane, North Finchley, London, N.12
(5 minutes from Tally Ho Corner) (1613)

CAPACITY AVAILABLE

FREE P.T.H. PROTOTYPE of the finest quality with EVERY P.C.B. artwork designed by us. Competitive hourly rates, and high standard of work. Halstead Designs Limited, 34, High St., Halstead, Essex. Tel. (0787) 477408/474554. (2126)

VALVES, PROJECTOR Lamps, 6000 types, list 75p, world wide export. Cox radio (Sussex) Ltd., The Parade, East Wittering, Sussex. Phone (0243) 672023 (1991)

SERVICES

TURN YOUR SURPLUS i.cs transistors etc. into cash, immediate settlement. We also welcome the opportunity to quote for complete factory clearance. Contact COLES-HARDING & CO, 103 South Brink, Wisbech, Cambs. 0945 584188. (9509)

PCB REPAIRS BY EXPERTS.

For fast, reliable diagnosis and repair of most printed circuit boards UK and overseas, contact the experts: Jaecrow Systems Services, 29/31 Lower Coombe Street, Croydon, Surrey CR9 1LX. Ring 01-680 9191 for full details without obligation.
Quote ref: EW485 (2471)

SMALL BATCH PCBs, produced from your artwork. also DIALS, PANELS, LABELS. Camera work undertaken. FAST TURNAROUND. Details: Winston Promotions, 9 Hatton Place, London EC1N 8RU. Tel. 01-405 4127/0960. (9794)

DESIGN AND MANUFACTURE. ANALOGUE, DIGITAL, RF AND MICROWAVE CIRCUIT AND SYSTEM DESIGN. Also PCB design, mechanical design and prototype/small batch production. — **Adenmore Limited,** 27 Longshot Estate, Bracknell, Berks. Tel: Bracknell (0344) 52023. (656)

FOR THE BEST PCB SERVICE AVAILABLE

***Circuit Design & Development**
Digital and Analogue

***Artwork Layout**
PCB artwork layout and mechanical detailing. P.O. approved standard.

***Board Manufacture**
Prototype to semi-production, excellent rates.

***Wiring & Assembly**
PCB assembly, wiring and cable forming. Flow soldering facilities available.

***Test**
Full test facilities available.

One or all services available. Please telephone Chelmsford (0245) 357935, or write to HCR Electronics, The Industrial Unit, Parker Road, Chelmsford. (30mins from Liverpool Street St.) (1169)

DESIGN AND DEVELOPMENT SERVICE. RF transmitters and receivers. Telemetery U.H.F. V.H.F. Analogue and digital circuits, control systems. Full manufacturing facilities. RCS Electronics, Wolsey Road, Ashford, Middx. Phone Dr. Eric Falkner on 53661. (2637)

CAPACITY AVAILABLE

TW ELECTRONICS LTD
THE PCB ASSEMBLERS

More and more companies are investigating the advantages of using a professional subcontractor. Such an undertaking requires certain assurances.

TW are able to satisfy all of them – quality, competitive pricing, firm delivery and close co-operation with the customer.

Assembled boards at 100% inspected before flow soldering and reinspected after automatic cropping and cleaning.

Every batch of completed boards is issued with a signed certificate of conformity and quality – our final assurance.

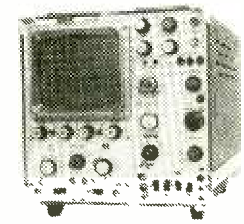
For further details, contact us at our new works:

Blenheim Industrial Park
Bury St. Edmunds
Suffolk IP33 3UT
Telephone: 0284 3931 (1466)

• Layout • Fast service
• Artwork • Competitive
0386-832152
pcb design
Williams P.C.B. Artwork, 49 Westbourne, Honeybourne, Evesham, Worcs, WR11 5PT
(2537)

SMALL SELECTION ONLY LISTED
RING US FOR YOUR REQUIREMENTS WHICH MAY BE IN STOCK

Portable Battery or Mains Oscilloscope. SE Laboratories 111 Oscilloscope — Solid State — General purpose — Bandwidth DC to 18/20MC/S at 20MV/CM — Dual Channel — Rise time 19NS — Calibrated Sweep — Calibrator — Display 10CMS×8CMS — Power AC — 95 Volts to 100-190 Volts to 260 or 24 Volt DC battery — Size W 25 5.CM — H25.5CCMS — 56CMS Deep — WT11 4KGS — Carrying handle — Tested in fair condition with operating instructions £120 00



Latest Bulk Government Release — Cossor Oscilloscope CDU150 (CT531/3) £150 only. Solid state general purpose bandwidth DC to 35MHz at 5MV/CM — Dual Channel — High brightness display (8×10cm) Full delayed time base with gated mode — Risetime 10NS — Illuminated graticule — Beam finder — Calibrator 1KHz squarewave — Power 100 — 120V.200V — 250 volts AC — Size W 26CM — 41CM deep — WT 12.5 K.G. carrying handle — colour blue — protection cover front containing polarized viewer and camera adaptor plate — probe (1) — Mains lead. Tested in Fair condition with operating instructions — £150.00.

Communication Recievers Racal **500KC/S to 30MC/S in 30 bands 1MC/SWIDE** — RA17 MK11 **£125.** RA17L **£150.** RA117E **£200.** New Metal Louvred Cases for above **£25. All receivers are air tested and calibrated in our workshop — supplied with dust cover — operation instructions — circuit — in fair used condition.** Racal Synthesisers **(Decade frequency generators)** MA350B **Solid State for use with — MA79 — RA217 — RA1218 Etc £100 to £150.** MA250 — **1.6MC/S to 31.6 MC/S £100.** MA1350 **for use with RA17 receiver £100.** MA259G **Precision frequency standard 5MC/S — 1MC/S — 100KHz £100 to £150.** Panoramic Adaptor **RA66 £150.** RA137 and RA37 **£40 to £75 LF convertors 10 to 980KC/S.** RA218 **Independent SSB unit £50** RA98 **SSB-ISM Covertor £50.** RA121 **SSB-ISB convertor £75.** EC964/7K **Solid state — single channel — SBB — mains or battery — 1.6 to 27.5 MC/S and 400 to 535KHz £100 with manual** Plessey PR155G **Solid State 60KC/S — 30MC/S £400.** Creed 75 Teleprinters — **Fitted tape punch and gearbox for 50 and 75 bauds — 110volts AC supply — in original transport tray sealed in polythene — lik new £15EA. Redifon TT11 Audio Teleprinter convertor receiver solid state — supply 110 or 240AC — Made for use with above teleprinter enabling print-out of messages recieved from audio input of communication receiver £15 with circuit tested.** Redifon TT10 Convertor **as above but includes transmit facilities £20.** Oscilloscopes — stocks always changing **Tektronix 465** — 100MC/S £750 **FM Recorder** Sanghmd Sabre 111 14 channels £350. **Transtel Matrix printers — AF11R** — 5 level Baudot Code — up to 300 Bauds — for print out on plain teleprinter paper £50 to £100 **Transtel AH11R** — As above but also 8 level ASC11 (CCITT No 2 and CCITT No 5) Like new £100 **Army field telephone sets.** Type F — L and J — Large quantity in stock £6 to £15 depending on type and quantity P O.R **Don 10 Telephone Cable** — half mile canvas containers £20 **Night viewing infra-red AFV periscopes** — Twin Eyepiece — 24 volt dc supply £100ea Original cost to government over £11,000ea **Static invertors** — 12 or 24 volt input — 240 volt AC sinewave output — various wattages P O R **XY Ploters and pen recorders** various — P O R **Ferrograph series 7 Tape recorders** mono £100, stereo £150 **Signal Generators various — TF995/A3** £60 **TF801D/8s** — 10MC/S to 485MC/S £90 **TF144H/A4** £90 **TF1060/2** £60 **HP606A** — £90 £140 **HP608** £50 **HP614A** £100 **HP618B** £100 **HP620A** £100 **Marconi TF1064B/5** £100 **TF791 Deviation meter** £100 **TF893A Power meter** £50 **Aerial mast assembly** 30ft high complete with 16ft whip aerial to mount on top – guyropes – insulators – Base and Spikes etc . in heavy duty carrying bag – new £30 **Racal frequency counter** Type 836 £50 **Tektronix plugs-ins** — 1A1 £50, 1A2 £40, 1A4 £100 M£50 All items are bought direct from H M Government being surplus equipment Price is Ex works S A E for enquiries Phone for appointment for demonstration of any items Also availability or price change V A.T and carriage extra

EXPORT TRADE AND QUANTITY DISCOUNTS GIVEN
JOHNS RADIO (0274) 684007
WHITEHALL WORKS,
84 WHITEHALL ROAD,
EAST BIRKENSHAW, BRADFORD
BD11 2ER

WANTED REDUNDANT TEST EQUIPMENT — RECEIVING AND TRANSMITTING EQUIPMENT — VALVES — PLUGS — SOCKETS SYNCHROS ETC
(2743)

ARTICLES FOR SALE

QUARTZ CRYSTALS OSCILLATORS AND FILTERS of all types. Large stocks of standard items. Specials supplied to order. Personal and export orders welcomed — SAE for lists please. OEM support thru:- design advice, prototype quantities, production schedules.
Golledge Electronics. Merriott, Somerset TA16 5NS. Tel: 0460 73718 (2472)

ENCAPSULATING EQUIPMENT FOR coils, transformers, components, degassing silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment, low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon CR0 2QP. 01-684 9917. (9678)

MORSE READING PROGS. Work on clean signals without hardware interface. ZX81 1K UNEXPANDED MEMORY. Translated code with word and line spaces for easy reading Automatic scroll action. £7 incl. (2532)

WAVEGUIDE, Flanges and dishes. All standard sizes and alloys (new material only) from stock. Special sizes to order. Earth Stations, 01-228 7876. 22 Howie Street, London SW11 4AR. (2099)

Chart recorders 1,2,6,20 pen. Stabilised power supplies. Pye Megohmmeter 0.3—200,000 M-ohm. Muirhead Variable Air Standard Capacitor, micrometer head to 1/10,000 £39. Sullivan Air Capacitor standard µµF, £25. EHT meter. 1,2,3,4,5 KV EHT Supply. 20-amp variable resistance box £29. Video oscillator. AF Waveform Analyser. Taylor-Hobson Surface Recording & Measurement equipment, Amplifier/supply unit, Rectilinear recorder, transducer £95. Pressure transducers. GEC Insulation Flashover test-set £30. Industrial Cleaner Concentrate, carpet machine use, plastics, floors etc., deodorant, antiseptic, anti-static, dilute 25-50 times £3/litre, one large drum only available. Oscilloscope Ignition Analyser Unit, diagnostic manual £39. FM/AM Deviation/Modulation Meter £75. FM/AM Generator £89. 1HP single phase capacitor motor £35, 1½hp £45. Micro Spot Welding heads £35. £65. Books, manuals, circuit information etc., Siemens Capacitance Bridge, £65. TEL

040 376236 (2016)

FM BROADCAST EQUIPMENT

A special range of high quality transmitters, power amplifiers, stereo encoders, UHF repeater links, compressors, antennas etc.

Built to high specifications at an economic price. VHF/UHF data and telemetry systems (MPT 1309) available ex-stock.

Full catalogue available.

Cyberscan International, 3 Eastcote View, Pinner, Middx HA5 1AT. 01-866 3300

(2542)

T.I. DATA BOOKS

Opto Electronics	£5.00
Linear Circuits	£9.00
TTL (7th Ed.) Vol.1.	£9.00
TTL (7th Ed.) Vol.2.	£8.00
'Understanding' series	£4.50

Post free CWO. SAE for full list

MG Books, 24A Newgate, Barnard Castle, Co. Durham DL12 8NG.
Tel: (0833) 31130

(2540)

CROSS ASSEMBLERS. 6803/6303 6805 65002 Processors. BBC, Commodore 64 or Pet. Fast machine code execution. Suprorts expressions, directives, macros etc. Performance warranty. £20 each (BBC — CWO) full details (s.a.e. please) Tylek Ltd., 2 Parkview, Cashgreen, Stroud, Glos. 045-36-77257 (2534)

MERCURY WETTED REED RELAY

No contact bounce or noise. OK for "SPARKLESS" use. D.P.C.O. 5v 10mA Coil. 0.1" grid pcb. Clare HGS2MY-5081 ex IBM.
1-25, £2.80, 25, £2.15, 100, £1.85 p&p 50p **LINDEN ELEC.** 15 Garden St. Darlington **0325/462367**

(2425)

REFURBISHED DIABLO SERIES 30 disk drives. Removable model £225. Fixed model £175 includes power supply and I/O cable. — Computer Peripheral Services 0953-883827. Professional disk drive refurbishment and repair service. Specialists in CDC, Wangco, DRE & others. (2533)

WAYNE KERR FREQUENCY RESPONSE ANALYSER (20HZ-30KHZ and 200HZ-200KHZ) plus 4-trace digital store. Type RA200/ADS1. Excellent condition. £2800 o.n.o. Tel. (063878) 518. (2453)

When replying to classified advertisements, readers are recommended to take steps to protect their interests before sending money

(2519)

BUSINESS OPPORTUNITY

MARKETING OF ELECTRONIC EQUIPMENT PRODUCTS. Distributor seeks additional products which will fit in to electronic production and test areas. Reply Harrison. Grange Electronics Ltd., Stone Lance Industrial Estate, Wimbourne, Dorset. BH21 1HD. Tel: 0202-884752. (2532)

OPTOELECTRONICS DATA BOOK 1984

Price by Texas £6.00

DIGITAL ELECTRONIC CIRCUITS & SYSTEMS by N.M. Morris PRICE: £5.45

MICROELECTRONICS: A PRACTICAL INTRODUCTION by R.A. Sparkes PRICE: £8.50

SOLDERING IN ELECTRONICS by R.J. Klein Wassin Wassink PRICE: £51.00

OPTICAL FIBER COMMUNICATIONS BY G. Keiser PRICE: £9.50

DIGITAL IMAGE ANALYSIS by S. Levialdi PRICE: £26.00

SEMI-CUSTOM IC DESIGN & VLSI by P.J. Hicks PRICE: £13.50

INTRODUCTION TO MOS LSI DESIGN by J. Mavor PRICE: £18.50

HANDBOOK OF BATTERIES & FUEL CELLS by D Linden PRICE £63.00

THE DESIGN & DRAFTING OF PRINTED CIRCUITS by D. Lindsey PRICE: £41 50

★ *ALL PRICES INCLUDE POSTAGE* ★

THE MODERN BOOK CO.

BRITAIN'S LARGEST STOCKIST of British and American Technical Books

19-21 PRAED STREET LONDON W2 1NP

Telephone: **01-402 9176**
Closed Saturday 1 p.m.
Please allow 14 days for reply or delivery

(2245)

SERVISCOPE

EAST STREET, FARNHAM, SURREY.
TEL: 0252 722666
CONTACT: G.P. SKINNER
A SELECTION OF TELEVISION AND ELECTRONIC COMPONENTS FOR DISPOSAL

68 PF Ceramic Cap	TEC 1500 Earth Strip UHG Tuner
470 PF Pulse Ceramic 12K	PHIL G8 Focus Control
PYE 731/728 — Mains Switch	PHIL G8 UHG Tuner
TEC — 8000/8500 Therm Cut Out	VRRistor — E299/DC/p348
GEC — 1040/Therm Cut Out	TEC 1400 Mains Dropper
IN4002	PHIL 210 Frame Out Put Transformer
BC308B	PHIL G8 AFC Assembly
BD137	PHIL G8 — Vision Selectivity Assembly
BC307	PHIL G8 — Vsion Gain Assembly
BAX 13	PHIL G8 — Sound Selectivity Assembly
TAA661	PCF80
PHIL 210 — Brightness Knob	PL36
PHIL 210 — Volume Knob	EF184
TEC 1500 — Brill/on-off Knob	

CATHODE RAY TUBES COLOUR
A51 — 110X/A51 — 220X A67 — 120X A56 — 120X

ALL AT KNOCK DOWN PRICES
— FOR A DETAILED LIST PLEASE APPLY TO
0252-722666

(2533)

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM

To "Wireless World" Classified Advertisement Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS

- Rate £4.00 PER LINE. Average six words per line. Minimum £25 (prepayable)
- Name and address to be included in charge if used in advertisement
- Box No. Allow two words plus £5
- Cheques, etc., payable to "Business Press International Ltd." and cross "& Co."

NAME ______

ADDRESS ______

REMITTANCE VALUE ______ ENCLOSED

PLEASE WRITE IN BLOCK LETTERS. CLASSIFICATION ______

NUMBER OF INSERTIONS ______

ELECTRONICS & Wireless world

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 96 — 103

OVERSEAS ADVERTISEMENT AGENTS

France and Belgium: Pierre Mussard, 18 — 20 Place de la Madelaine, Paris 75008.

Hungary: Ms Edit, Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget.
Telephone: 225 008 — Telex: Budapest 22-4525
INTFOIRE

Italy: Sig C. Epis, Etas-Kompass, S.p.a. — Servizio Estero, Via Mantegna 6, 20154 Milan.
Telephone: 347051 — Telex: 37342 Kompass.

Japan: Mr Inatsuki, Trade Media — IBPA (Japan), B.212. Azabu Heights, 1.5.10 Roppongi, Minato-ku 106.
Telephone: (03) 585 0581.

United States of America: Jay Feinnan, Business Press International Ltd, 205 East 42nd Street, *New York*, NY 10017 — Telephone (212) 867-2080 — Telex: 23827.
Jack Farley Jnr., The Farley Coi. Suite 1584, 35 East Walker Drive, *Chicago*, Illonois 60601 — Telephone (312) 63074.
Victor A. Jauch, Elmatex International, P.O. Box 34607, *Los Angeles*, Calif. 90034, USA — Telephone (213) 821-8581 — Telex: 18-1059.
Jack Mantel, The Farley Co., Suite 650, Ranna Building, *Cleveland*, Ohio 4415 — Telephone (216) 621 1919.
Ray Rickles, Ray Rickles & Co., P.O. Box 2028, *Miami Beach*, Florida 33140 — Telephone (305) 532 7301.
Tim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., *Atlanta*, Georgia 30305. Telephone (404) 237 7432.
Mike Loughlin Business Press International, 15055, memorial Ste 119, *Houston*, Texas — Telephone (713) 783 8673.

Canada: Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 — Telephone (416) 364 2269.
*Also subscription agents.

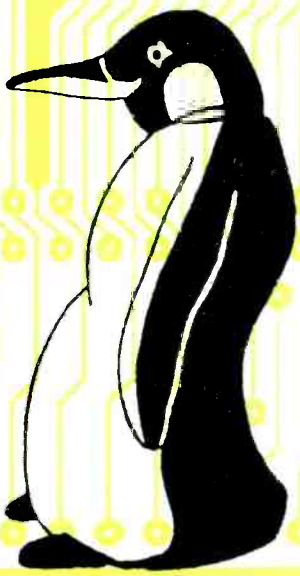
Printed in Great Britain by Index Printers Ltd., Oldhill, Dunstable, and typeset by Legendary Characters, South Street, Lancing, for the proprietors, Business Press International, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. © Business Press International 1985 *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA. A. H. Wheeler & Co. CANADA. The Wm. Dawson Subscription Service Ltd., Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th Floor, 111 Eighth Avenue, New York, N.Y. 10011.

CIRCUIT BOARD DESIGN WITHOUT THE TEDIUM

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

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

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



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

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

System Requirements

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

The Smart Buy

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

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

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

Starter kit plus 10M hard disk drive £4995.00

Colour monitor £395.00

Microsoft Mouse £149.00

Pen and ink plotters from £1795.00

smARTWORK £895.00

smARTWORK Demo disk.... £10.00

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

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

Terms: Strictly CASH WITH ORDER.

Conguin Software, 20 Morecambe Road, Lancaster LA1 5JA
Phone: 0524 381423 CIRCLE 2 FOR FURTHER INFORMATION

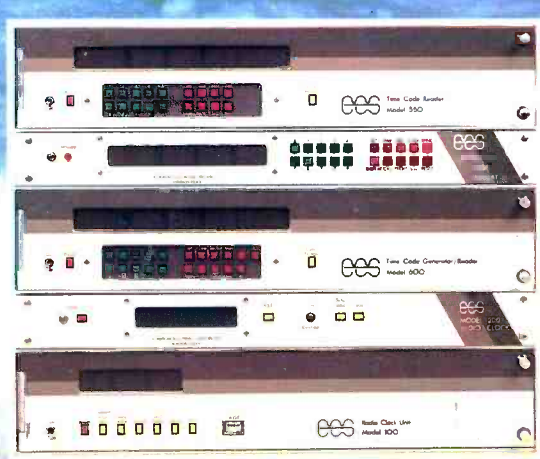
Spot On!

Time has been our business since 1974.
Precision has been our aim.
We have experience in display,
code generation, off air time,
off air frequency and
frequency standards.
Single units to the largest system.

Our time is at your disposal.

ARDEA. WERNER CURTH

European Electronic Systems Limited,
Woodham Mortimer Place,
Maldon, Essex. CM9 6SW.
Telephone: 024541-5911.
Telex: 995917



Time Code Reader.

MSF Rugby Simulator.

Tape Search System.

Radio Clock (5 mSec)

Radio Clock (500 μSec)

Made in England.

CIRCLE 3 FOR FURTHER INFORMATION