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Wireless World

JANUARY 1984

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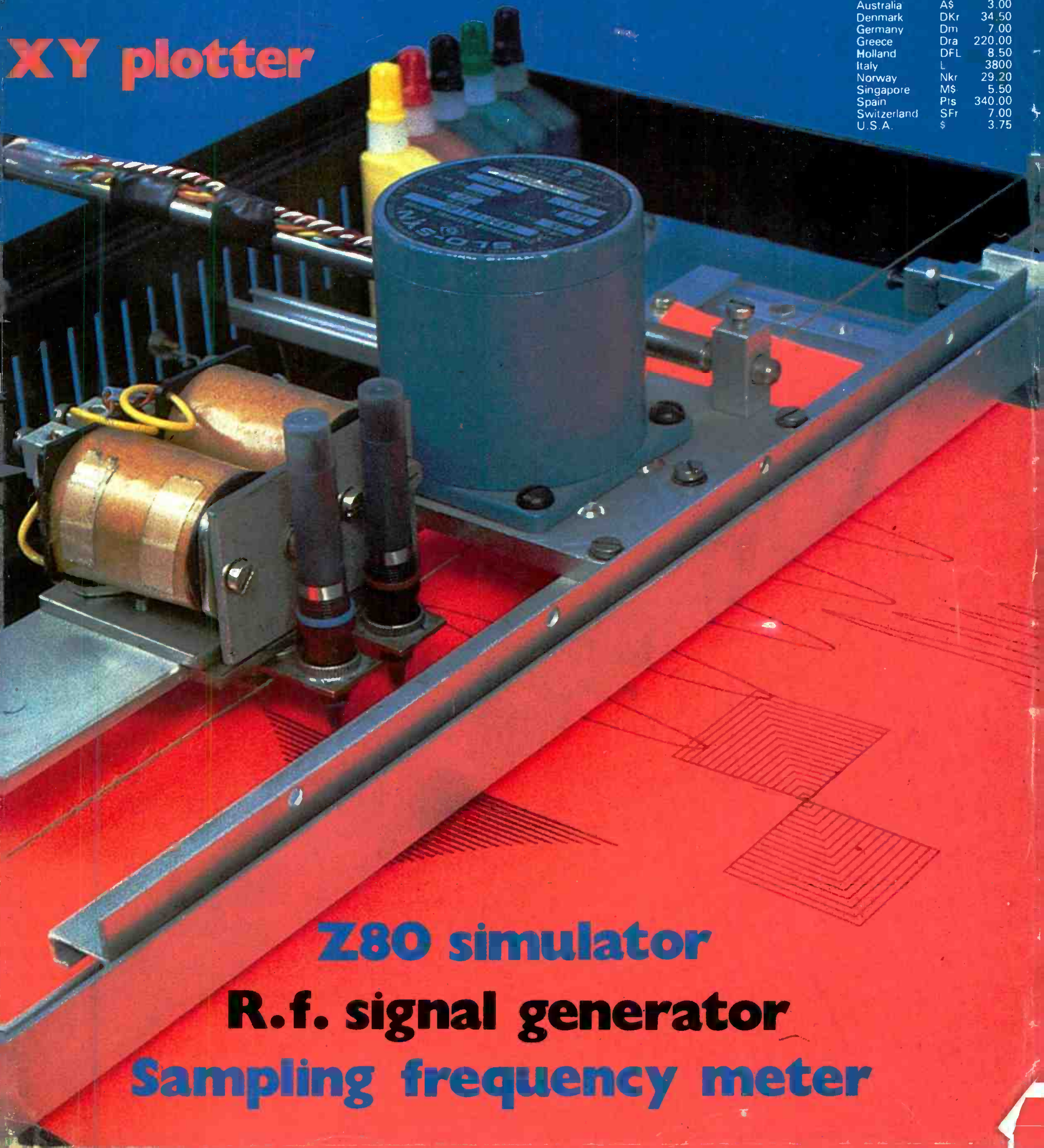


XY plotter

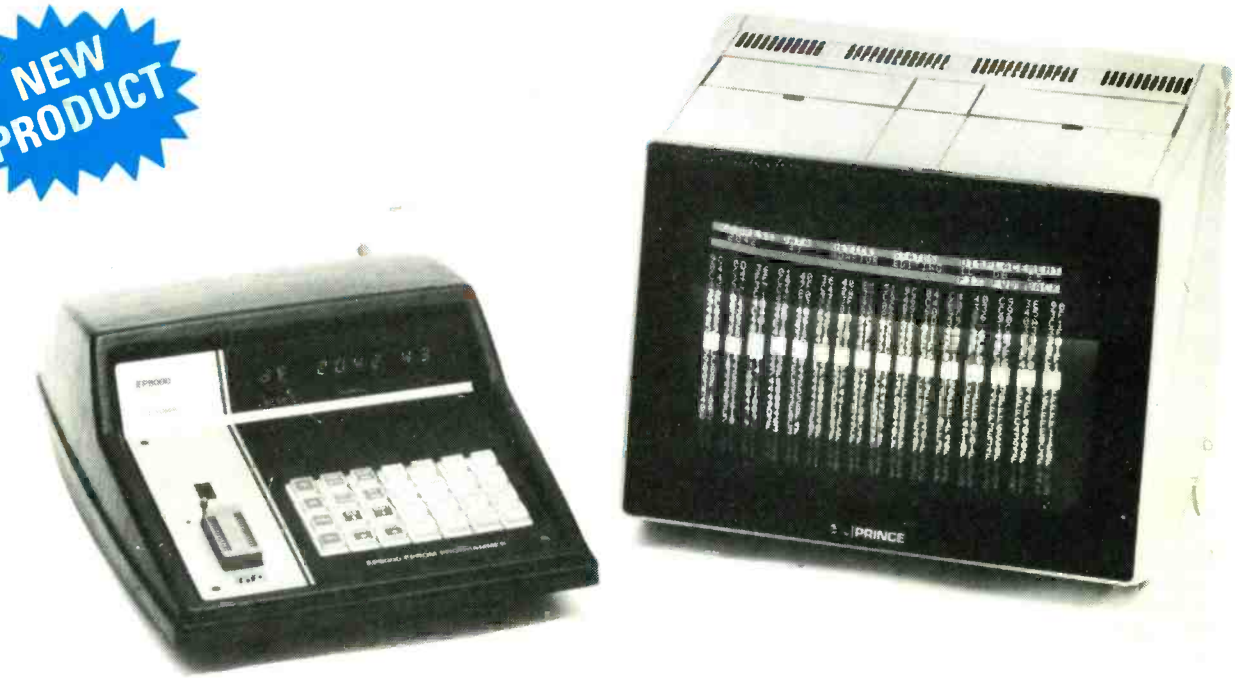
Z80 simulator

R.f. signal generator

Sampling frequency meter

EP8000 *EPROM EMULATOR PROGRAMMER*

NEW PRODUCT



The new microprocessor controlled EP8000 Emulator Programmer will program and emulate all EPROMs up to 8k x 8 sizes, and can be extended to program other devices such as 16k x 8 EPROMs, Bipolar PROMs, single chip microprocessors with external modules.
Personality cards and hardware changes are not required as the machine configures itself for the different devices.
The EP4000 with 4k x 8 static RAM is still available with EPROM programming and emulation capacity up to 4k x 8 sizes.

FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
- No personality cards/characterisers required.
- Use as stand alone programmer, slave programmer, or EPROM development system.
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VAT should be added to all prices

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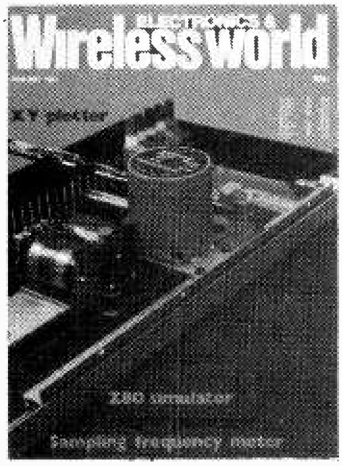

Cover picture shows Philip Hill's XI plotter, the construction of which is described on page 24.

NEXT MONTH

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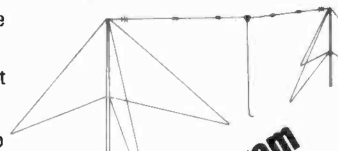

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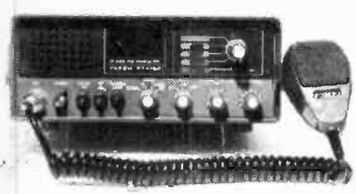

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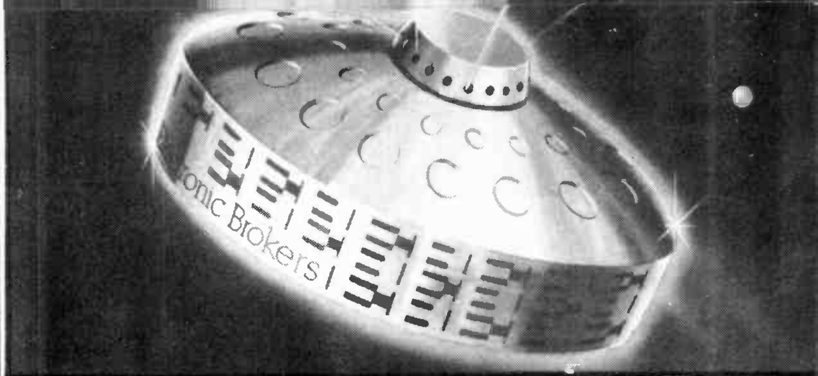

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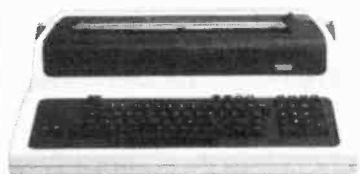

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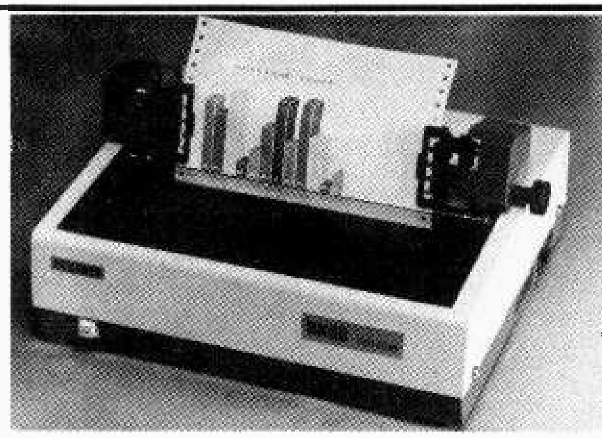

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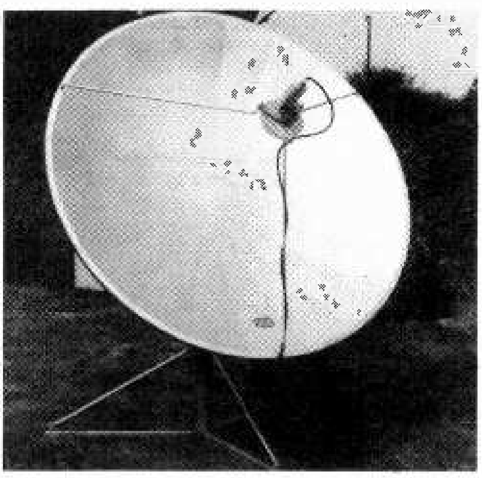

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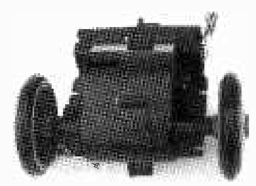

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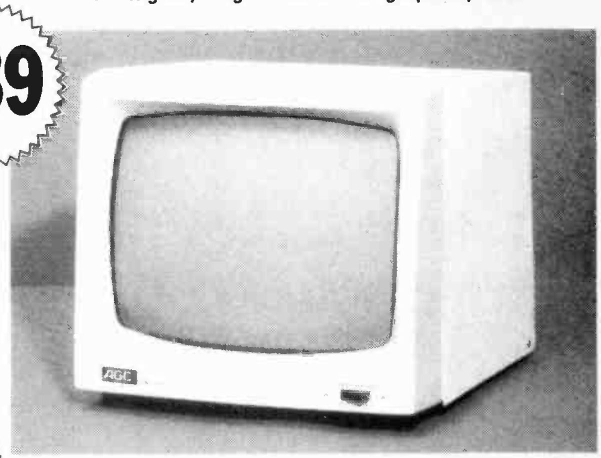

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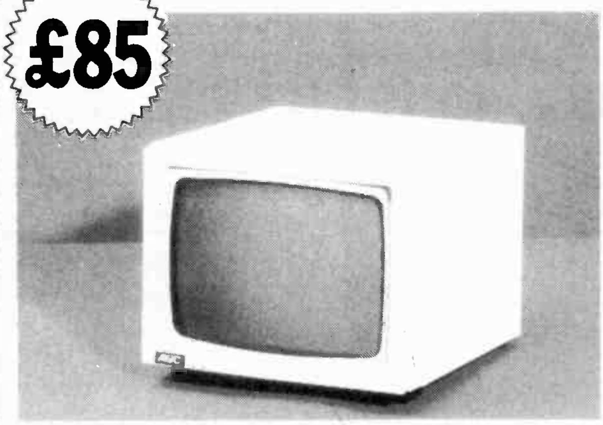

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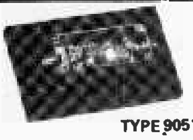

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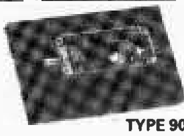

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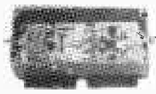

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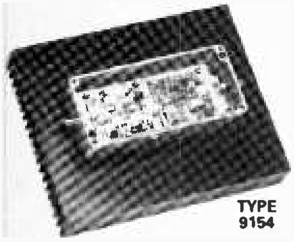

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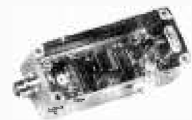

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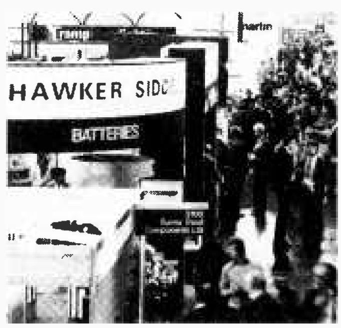

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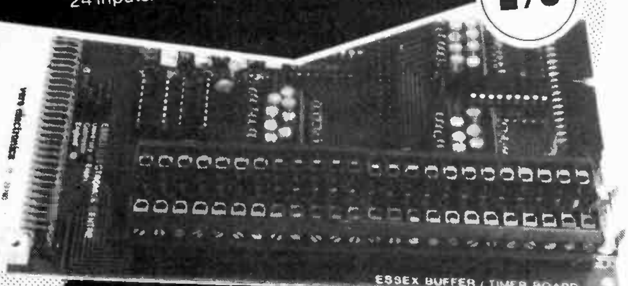

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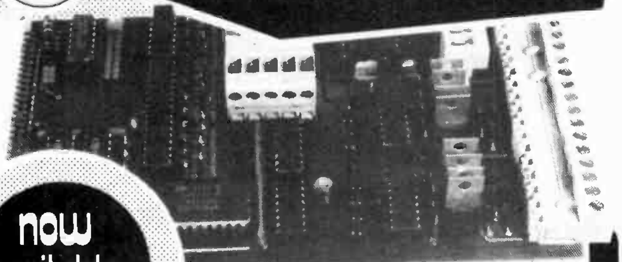

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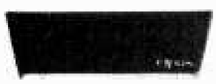

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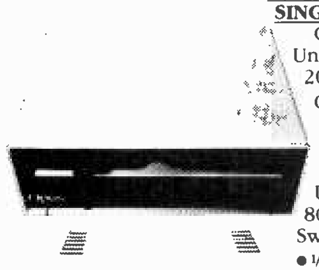

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So you want to be an author?

A steady stream of letters and telephone calls to *Wireless World* continues to draw our attention to the diffidence with which some would-be contributors approach the task of writing for publication. There are evidently fears that their writing style might not compare well with some of our more august authors and that the requirements for submitted articles are so rigid that they cannot hope to do the work properly. An impression one also gains is that they are sometimes deterred from exposing their work to the public gaze by the possibility of subsequent criticism in the Letters pages.

There is no shortage of material to publish, but the enquiries do indicate that a large number of potential contributors are holding back, and that new blood to top up the bank of established authors is congealing in silence.

Perhaps these dark fears can be dispelled. A short note giving guidance to contributors appeared some time ago, but a great many people will not have seen it: a reiteration may not, therefore, be out of place.

First of all, please do not think that, because your writing style owes nothing to the great literary figures, your work will be rejected. It is a well-known fact that there are engineers and there are writers and not very often engineers who are also writers. The editorial team is perfectly happy to grind the sharp corners off awkward prose, to translate stilted English into the readable variety and to correct spelling and punctuation. The essential requirement is that the submitted piece should contain *all* necessary information, including details of any difficult to obtain components, if the piece is a design for construction.

This is not to say that authors should not take the trouble to write good English – we cheer when a good, readable article comes in – but we can cope with writing that needs improvement. And please, do not imagine that polysyllables and a passive writing style is needed. Formality may have its place in company reports (though even then, it makes heavy reading), but in *Wireless World* we prefer the simple style, the active voice and the minimum of the 'it can be seen that' kind of remark. The function of technical writing is to explain, not to demonstrate the author's knowledge.

Drawings must be clear, but not necessarily masterpieces of draughtsmanship: if they are readable, that is all we ask. Photographs can be slides, glossy prints or negatives. To be helpful, illustrations and captions are better separated from the text, which ideally should be typed double-spaced with wide margins to allow room for our annotations and printer's instructions.

The comment on published work often seen in letters from readers need not be taken as a direct attack on one's ancestry and prospects for the after-life – the letters usually contain useful information and are quite impersonal (on the whole, at any rate) often offering very worthwhile suggestions for improvement or containing comment which clarifies obscurities in the original piece.

Articles published in *Wireless World* are, or should be, interesting, informative, instructive and entertaining. If yours is one or all of these, do not hang back – let us have a look: you have nothing to lose.

Communicating pictures

In the UK there has been considerable soul-searching over the award of 12 interim cable tv licences to 37 applicants. Similarly, the IBA is required by Parliament to pursue what some people regard as a long and tortuous path in awarding the ITV and ILR programme contracts. But at least the UK has not yet had to face up to the mammoth number of applications flooding into the FCC in respect of "low-power television", "multi-channel multipoint distribution service", over-air "subscription tv", plus all those who see a viable future in direct broadcast satellites, high-definition television, "instructional tv fixed service", "satellite master-antenna systems", teletext, videotext, electronic mail and the like.

FCC already face a backlog of about 8000 low-power tv applications to run virtually de-regulated "secondary status" tv stations limited to 10 watts transmitter power on u.h.f. and 1kW on v.h.f. Many of the applications are to change current low-power, transposer-type, gap-filling relay stations to permit insertion of local programme material. To try and clear some of the backlog FCC have instituted a form of "lottery" to pick winners for popular areas, though based on the idea of giving those applicants who meet most closely the desired criteria more "chance" of being drawn out of the hat than others – a concept that might not go down too well in the UK. The lottery is "rigged" to favour applications that promote minority ownership and diversity. Like a roulette wheel, some numbers are more likely to turn up! There are also over 20,000 applicants for a limited number of MMDS frequency channels. This technique, fast rivalling cable, uses omnidirectional microwave (2 GHz) transmitters, often in conjunction with satellite feeds, to send video or other services direct to subscribers. It is regarded by FCC as a "common-carrier" system. FCC have been allocating only two MMDS channels to any given market, but has been pressurised to increase this to 14 channels in each of the "top 50" markets.

More homes

Distribution of tv and radio programmes over dedicated distribution satellites, initially to provide feeds for cable systems, is rapidly extending in the USA to all multipoint services, including major tv networks who until recently have remained faithful to long-established terrestrial microwave links. Television receive-only dish aerials are located alongside many American stations, including over 500 commercial tv stations, several with more than one dish to receive from different satellites, and many more than this are installed for the cable networks.

Despite the large increase in American subscribers to cable tv, from about 7 million to over 30 million in the past ten years, the effect on audiences for broadcast tv from the network affiliate and independent stations has been far less than predicted. One reason for this is the continued increase in the total of American "tv homes", known as "HUT" (homes using tv). In the past decade this has risen from about 65 million to well over 80 million. One result is that network tv has been achieving its largest audiences ever with, for example, the final episode of M.A.S.H. on February 28, 1983, reaching the first-ever national audience of over 50-million viewers.

The reasons for the continued increase in tv homes in the USA – a rate of increase far greater than in the UK – appears to reflect a smaller average size of households rather than growth of total population. The average size of households has dropped by about 12 per cent in the past decade and is now only two-thirds the size it was in the 1930s. Three main factors account for this: the declining birth-rate; fewer old people living with grown-up children; and an 80 per cent increase in the past decade of "single parent families" reflecting the high divorce rate. These factors have had the unanticipated effect of cushioning the commercial broadcasters against audience fragmentation by cable, as well as having a significant impact on the American consumer electronics market.

In the UK, tv licence totals at the end of September 1983 were: black-and-white 3,575,234; colour 14,925,023; old people's homes 539,000; and dealers' demonstration 20,000. This gives a UK HUT of approximately 19 million, plus the unknown number of licence evaders. At the end of 1972 the corresponding figures were: colour 2,815,703; black-and-white 14,182,880 and a HUT of roughly 17.2 million, plus the licence evaders. Both in the USA and UK there has, of course, been a large increase in the number of multi-set homes.

Sensitive at 3 mm

A cooled 75-95 GHz receiver built at Helsinki University for use with the Finnish 13.7-m diameter radiotelescope of very high profile accuracy is believed to be one of the most sensitive millimetric receivers so far built for use at wavelengths of the order of 3mm.

The double-sideband noise temperature, when used as a continuum receiver with a bandwidth of 500MHz, is about 100 K. Since no provision is made for rejection of the image band, the s.s.b. noise temperature for spectral line observations is rather over 200 K.

The front-end comprises a Schottky mixer-diode chip and 1.4 GHz i.f. amplifier cooled to 20K with a closed-cycle helium refrigerator. The i.f. amplifier, provided by the University of Massachusetts, uses two Mitsubishi MGF 1412 GaAs fet devices with a noise temperature of about 50K at room temperature and 12 K when cooled to 20 K. The local oscillator is a klystron.

Secretly on satellite

Portable communications equipment displayed recently on Russian television is further evidence of the growing use of satellite systems for long-distance clandestine communications. The American-made equipment included a keyboard transmission system apparently for enciphering and sending text in high-speed bursts. The equipment was seized by the Russians from an English "journalist" shot dead while using the identity "Stuart Bodman" inside Afghanistan on what would appear to have been a freelance mission on behalf of an American intelligence agency. Similarly, a few months ago an American diplomat was expelled from the USSR after it was alleged that he was caught communicating via satellite from his car. The portable communications equipment, believed to have been manufactured by Motorola, appears to be much smaller and lighter than the man-pack satellite equipment made by Ferranti, based on work at the Royal Radar and Signals Establishment. A year or two ago an American communications engineer presented a conference paper suggesting that the two-way long-distance radio "wrist-watch" could move before long from the realms of tv spy dramas to reality.

However an indication that intelligence agencies still rely also on more traditional h.f. systems is evident from recent full-page advertisements in American amateur-radio journals seeking to recruit more technicians and operators for the CIA, proudly proclaiming itself to be "an equal opportunity employer."

The major advantage of using satellites for clandestine operation must be the restricted area from which the exact location of the ground equipment could be determined by means of direction-finding. Extremely compact and lightweight equipment would suffice to communicate via a low-orbit satellite but the equipment seized in Afghanistan must be approaching the practical limits with current technology for use with geo-stationary satellites.

The October Communications Commentary mentioned military interest in millimetric communcations in frequency bands of very high attenuation. This is underlined by the Norden 54 GHz omnidirectional radio system noted in "Jane's Military Communications 1983" developed "to take advantage of the signal-

COMMENTARY

hiding characteristics of this frequency band". With a restricted range of about 1.6km (omni-directional aerials at each end) it is claimed to reduce probability of interception or disruption by jamming. Norden also make hand-held 54 GHz equipment.

Giant space platforms

In the 1983 Shoenberg Memorial Lecture of the Royal Television Society, Dr Delbert Smith, an American lawyer with special interest in space communications, forecast the early demise of single-purpose satellites launched by expendable rockets and the development of multi-purpose space platforms the size of a couple of football pitches, each carrying a full range of telecommunications facilities and beaming down 40 channels of DBS television from large parabolic aerial dishes. The platforms, he believes, will be assembled in low orbit, using material brought up in the cargo bays of several Space Shuttle-type launchers. The assembled platforms would then be shot into geo-stationary orbit and serviced by unmanned repair vehicles, using complex robotics technology to replace complete transponders, and sent up from manned space laboratories. Just six large platforms could cater for virtually all telecommunications and tv requirements up to the end of the century.

But he also forecast the creation of new multinational corporations and the growth of specialised space insurance business. Attempts to "regulate" tv broadcasting across frontiers would fail and the concept of "prior consent" on the part of the target country could not be enforced, he believes. Voice of America, he hinted, are actively planning radio and tv satellite broadcasting to foreign countries. The platforms, with multiple ownership and privately funded, will challenge PTT and Intelsat-type telecommunications monopolies, and bring many legal problems to lawyers.

AMATEUR RADIO

First DBS news

What is being claimed as the "first ever" transmission of a regular radio new service intended for direct reception from space took place on October 15. This was launched by British radio amateurs using the callsign GB2RS via the special H1 channel (145.975 MHz) using s.s.b. (upper sideband).

The 15-minute bulletin was compiled jointly by David Gough, G6EFD, Kim Mair and Ron Broadbent, G3AAJ and recorded on tape by John Nelson, G4FRX. The tape was then transmitted by Graham Shirville, G3VZV of Milton Bryan, Bedfordshire.

Coverage area of Oscar 10 in its highly elliptical orbit varies with its position but typically these broadcasts should be receivable over much of Europe and Asia or alternatively in Europe and the eastern seaboard of North America. Reception reports of these Sunday morning and afternoon transmissions (times vary to suit orbital data) are needed and should be sent to RSGB or AMSAT UK, London E12 5EQ. Callsign is likely to change to GB2AUK.

Amateur radio provided emergency communications out of Grenada during the initial stages of the American invasion of the island. The DTI does not encourage UK amateurs to become involved in such communications and has reminded them that if they do receive emergency traffic on any occasion they should contact the Radio Regulatory Division (01-275 3000) before passing on any third party emergency messages to individuals or to the media.

The University of Surrey has estimated that during the two years in orbit of UOSAT some 5000 amateur, educational and professional ground stations have received data from the satellite. A booklet on UOSAT has recently been distributed to schools. The UOSAT team is currently building , to a tight timescale, a second satellite to develop the objectives of the first. Subject to acceptance of the proposals by NASA there is a possibility of a launch early in 1984.

G. Shirville, G3VZV, as a result of observations during a recent period of high activity by amateur television stations using 435 MHz, is convinced that serious mutual interference between the tv amateurs and those using 435 MHz as a satellite up-link frequency is unlikely to occur. There remains a potential problem with the Oscar 10 transponder which has a 436 MHz downlink.

More on "ten"?

The RSGB, concerned with intrusion by CB operators into the "exclusive" 28.0 to 29.7 MHz amateur band, is seeking to encourage more legal use of this band during the forthcoming period of low solar activity. From about 1984-87, reliable long-distance contacts via ionospheric reflection are likely to be possible only rarely; nevertheless the band remains entirely suitable for down-links from amateur satellites; for medium-distance contacts using Sporadic E layers; auroral reflection; and by meteor scatter. It can also be used for extended-range and short-range fixed and mobile communications, on ground wave or by using ducts, etc. Efforts are being made to introduce a band plan that includes a degree of channelling for narrow-band frequency modulation, including provision for 29 MHz repeaters. Despite declining solar activity this winter has seen good "openings" on 28 MHz with 14 beacons, including one in Antartica audible on October 28.

Ageless Morse?

The minority of British Class B licensees who have been lobbying to eliminate the Morse test as an essential qualification for h.f. operation continue to seize every opportunity of putting their case and ignoring all counter-arguments. One wonders what they will make of the decision of the French authorities to issue F6 licences valid for h.f. without an obligatory Morse test – but only to persons over 65 years of age. The American ARRL, the largest of the national societies, remains adamant that "It is *wrong* to eliminate the Morse Code requirement in the Amateur Service".

Here and there

Clive Elliot, G4MBS (ex-G8ADP) who pioneered the use of rain-scatter on 10 GHz for amateur contacts, can now operate mobile or stationary-mobile in all-weather conditions and from convenient high sites by means of a permanently-equipped ex-Army Land Rover. This has a roof-mounted 2.5ft dish aerial controlled from the driver's seat using an aeronautical compass.

The experimental 144 MHz s.s.b. (pilot carrier) repeater, GB3SF, to be located at Sheffield has now been licensed on an experimental basis for one year. The input and output frequencies are 10 kHz on the h.f. side of the R7 repeater channel (145.185 MHz and 145.785 MHz). The frequency off-set is intended to minimise interference to n.b.f.m. repeaters or other users.

RSGM membership at June 30, 1983 totalled 33,868 compared with 32,215 the year before; however, the increase of 1653 required 5498 new members . . . The British Amateur Television Club is to hold its 1984 Convention on May 20 at a larger Post House Hotel complex at Crick, near Rugby . . . Amateur tv activity on the 23cm band appears to be increasing . . . I. Waters, G8ADE has developed an extremely sensitive detector of 15,625 kHz line sync pulses, even when buried under noise, to provide an audible automatic alarm system to monitor for amateur tv activity . . . The British Amateur Radio Teleprinter Group now provides information on Prestel, British Telecom's viewdata service. Page number 8008 2001 . . . A Korean radio amateur, HL1LJ, was a member of the crew of the Boeing 747 (Flight 007) shot down in the Far East.

PAT HAWKER, G3VA

Computer-controlled XY plotter

An alternative to expensive, commercial plotters, which is made from easily obtained materials and exhibits a very high performance. Resolution is around 0.002in per step and total cost is less than £100

by P. N. C. Hill

The microcomputer is rapidly becoming an essential tool for many engineers. It can be used to perform calculations and repetitive tasks and to help in decision making by detailed analysis of data. However, to do this it must be able to communicate with the outside world. Half the battle is to represent the machine's output in a way which is understandable to humans. It is true to say that a picture paints a thousand words; it is for this reason that an XY plotter is such a useful computer peripheral.

The cost of such a piece of equipment is way beyond the budget of most amateur constructors, so an alternative was sought.

The principle is simple enough: two precision stepper motors move a pen over a sheet of paper. One controls the movement in the X direction whilst the other controls the movement in the Y direction. A facility to lift and drop the pen onto the paper is also added to enable unconnected lines to be drawn. An interface is also included so that the computer can control the movements of the pen.

Stepper motors

The stepper motors form the central part of the project. Because of this they must be good quality precision motors with sufficient torque to move the pen without slipping or missing steps. A pair of 12V, 200 step-per-revolution, 25oz. in. motors were used in the prototype, purchased from Stewart of Reading at £12 each as second-hand but unused. The cost of new motors is not really justified, as I have been quoted £60 for motors of this type. An alternative source may be scrapped computer peripherals such as printers, disc drives, etc.

The motors used were of the four-pole variety and so have no permanent-magnet rotor. The rotor can be made to rotate by successively energizing each of the four coils in turn, stepping round to face each of the energized coils.

Although the positioning of the coils and the shape of the rotor allow 200 positions per revolution to be obtained by this method, it can be seen that, if two adjacent coils are energized in the following sequence, 1, 1+2, 2, 2+3, 3,... then 400 steps per revolution are obtained. This, combined with a pulley drive wheel of 0.8in circumference, gives a theoretical resolution of 0.002 in per step. The positioning of the pen is not repeatable to this accuracy but the resolution is greater than the thickness of the pen so perfect curves can be drawn.

Motor-drive

The operation of stepper motors is by no means straight-forward, as the inductance of the windings combined with the mass of the rotor and associated resonances limit the maximum slip-free acceleration rate, as well as the maximum (and in some cases minimum) step rate.

To achieve the best possible performance from a given motor the driver characteristics must be tailored to suit the requirements of the motor. If the manufacturers' data is available this task is made considerably easier. However, in the case of the second-hand motors, no data was available, so that trial and error methods had to suffice.

Each motor has four phases and so four identical drivers. The circuit for each of these is shown in Fig. 2. Tr_1 and Tr_2 operate in one of three modes: cutoff, saturation or conduction of a small holding current. The power dissipation in the output transistors is therefore kept to a minimum so no heat sink is required. The open collector t.t.l. buffer, B_1, will ground the base of Tr_1 when its output is low. This will put both transistors into cutoff. When the buffer output is high, current flows into the base of Tr_1 via R_1 and R_2 so saturating both transistors. If, however, the output of B_2 is low then some of the current that would have flowed into the

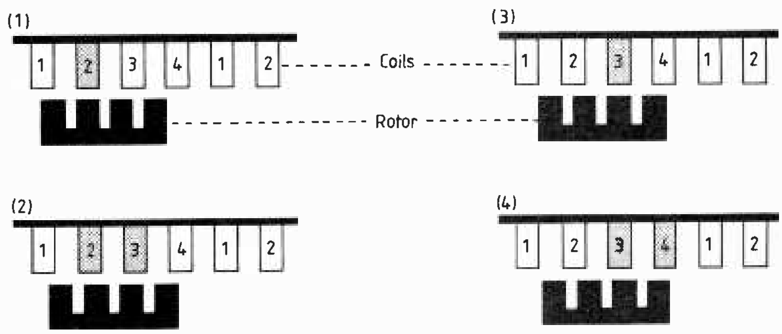


Fig. 1. Internal configuration of a typical four-pole stepper motor. The sequence shows how the half stepping is achieved.

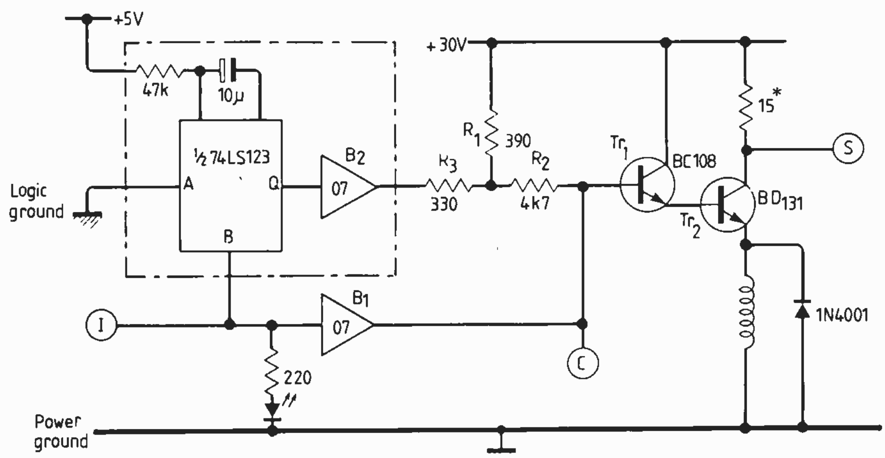


Fig. 2. Motor driver circuit. The enclosed section is required only once for each motor.

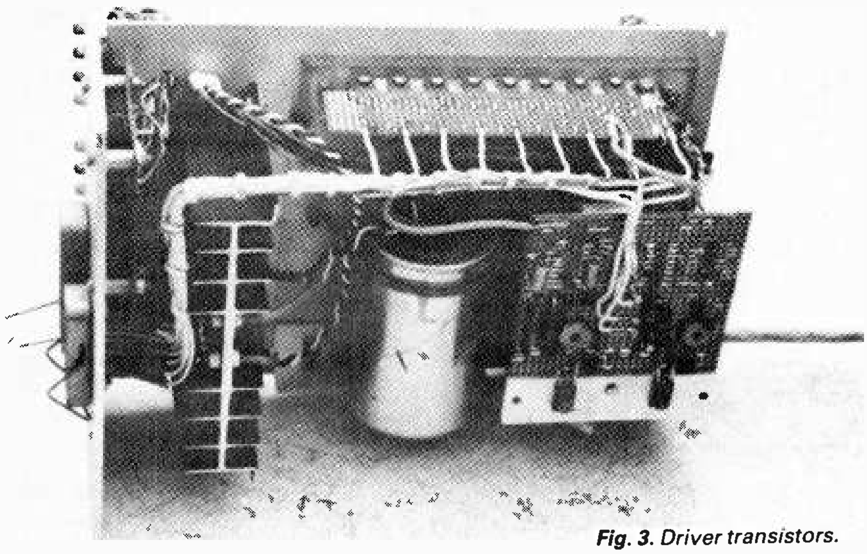


Fig. 3. Driver transistors.

base of Tr_2 is taken by R_3. This causes a small quiescent current of about 100mA to flow in the stepper motor coil. The ohmic heating in the motor windings is drastically reduced, whilst the low current ensures that the motors do not continue to turn after each step because of momentum. It is the monostable associated with each motor drive circuit that controls the state of B_2 output. Only when a step command is issued is the monostable triggered to deliver a short (100ms) pulse.

The relatively high supply voltage of 30V ensures that the back e.m.f. induced in the motor's coils is quickly overcome whilst the current pulsing ensures that ohmic heating is kept on a minimum. By adjusting the current pulse width and the relationship between R_1, R_2, R_3, the optimum preformance can be obtained from the stepper motor.

Driver current limit

The driver circuit was designed to be usable with almost any four-pole stepper motor, as it was intended to use the finished product as a piece of test equipment for future projects using stepper motors. It was partly for this reason that protective circuitry was included to prevent damage due to shorted outputs etc. Figure 4 shows how this was done. The op-amp ensures that a sharp cutoff is obtained when the current threshold is reached.

Control circuitry

As was mentioned before, the sequence in which the current is switched in the coils controls the direction of movement of the motor. Figure 5 shows the required sequence for the four-pole stepper motors. It is simple in nature, but it must be possible to stop at any point and then reverse the process so that the motors can move both forward and backwards. The first thought, as regards the implementation, was to use an up-down counter with combinational logic converting the three-bit binary output into the correct signals to control the driver stages. However, the realisation of this is excessively complicated and requires far too many chips to be practical, particularly as two such control circuits are needed.

The control circuit obviously has eight outputs (four for each motor) so a sequential circuit built with an eight bit r.o.m. would be suitable.

A rom can be used as a sequential controller by connecting its outputs back to some of its inputs via an edge-triggered latch. Each time the latch is triggered the present state of the outputs is fed back to the inputs. The new state of the outputs then depends on the contents of the rom at the location addressed. Figure 6 shows the block diagram of a typical rom-based controller system.

Controller implementation

The implementation of both motor controllers in one eight-bit rom is slightly more involved. Both must operate independently despite the coding for each being in the same area of memory, the contents of the coding for each being in the same area of memory. The contents of each memory cell can be represented by a two-digit hex. number. The left hand digit thus refers to one of the controllers whilst the right hand digit refers to the other. Each byte of memory thus consists of two unconnected nibbles of data. The coding is arranged so that each controller can operate totally independently, and the code must actually take care of all possible states of one controller for every state of the other. The result is one kilobyte of code, the listing of which is given in Appendix 1.

Figure 8 shows the controller circuit. The two address lines A8, A9 are used as direction control inputs. Outputs from the latches are connected to the driver stages as described earlier. The facility to move the plotter manually is also included. The output of the 555 astable is gated to either or both of the clock inputs on the latches when the appropriate switches are closed, its frequency being decreased when the centre button on the front panel is depressed, so both fast and slow manual adjustment is possible.

Pen lift control

The pens can be lifted off the paper by energizing the electro-magnet concerned. Current pulsing is adopted here too to reduce ohmic heating. A short, high-current pulse ensures that the pen is lifted smartly off the paper where it is kept by a much lower holding current. The circuit is shown in Fig. 9, and the best performance is once again achieved by suitable choice of R_5, R_6 and the current pulse width.

Plotter mechanics

Two precision stepper motors form the basis of the plotter. However, if the mechanics of the plotter are inadequate then their resolution and repeatability are wasted.

Rather than move the pen in both the X and Y directions it is obviously very much easier to limit the movement to one of the directions whilst moving the paper in the other. Various slider mechanisms were tried, but all proved to limit the perform-

Coil 1	Coil 2	Coil 3	Coil 4
0	0	0	1
0	0	1	1
0	0	1	0
0	1	1	0
0	1	0	0
1	1	0	0
1	0	0	0
1	0	0	1

Reverse ↑ Forward ↓

Fig. 5. Sequence for energizing stepper motor windings.

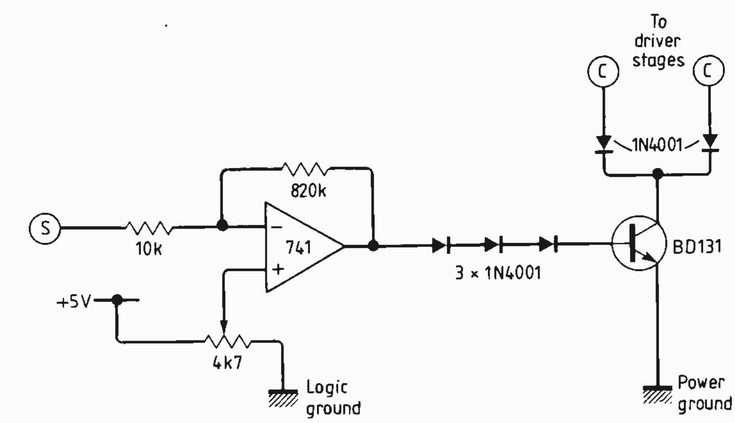


Fig. 4. Driver protection circuitry. RV_1 sets maximum output current.

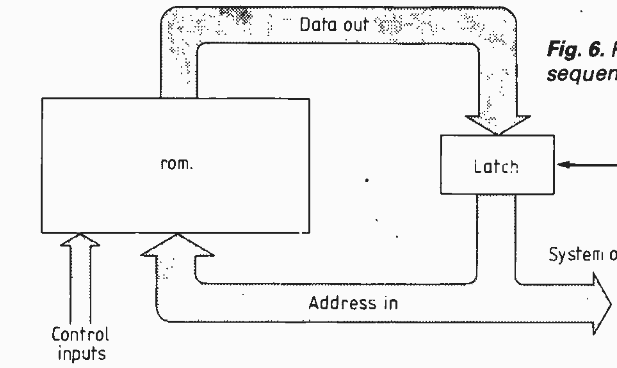


***Fig. 6.** Flow diagram of a simple rom sequential controller.*

Address	Data (reverse) A_4=0	Data (forward) A_4=1
0000....	0001 d	0001 d
0001	0011	1001
0010	0110	0011
0011	0010	0001
0100	1100	0110
0101	0001 d	0001 d
0110	0100	0010
0111	0001 d	0001 d
1000	1001	1100
1001	0001	1000
1010	0001 d	0001 d
1011	0001 d	0001 d
1100	1000	0100
1101	0001 d	0001 d
1110	0001 d	0001 d
1111	0001 d	0001 d

etc

***Fig. 7.** Rom coding for a simple, four-output sequencer. The four outputs are fed back to the four least significant address inputs via edge-triggered latches. Each time the latches are triggered the system moves onto the next state. A change from the forward to the reverse sequence is accomplished by changing the state of address line A_4.*

All locations marked 'd' are dummies and are never normally used. However they point back into the sequence to enable the system to be self-starting on power up.

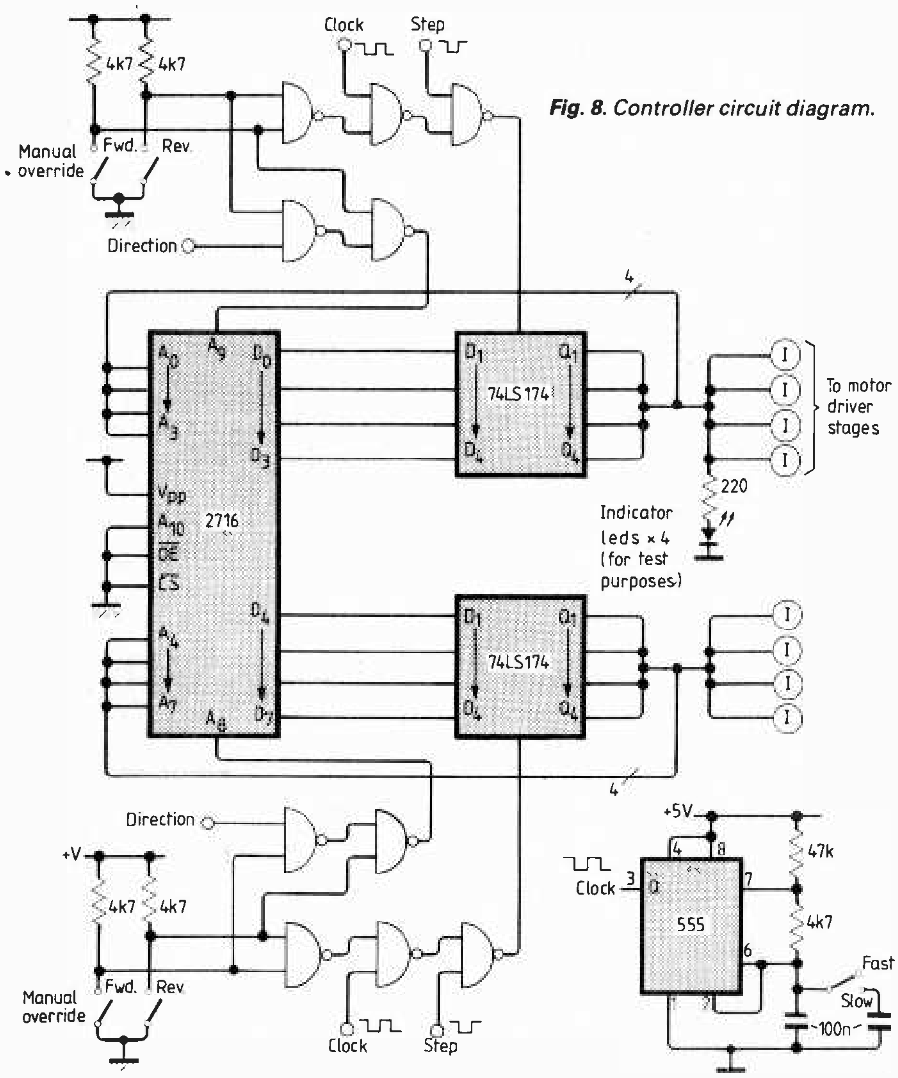


***Fig. 8.** Controller circuit diagram.*

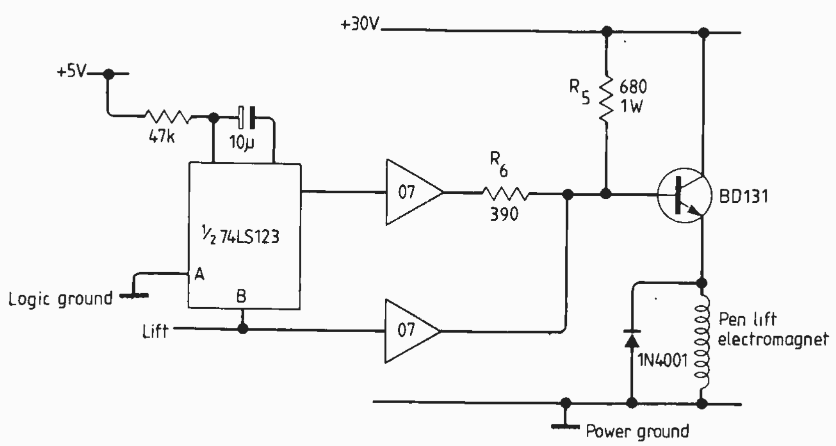


***Fig. 9.** Pen lift control electronics.*

ance of the plotter because of excessive friction. The simplest solution turned out to be the best: the principle can be seen in Fig. 11. The moving part of the slider rides on two ball-bearings which in turn rideon a narrower channel fied to the base of the machine. As the lower fixed partof the slider is narrower than the moving part, the ball-bearings move less relative to the upper channel than to the lower channel. This, in turn, means that the upper channel can be much shorter than the lower channel, making the entire plotter much more compact. The aluminium mouldings used were originally intended for use as curtain rails, of which several types are available, all of which conveniently differ slightly in size, so careful selection will be required. A local bicycle shop will doubtless be able to help with the ball-bearings. The resulting slider mechanism is ideal as both friction and stiction are very low, the only drawback being that the mechanism does not hold together when turned upside down!

The sliding trollies are kept upright by small wheels. A second channel and ball-bearings was not used as this would require very accurate alignment of both channels. The wheels run on a flat metal surface and are made from plastic (tap washers) so that they rotate rather than slide. Very small (¼in) ball races form the wheel bearings.

A flat Perspex sheet was used for the plotter bed. This has a sliding rail at one end and two sets of wheels at the other and is mounted in a metal tray which forms the base of the machine. The pen-carriage slider was then fixed on stilts above the plotter bed. The carriage then fits on above this so that it slides perpendicular to the movement of the bed. See Fig. 12.

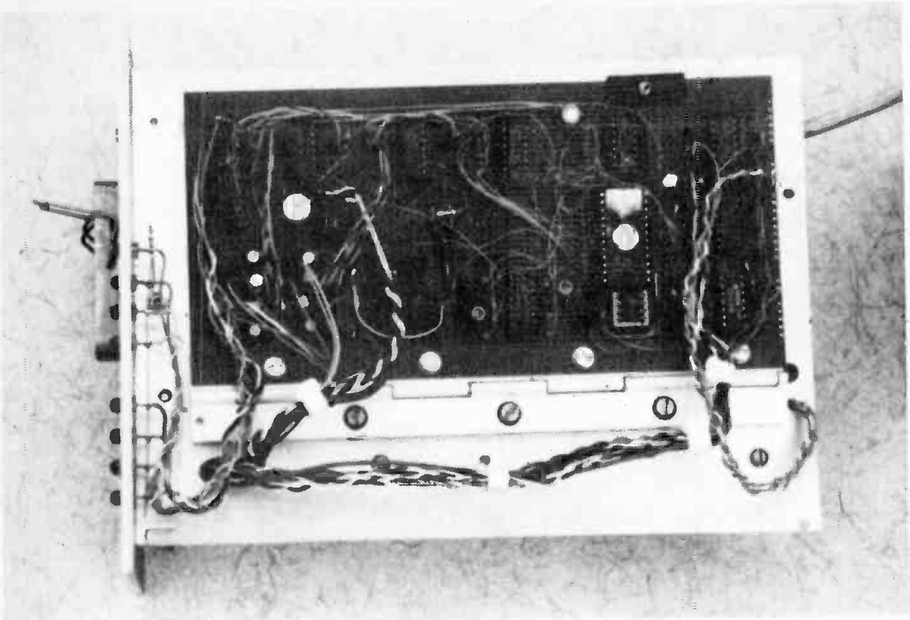


Fig. 10. Controller p.c.b. Interconnections are made with wire-wrap wire from pins on the component side.

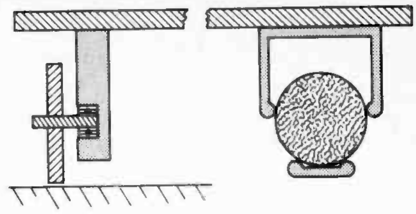


Fig. 11. Slider mechanism. Two ball-bearings are used in each slider.

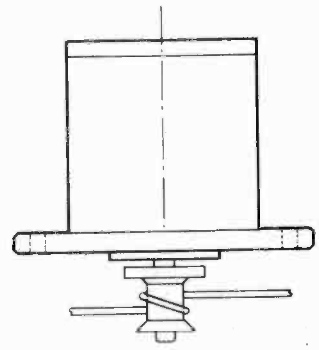


Fig. 13. Shows the pulley and thread arrangement for one of the stepper motors.

Stepper-motor mountings

The motors are mounted on the carriages which they move so that there is sufficient weight to keep the ball-bearing sliders in place. This extra weight limits the acceleration of the plotter and so the average plotting speed. However, it does not affect resolution or repeatability. The motors drive small flat pulleys round which is wrapped a thin piece of thread (cotton button-hole thread works best) which is kept in tension by a small stiff spring at one end. These pulleys must be of accurately known circumference if scaled plots are required. Figure 13 shows the suggested profile. To prevent slipping, the active area should be lightly knurled, and it should also be noted that in order to prevent the carriage twisting, the pulley and thread should be close to the ball-bearing slider. The wires running to the motors can be fairly thin and flexible so that they do not hinder the movement of the carriage.

Pen and pen mounting

Several types of marker were tried but none were ideal. Felt- and fibre-tipped pens produced lines of different thickness, depending on drawing speed. Since the speed will vary according to the nature of the shape being drawn, these pens were unsuitable. Ball-pens all require pressure to function correctly but the resulting friction affects the plotter's performance. The best choice so far has been drawing pens of the Rotring kind, which do not blotch and produce lines of known constant thickness. However, they do clog if left with their caps off for any length of time.

The pens write on the paper under their own weight and are lifted off the paper by an electromagnet, the mechanics of which can be seen in Fig. 14 and in the photograph in Fig. 15. The pen screws into a metal ring which is soldered to the brass lever. Threaded collars can be bought from Rotring stockists as adapter rings.

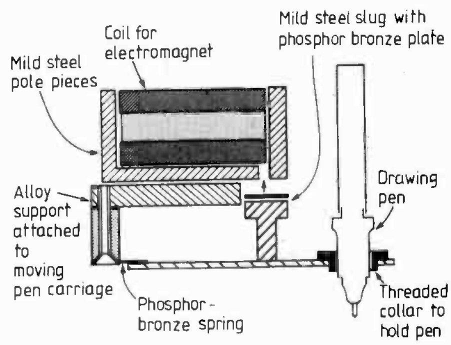


Fig. 14. Cross-section of pen lifting mechanism. More than one can be used to provide different coloured pens.

The mild steel slug is attracted to the poles of the electromagnet, but is prevented from making direct contact by a thin piece of phosphor-bronze soldered to its surface, to prevent a closed magnetic path from being formed, which would cause the slug to stick even when the power is switched off. To ensure that the pen is picked up smartly, the electromagnet is pulsed hard on for a few hundred milliseconds. The current is then reduced to a lower holding value to prevent overheating of the coil.

Computer interface

The computer is able to control every movement of the pen over the paper, but the problem comes when one has to describe to the computer what the picture required looks like. One of the most suitable languages is probably Forth, which is a control-based language, which is made for such applications. Words can be defined to perform specific rudimentary tasks such as line and arc or circle drawing.

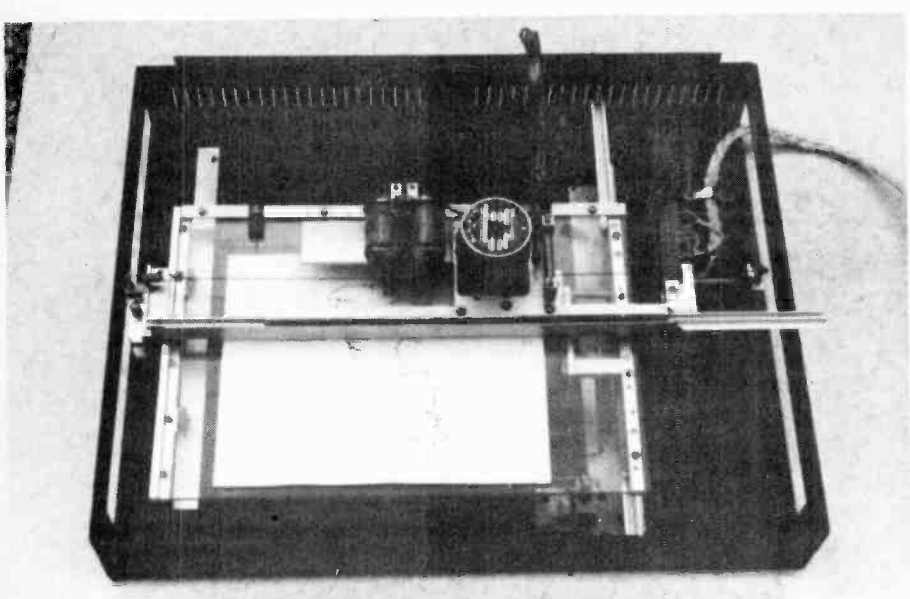


Fig. 12. Shows the completed plotter with a map of a well known country drawn on the machine earlier.

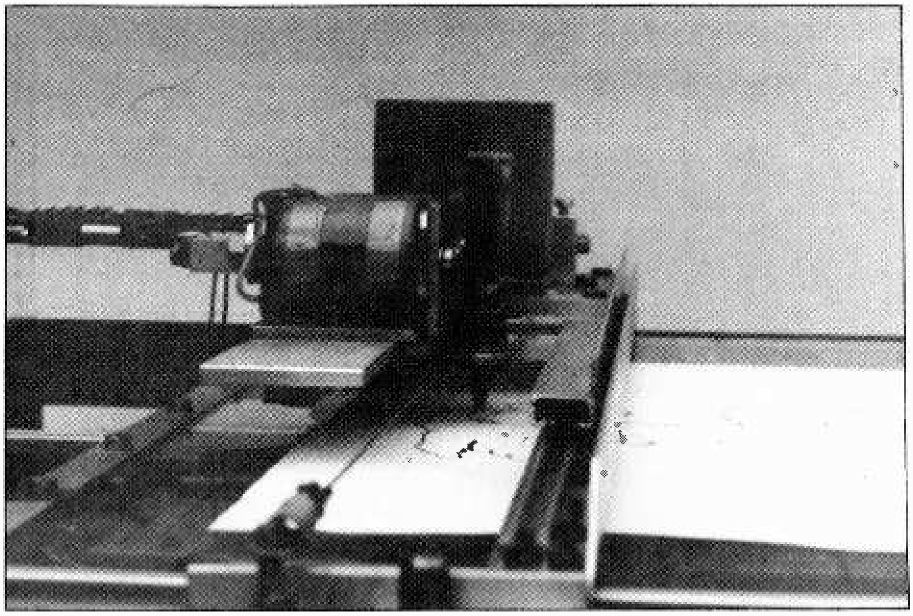


Fig. 15. The pen carriage with the lifting mechanism. The stepper motor is visible behind the pens.

Once these words are in the dictionary, they can be used as the building blocks for more complex words, which may do anything from drawing a square to plotting a map of the world.

The word used to draw straight lines might be given two parameters x,y. Execution will cause the pen to move from its current position to the point x,y relative to where it was before. The pen must draw the best possible approximation of a straight line and end up at exactly the point x,y. Failure to ensure the latter will lead to accumulating errors when x and y have no common factors. The easiest technique used so far is to approximate successively the gradient of the line being drawn to the required gradient. If the line is too steep then an extra step in the x direction is made. Conversely, if the line is too shallow then the pen is moved a step in the y direction. This is illustrated in Fig 16: the method is not perfect, so any suggestions would be most welcome.

The circle drawing word is more of a problem. If a floating point language is available, then a plot of x=SQR(r*r−y*y) will suffice. However, if an integer language such as Forth is being used, then all calculations must be done in fixed-point format, using a numerical method for the function evaluation. In order to avoid compounding errors all calculations should be done with sufficient accuracy (double precision arithmetic).

It is also important to ensure that every time the pen is moved a record of the number of steps moved is kept. This number is then subtracted from the required number to leave a fraction as a remainder. This is then added into the calculation following to ensure that errors do not accumulate.

Drawing alphanumerics

Although alphanumerics consist of a combination of curves and straight lines, a good character set can be made up by using straight lines only. This naturally makes the software very much easier.

The entire character set and more can be held in a few kilobytes of memory. Each pair of memory locations contain the x and y coordinates of the new position of the pen relative to its previous position. In addition various control codes are added to lift and drop the pen(s). For example, FFH and FEH can be used as control codes because it is unlikely that either will be used for coordinates.

Figures 17 and 18 show how one letter is coded. The entire ASCII character set can be coded in such a way with the least complicated characters taking up the least space in the memory table. Once the basic shape of all the characters has been recorded in the computer the software which uses the data to move the pen can be made to manipulate the shapes of the characters.

Character spacing can be altered by moving the pen between each character. The line along which the characters are drawn can be rotated by using simple matrix algebra. Characters can be slanted to produce italics by manipulating the coordinates as follows: $x=x+c*y$. The larger the value of 'c', the more the character slopes.

The size and aspect ratio can be altered by multiplying the x and y coordinates by constants.

The artwork shown in Fig. 21 was partly drawn on the plotter. All the bus interconnections along the lines of memory chips were plotted as was the lettering. The individual connections at the end of the board and the thickened supply lines were drawn in later by hand. As the lettering indicates, the design is laterally reversed as this is the pattern seen from the component side which is naturally the easiest side from which to design. It would not be difficult

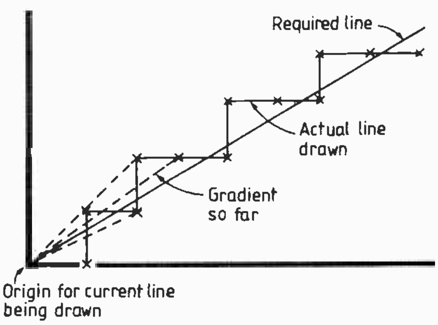


Fig. 16. Plotting a straight line by approximation of the gradient.

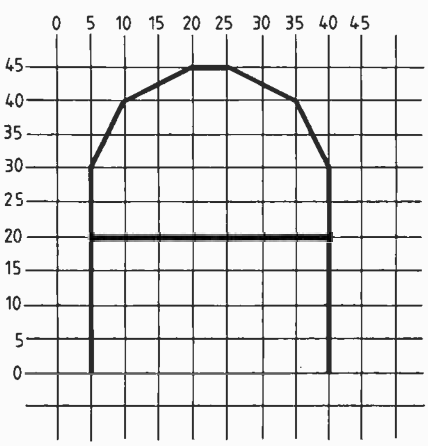


Fig. 17. Makeup of a character.

x coordinate	y coordinate	
5	0	Move to start of letter
255	255	Pen down
0	30	
5	10	
10	5	
5	0	Top of the letter
10	−5	
5	−10	
0	−10	
255	254	Pen up
−35	0	Move to start of horizontal
255	255	Pen down
35	0	Draw horizontal
0	−20	Complete the upright
255	254	Pen up
5	0	Move to start of next character

Fig. 18. Make-up of characters by approximation of shape with short straight lines. The table shows the required sequence to reproduce the letter 'A'.

ABCDEFGHIJKLMNOPQRSTUVWXYZ 1234567890

Fig. 19. An example of lettering drawn by the plotter. The alphabet was drawn with a resolution of 200 steps per revolution. The steps are just discernible.

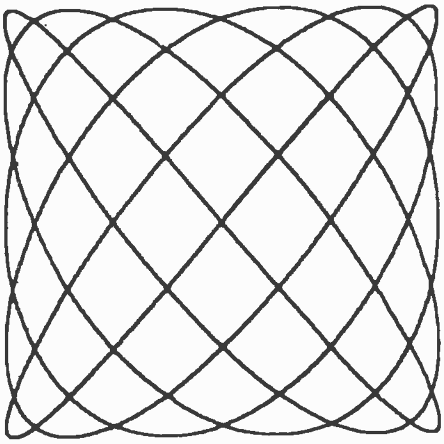


Fig. 20. Lissajous figure plotted from floating point Basic.

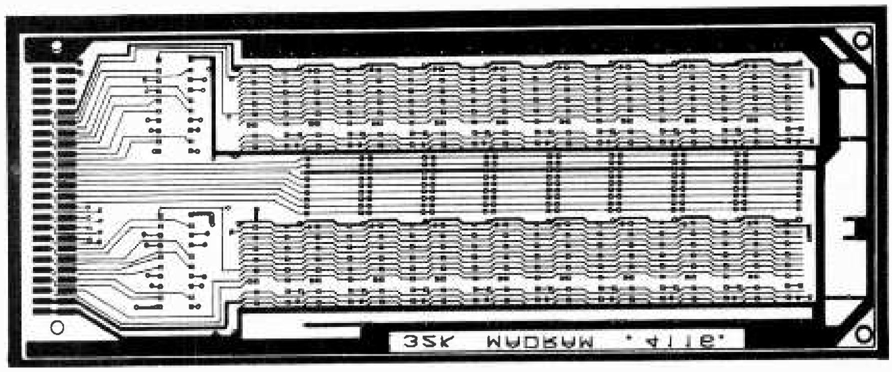


Fig. 21. Artwork for a memory board. All bus interconnections were drawn by the plotter.

to draw the design directly onto the bare copper board with etch resistant ink from one of the commonly available p.c.b. pens. However, this was not done, as photographic facilities were available at the time.

Copying diagrams

The map shown on the picture of the plotter in Fig 12, was copied from the back of a holiday brochure. The original was placed on the plotter bed and an empty pen was used as a pointer. The pen was then moved over the outline of the map under the control of a joystick and some simple software. The further the joystick was moved away from the centre position the larger each 'jump' was in that direction. The series of small straight lines was stored in the computer's memory in much the same way as for the alphanumeric character generator. When the collection of numbers was played back, again with much the same software as for the alphanumerics, the map was reproduced. The result could, of course, be manipulated in much the same way as the characters.

Some applications

Apart from plotting graphs and histograms it might at first appear that the plotter does not have many applications for the amateur enthusiast. However the applications are only limited by the ingenuity of the driving software.

Once a circuit has been perfected it is very often required to transfer it to a printed circuit board. This can be extremely tedious as the entire design must be drawn out and taped onto a sheet of drawing paper. The artwork is then usually photographically reduced and then transfered to the board by using photosensitive laquer. The operation is both time consuming and expensive.

The plotter can help by performing much of the tedious repetitive draughting work. Specific building blocks such as i.c. pads can be described to the computer in the same way as the alphanumeric characters. If a c.r.t.-based graphics display is available then this can be used to draw out and check the design of the board before it is plotted.

Appendix 1. Rom coding

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
7C00	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7C10	11	33	36	32	3C	11	34	11	39	31	11	11	38	11	11	11
7C20	11	63	66	62	6C	11	64	11	69	61	11	11	68	11	11	11
7C30	11	23	26	22	2C	11	24	11	29	21	11	11	28	11	11	11
7C40	11	C3	C6	C2	CC	11	C4	11	C9	C1	11	11	C8	11	11	11
7C50	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7C60	11	43	46	42	4C	11	44	11	49	41	11	11	48	11	11	11
7C70	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7C80	11	93	96	92	9C	11	94	11	99	91	11	11	98	11	11	11
7C90	11	13	16	12	1C	11	14	11	19	11	11	11	18	11	11	11
7CA0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7CB0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7CC0	11	83	86	82	8C	11	84	11	89	81	11	11	88	11	11	11
7CD0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7CE0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7CF0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7D00	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7D10	11	39	33	31	36	11	32	11	3C	38	11	11	34	11	11	11
7D20	11	69	63	61	66	11	62	11	6C	68	11	11	64	11	11	11
7D30	11	29	23	21	26	11	22	11	2C	28	11	11	24	11	11	11
7D40	11	C9	C3	C1	C6	11	C2	11	CC	C8	11	11	C4	11	11	11
7D50	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7D60	11	49	43	41	46	11	42	11	4C	48	11	11	44	11	11	11
7D70	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7D80	11	99	93	91	96	11	92	11	9C	98	11	11	94	11	11	11
7D90	11	19	13	11	16	11	12	11	1C	18	11	11	14	11	11	11
7DA0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7DB0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7DC0	11	89	83	81	86	11	82	11	8C	88	11	11	84	11	11	11
7DD0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7DE0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7DF0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7E00	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7E10	11	93	96	92	9C	11	94	11	99	91	11	11	98	11	11	11
7E20	11	33	36	32	3C	11	34	11	39	31	11	11	38	11	11	11
7E30	11	13	16	12	1C	11	14	11	19	11	11	11	18	11	11	11
7E40	11	63	66	62	6C	11	64	11	69	61	11	11	68	11	11	11
7E50	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7E60	11	23	26	22	2C	11	24	11	29	21	11	11	28	11	11	11
7E70	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7E80	11	C3	C6	C2	CC	11	C4	11	C9	C1	11	11	C8	11	11	11
7E90	11	83	86	82	8C	11	84	11	89	81	11	11	88	11	11	11
7EA0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7EB0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7EC0	11	43	46	42	4C	11	44	11	49	41	11	11	48	11	11	11
7ED0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7EE0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7EF0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7F00	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7F10	11	99	93	91	96	11	92	11	9C	98	11	11	94	11	11	11
7F20	11	39	33	31	36	11	32	11	3C	38	11	11	34	11	11	11
7F30	11	19	13	11	16	11	12	11	1C	18	11	11	14	11	11	11
7F40	11	69	63	61	66	11	62	11	6C	68	11	11	64	11	11	11
7F50	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7F60	11	29	23	21	26	11	22	11	2C	28	11	11	24	11	11	11
7F70	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7F80	11	C9	C3	C1	C6	11	C2	11	CC	C8	11	11	C4	11	11	11
7F90	11	89	83	81	86	11	82	11	8C	88	11	11	84	11	11	11
7FA0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7FB0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7FC0	11	49	43	41	46	11	42	11	4C	48	11	11	44	11	11	11
7FD0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7FE0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
7FF0	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11

Assembly language programming

Digital signals lend themselves to processing, but they can only signal two conditions and are, therefore, of limited use in the outside world. Analogue interfaces, the subject of Bob Coates' ninth tutorial, use a number of bits to sense or produce a signal with many possible voltage levels.

by R. F. Coates

Digital i.cs such as microprocessors recognize signals with two voltage levels representing either a one or a zero, but to be useful they often have to process and generate analogue signals with many different levels. Analogue interfaces are used for this purpose and they fall into two main categories; a digital-to-analogue converter, d-to-a, turns digital information from the processor into an analogue output signal with many levels, and an analogue-to-digital converter, or a-to-d, senses, analogue-input signals and turns them into digital information suitable for the microprocessor. Usually, analogue converters are separate i.cs but some microprocessors such as 'R' versions of the 6805 have built-in analogue converters.

Digital-to-analogue converters

Such converters turn a binary number represented by digital logic levels into an output voltage which is proportional to the weighting of the binary value. Most common i.cs used for this purpose take an eight-bit binary value and produce an analogue output at any one of 256 discrete levels (2^8). An 'R-2R' ladder network similar to the two-bit version shown in Fig. 1 is usually used. Here the two digital inputs b_0 and b_1 drive transistor circuits whose outputs switch between 0 and 5V supply rails on receiving a logical zero or one respectively. When both inputs are at zero, the equivalent circuit Fig. 2(a) shows that the output is about 1.25V. With respect to accuracy, the value R is unimportant but the resistors must be matched. If input b_0 is taken to logical one, the output becomes half the supply voltage as equivalent circuit Fig. 2(b) shows. With b_0 at zero and b_1 at one, the output is 3.75V, Fig. 2(c), and with both inputs at logical one, the output is the same as the supply voltage, Fig. 2(d).

This principle, using two digital inputs with four possible binary values to give four output-voltage levels, can be extended to produce an 8-bit d-to-a with 256 possible output levels. Circuits of Fig. 2 assume no output loading and in practice such converters are usually followed by an op-amp buffer to ensure that the resistor network is not loaded.

Picotutor analogue board

An analogue interface board designed for Picotutor around Ferranti's ZN425E i.c. was described in the January 1983 issue of *Wireless World*, pp. 70-72. Its circuit diagram shows the eight data lines that connect to Picotutor port A lines and an op-amp that serves to buffer the converter and multiply the output voltage by two. Instead of the R-2R ladder being fed directly from the 5V supply rail, which may not be accurately regulated, the ZN425 has its own regulated ladder feed which is typically 2.55V. Output range of the device is therefore 0 to 2.55V with steps of $2.55/2^8$ which is 10mV. The converter circuit is shown at the end of this article.

After setting up as prescribed under the heading Voltage generation in the January 1983 issue, operation of the board can be seen without having to write a program. First, port A lines must be set as outputs by keying in MO, 004, FF which sets the A data-direction register at address 004 to all ones. Press the down-arrow key until the port A data register address, 000, is reached. A voltmeter then connected to analogue board output will show that changing the contents of this address from 00 to FF will change the analogue output from 0V to 5.1V, provided that gain potentiometer R_3 is set correctly. Without

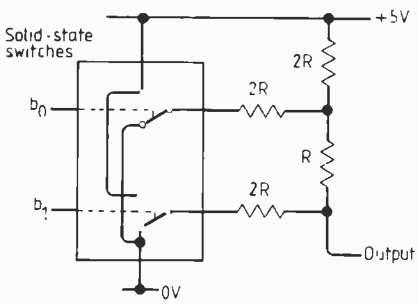


Fig. 1. Basic digital-to-analogue converter circuit. Two digital input bits, b_0 and b_1, are converted to one of four output levels using an R-2R network. Bit b_0 is the least-significant digit of a binary word and b_1 is the most significant.

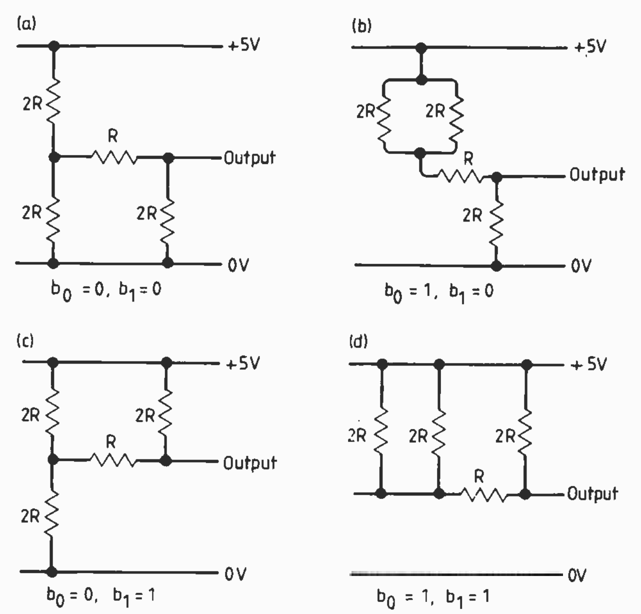


Fig. 2. Equivalent circuits of the network shown in Fig. 1 for the four input permutations.

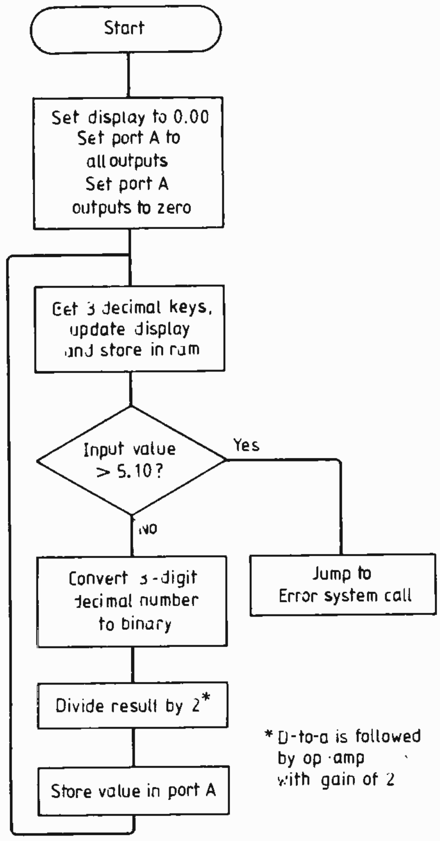


Fig. 3. Picotutor contains a program for converting three decimal digits entered on the keypad to binary form. This binary value is sent to the digital-to-analogue converter board through port A.

writing a program though, the output voltage has to be set using binary numbers as opposed to decimal ones.

Voltage generator

There is a routine in the Picotutor monitor which allows decimal voltage values to be keyed in and appear at the analogue output. Access to this routine is through location 0CE which contains a jump to the actual routine. Three decimal digits are entered as one unit and two decimal places; these are converted to binary form and stored in the d-to-a converter by the program whose flow diagram is shown in Fig. 3. List 1 is assembled source code derived from the flow diagram. Display is initially cleared by CLRDIS and 0.00 placed on the right of the display. Port A is set for all outputs and at zero. At the start of the main loop, index register X is loaded with the address of the first display digit which is units-volts. System call THEX7 is then used. This call, not given in the list of system calls (see September 1983 issue), is similar to THEX but it only reads one key entry and if it is greater than seven, aborts to START. If the value is less than or equal to seven, the call stores the seven-segment equivalent in the effective address given by the index register, increments the index and returns with the decimal value of the key in the accumulator. If you wish to use the call in your own programs, it can be accessed at address 095. This value is then stored in ram address POINT.

We need the decimal point indication with this digit, which THEX7 will have turned off, so this is done next. THEX is then called to get the next two key entries, updating the display and returning with the two key entries in two accumulator nibbles; these are stored in POINT+1. POINT and POINT+1 should now contain a three-digit decimal value. The maximum output from the analogue board is 5.10V, so the program checks that the entered value is not greater than this. If so, the routine is left and a jump to ERROR displays the error message. Having decided that the entered value is within limits, it is now converted to binary by calling BCDBIN. The index register is first loaded with the address of some spare ram to receive the result. If bit C in the condition-code register is set on return from BCDBIN it means that one or both of the second or third digits was not a decimal digit but one of the A to F keys, which also results in an error. The valid binary value in 0,X and 1,X, is now divided by two by LSR0,X and ROR1,X which shifts the two 8-bit bytes right by one bit. This is because the ZN425E can only produce a maximum voltage of 2.55V and we are adding a ×2 gain amplifier to achieve a maximum output of 5.10V.

The binary value divided by two is stored in port A and passed on to the inputs of the ZN425E. The program then loops back to wait for the next value to be entered.

Analogue-to-digital conversion

These circuits allow a microprocessor to read an analogue voltage rather than generate one but the most common method of converting analogue signals to digital form uses a d-to-a converter and comparator, Fig. 4. Output from the d-to-a is taken to one of the comparator inputs and the voltage to be measured to the other input. Output of the comparator is taken to an input of the microcomputer. If the d-to-a output is less than the unknown voltage, the comparator output is low, and if greater than the unknown voltage it will be high. To determine the unknown voltage all that is needed, knowing what voltage output the d-to-a will give for a given digital input, is to perform the operation shown in Fig. 5.

Starting with zero output from the d-to-a, check to see if it exceeds the unknown, if not, increment the converter output voltage by one step and check again, and keep doing this until the d-to-a voltage exceeds the unknown one. The binary value driving the d-to-a converter is now approximately the same as the unknown voltage and can be read by the processor.

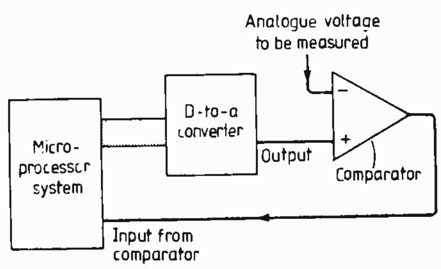


Fig. 4. Most common analogue-to-digital circuits use a digital-to-analogue converter and comparator as shown here.

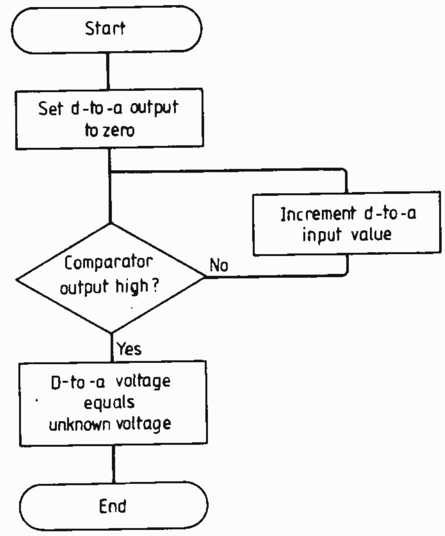


Fig. 5. Flow diagram for simple analogue-to-digital conversion. In this method, output from the converter is increased one step at a time from zero until the comparator switches.

On Picotutor, the analogue-board op-amp previously used as a buffer is now used as the comparator. With the analogue interface still connected as described for voltage generation, move S_1 to the a-to-d position (toward IC_2). This disconnects the op-amp feedback loop and connects its inverting input to the slider of R_2 and hence to the analogue-input terminal. An extra link is needed between the analogue-out pin and an input on the 68705. Any spare input would do but use the interrupt pin, int., for convenience. In this example the interrupt-request pin is used in a mode not available on most microprocessors. If the interrupt mask is set, the interrupt pin may be treated as a normal digital input, its state being tested by branch-if-interrupt-high/low instructions. If the analogue input pin is connected to +5V, the input voltage can be varied between 0 and +5V by adjusting R_2.

List 2 is an assembly language example for operating the a-to-d converter. It is based on the flow diagram of Fig. 5 but after having determined the voltage, the program stores its hexadecimal equivalent in the display, refreshes the display, then loops back and starts again. Adjusting R_2 while the program is running will cause the display to change. If R_2 is over half way though the display will blank (fully anticlockwise setting is +5V) because the ZN425E reference, and hence the maximum output, is only 2.55V. If the unknown voltage exceeds this level the interrupt line remains permanently low so the program gets stuck in loop 2 and never refreshes the display.

But there is a shortcoming in this simple algorithm. If the unknown voltage is low, then it finds a match fairly quickly, but if it is at full scale it will need to execute loop 2 256 times. This will take in the region of 3ms, which may not seem long, but means it is only possible to sample at a rate of 300Hz. If the a-to-d device could convert to 12 bits, this becomes 50ms and a maximum sample rate of 20Hz. As 12-bit a-to-d converters with a sampling frequency of

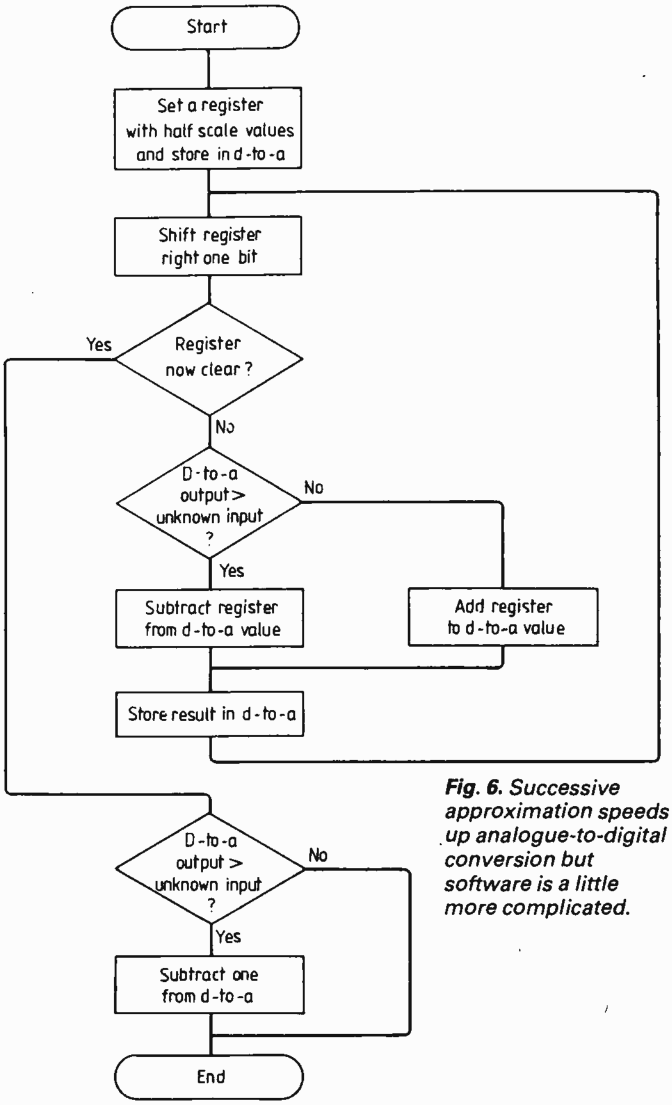


Fig. 6. Successive approximation speeds up analogue-to-digital conversion but software is a little more complicated.

List 1. Picotutor voltage-generator source list.

```
*
*
* V G E N  --  VOLTAGE GENERATOR. REQUIRES CONNECTION OF ANALOGUE
*              INTERFACE, D-A FORM
*
*
VGEN    JSR    CLRDIS    CLEAR DISPLAY
        LDA    #H'DF'     PUT "0." IN 4TH DISPLAY
        STA    DISBUF+3
        LDA    #H'DD'     PUT "0" IN 5TH & 6TH DISPLAYS
        STA    DISBUF+4
        STA    DISBUF+5
        LDA    #H'FF'     SET PORT A TO ALL O/P'S
        STA    PORTAD
        CLR    PORTA     SET O/P TO ZERO
*
VGLOOP  LDX    #DISBUF+3 POINT X AT 4TH DISPLAY DIGIT
        JSR    THEX7     GET HEX KEY IN DISPLAY, BUMP X, VALUE IN A
        STA    POINT     STORE KEY VALUE
        LOA    OISBUF+3
        ORA    #B'00000010' ADD D.P. TO DIGIT JUST PLACED IN DISPLAY
        STA    DISBUF+3
        JSR    THEX      GET IN NEXT TWO KEYS COMBINED
        STA    POINT+1
        LDA    POINT     NOW CHECK THE 3 ARE NOT >5.10
        CMP    #5
        BLS    CHECK1    BRANCH UNLESS 1ST IS >5
ERR     JMP    ERROR
CHECK1  BNE    CHECK2    IF NOT 5, MUST BE 0-4 SO CHECK NO MORE
        LDA    POINT+1   1ST = 5, SO CHECK NEXT 2 ARE NOT >10
        CMP    #H'10'
        BHI    ERR
*
CHECK2  LDX    #H'6E'     POINT X AT SPARE RAM
        JSR    BCDBIN    CONVERT ENTERED NUMBER TO BINARY
        BCS    ERR       IF CARRY SET, ONE OF THE DIGITS >9
        LSR    ,X        OIVIOE RESULT BY TWO
        ROR    1,X
        LDA    1,X       GET DIVIDED RESULT (8 BITS)
        STA    PORTA     SET UP O-A WITH IT
        BRA    VGLOOP    AND GET ANOTHER VOLTAGE ENTRY
```

25kHz are not uncommon, a better algorithm must be used.

Successive approximation

A successive approximation algorithm may be used to speed up conversion. This involves a succession of guesses, where the next guess is based on the results of the previous one. D-to-a converter output is set to half way and the comparator output checked. The check will either say that the guess was too high or too low. If, for instance it is too low, then the unknown voltage must be between half and full scale. Next the d-to-a output is set to half way between half and full output, and checked again. This process is repeated, each time halving the error, until the converter output is within one bit of the unknown voltage. The highest number of steps required to achieve this is the same as the number of bits of the converter, in this case eight. This means that the longest time required to make a measurement on Picotutor is only 100μs, and for an equivalent 12-bit converter the time would be 150μs, a clear improvement over 50 milliseconds.

Successive approximation is a technique which lends itself to working in binary. Consider the starting point for a conversion, with the converter set at half output. With an 8-bit converter, this means storing 1000 0000 in the d-to-a. Comparator output is then checked to see if the converter output is less than or greater than the unknown input voltage. If less, the next least-significant bit must be added to the d-to-a value to get the new value

$$\begin{array}{r} 1000\ 0000 \\ +0100\ 0000 \\ \hline 1100\ 0000 \end{array}$$

If it is greater, the next least-significant bit must be subtracted from the d-to-a value

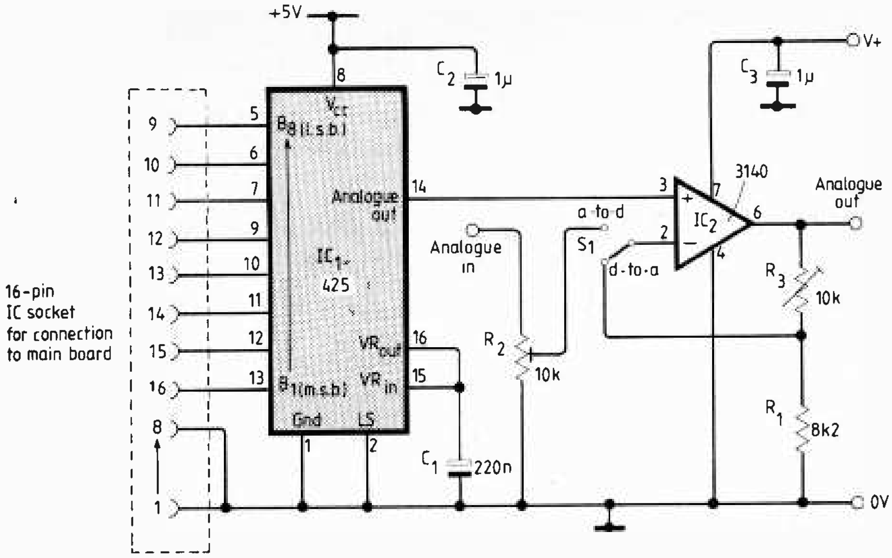
$$\begin{array}{r} 1000\ 0000 \\ -0100\ 0000 \\ \hline 0100\ 0000 \end{array}$$

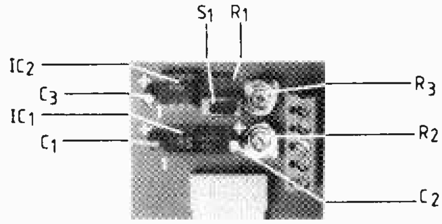
All that is necessary for a complete conversion is for the initial value to be repeatedly shifted right, and after each shift added to or subtracted from the value that the d-to-a is set to according to the result of the comparator test. This new value is stored back into the converter.

Figure 6 shows a flowchart for a conversion based on this technique. The main loop, for an 8-bit a-to-d converter, will be executed seven times; the last time a single bit in the rightmost position will be added to or subtracted from the d-to-a value giving a final resolution of ±1bit. To correctly set the last bit to zero or one, the comparator output is finally tested and one subtracted from the d-to-a if it is still too high.

Digital voltmeter

The digital voltmeter routine in the Picotutor monitor uses successive approximation. Added to the basic program though is the conversion from the 8-bit binary value to decimal, this being placed in the display with a decimal point in the correct place.





Circuit diagram of Picotutor's analogue interface which may be switched to operate as an a-to-d or d-to-a converter

List 2. Program for simple a-to-d conversion.

```
030   9B              SEI                 MASK INTERRUPTS
031   A6FF            LDA    #$FF         SET PORT A LINES AS O/P'S
033   B704            STA    PORTAD
035   BDB0            JSR    CLRDIS       CLEAR DISPLAY
037   3F00   LOOP1    CLR    PORTA        SET D-A TO ZERO
039   3C00   LOOP2    INC    PORTA        BUMPS UP D-A BY 1
03B   2EFC            BIL    LOOP2        BRANCH IF D-A VOLTAGE < UNKNOWN
03D   B600            LDA    PORTA        GET D-A VALUE
03F   BD9B            JSR    LSEG
041   B710            STA    DISBUF       STORE HEX DIGIT IN DISP. BUFF.
043   B600            LDA    PORTA
045   BD9E            JSR    RSEG
047   B711            STA    DISBUF+1     AND RIGHT HEX DIGIT
049   BD83            JSR    DISKEY       REFRESH DISPLAY
04B   20EA            BRA    LOOP1        AND REPEAT INDEFINITELY
```

List 3. Picotutor's d.v.m. program uses successive approximation.

```
*
*
* D V M  --   DIGITAL VOLTMETER.  REQUIRES CONNECTION OF
*             THE ANALOGUE INTERFACE CARD, A-D FORM
*
*
DVM     SEI                 SET INTERRUPT MASK
        LDA    #H'FF'         SET PORT A LINES TO O/P'S
        STA    PORTAD
        JSR    CLRDIS       CLEAR DISPLAY
LOOP    LDA    #H'80'         SET D-A FOR HALF F.S. O/P
        STA    PORTA
        STA    H'6E'          STORE ALSO IN A TEMP. REG.
SUCAP1  LSR    H'6E'          SHIFT RIGHT TEMP. REG.
        BCS    SUCAP4       IF CARRY SET, THEN 7 BITS HAVE BEEN SET SO FINISH
        LDA    PORTA        GET THE CURRENT D-A SET VALUE
        BIH    SUCAP2       IF INT LINE (ALOG COMP. O/P) IS HIGH, BRANCH
        ADD    H'6E'          INT LOW, INC D-A BY ADDING TEMP. REG.
        BRA    SUCAP3
*
SUCAP2  SUB    H'6E'          INT HIGH, DEC D-A BY SUBTRACTING TEMP. REG.
SUCAP3  STA    PORTA        SET D-A TO NEW VALUE
        BRA    SUCAP1       GO BACK & DO SAME WITH NLS BIT
*
SUCAP4  BIL    DISP         7 BITS SET, NOW SET 8TH
        DEC    PORTA        IF INT HIGH, DEC D-A. IF LOW, DON'T
DISP    CLR    POINT        PORT A CONTAINS 8 BIT CODE = ANALOG I/P
        LDA    PORTA        STORE IT IN POINT/+1
        STA    POINT+1
        LDX    #H'6E'         POINT X AT SPARE RAM
        JSR    BINBCD       CONVERT TO BCD
        LDA    ,X           GET MOST SIG OF THE 3 DIGIT BCD RESULT
        JSR    RSEG
        ORA    #2           ADD THE DECIMAL POINT
        STA    DISBUF       AND PUT IN DISPLAY
        LDA    1,X          GET THE OTHER 2 DIGITS
        JSR    LSEG         CONVERT MOST SIG TO 7 SEG
        STA    DISBUF+1     & STORE IN DISPLAY
        LDA    1,X          SAME WITH LEAST SIG
        JSR    RSEG
        STA    DISBUF+2
*
        LDX    #H'18'         CALL SR WHICH REFRESHES DISPLAY, H'18' TIMES
DISP1   JSR    DISKEY
        DEX
        BNE    DISP1
        BRA    LOOP
```

List 3 is an extract from the Picotutor source list showing the digital-voltmeter routine. After setting the interrupt mask, port A lines are set as outputs by storing FF in the data-direction register. You will notice here, and in List 1, that the method used to indicate hexadecimal numbers is different from that used by Motorola. Instead of \$FF, H FF is used. This is because the assembler used for this program was not produced by Motorola, but by Philips. Next the display is cleared and the main loop of the program is entered. The d-to-a converter is set for half value and a register at ram address 06E is also set with this value. This register is then shifted right, the current d-to-a value loaded into the accumulator; depending on the state of the interrupt line, the register is added to or subtracted from the accumulator and the result stored in the converter.

This loop, SUCAP1, is repeated until the bit that was originally set in bit 7 (H'80') has been shifted right through to bit 0 and into the carry bit of the condition-code register. When this carry bit is detected, the loop is terminated and execution continues at SUCAP4 where the last bit correction takes place. The binary d-to-a value is now converted to binary-coded decimal using system call BINBCD. This gives a three-digit result between 000 and 255 for the eight-bit binary input fed to it. Each digit is converted to seven-segment code, (the most significant one having the decimal point set on) and stored in the display buffer ram DISBUF. Finally DISKEY is called to light the display; it is in fact called a number of times to delay the program for about half a second before returning to LOOP to start a new conversion. If only one refresh was performed, samples would take place every 20ms which is a little too fast for a d.v.m. and could cause rapid flickering of the last digit if the voltage was half way between two digital values. Half a second is an adequate sampling rate in this sort of application.

Note that if the input voltage exceeds 2.55V, it will in fact give a full scale reading instead of blanking the display as in the previous example. An obvious refinement here would be to make the display give an over-range indication if the maximum value is exceeded.

To be continued

16-line p.a.b.x with options

With the basic exchange described, this third article concentrates on options including out-door telephone connection, call transfer, auxiliary-equipment switching, paging and self test.

by J. H. Kuiper

The section on call transfer outlined operation of the line-hold facility (ST relay switching). To provide 'music-on-hold' a tape recorder may be connected to $s_{1,2}$ contacts (normally closed) and an st contact used to start and stop the recorder. Frequency range of the recording should be limited to between 300 and 3400Hz to avoid interference with other callers and exchange circuits.

Ringer control

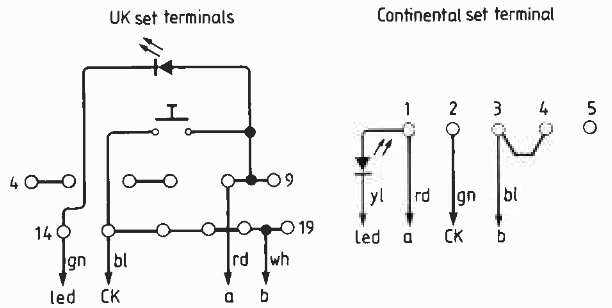
In the line interface a three-way switch and timer may be included to disconnect the ringer at certain periods, for instance each evening. Positions of the switch are normal, off and bypass; at all times visual indication is retained and dialling out is not affected.

Out-door connection

An outdoor telephone with electronic door-opener may be connected, which involves relays L, N door opener DO, terminator relay TD (oor) and contacts q_1 and q_2. All these are in the boxed section of the diagram. If this option is not required all boxed components may be omitted, but remember to strap the l_1 n.o. contact between the $\overline{g_3}$ bus and toggle. The g_3 bus is not required in this case. This option involves a special type of telephone so connection is different. As no calls originate from the door, ie, no dialling takes place there, and an originator relay is not required. Terminator relay TD will be assigned an easy to remember number at the driver outputs such as 11, or 1 in a small system. As it will also be undesirable to send ringer current to this telephone, the b-line has to be connected between ri_1 and the speech coupling capacitor while the a-line goes to ground through td_1 and n_1. Both positions are marked by an X. If the door telephone is a low-voltage type and ground is at 45V, a two-resistor voltage divider has to be included between td_1 and V_{ss} and the a-line connected to the junction of these resistors. Remember that reply relay R still has to operate from this lower voltage.

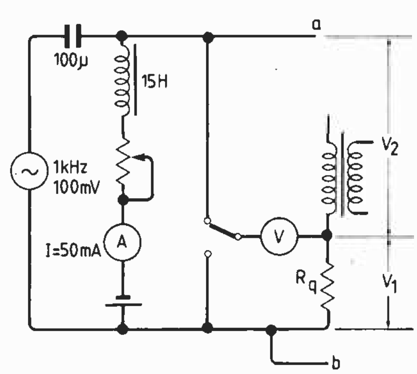
The circuit operates by dialling the door telephone, as described in the first section, when the doorbell is rung. TD acting switches td_1, which takes over the action of the called station lifting the handset in reply to the call, thus energizing R by completing a path from ground through n_1 to td_1, the door telephone and R coil to V_{ss}. Contact r_2 completes the speech path and further action of the r contacts is as for internal conversation. Contact td_2 disengages coil L which is normally powered so all ground keys operate relay DO instead of the toggle; operating the ground key will switch do_1 which may energize the door-lock.

Resetting is different in that this normally does not occur until both handsets are replaced or both II and R are in their off states. As the door telephone will have no handset to replace, relay N has been included. Replacing one handset disconnects II so ii_1, being off, will now provide power to N though td_2 which is still on. Contact n_1 disengages the door telephone and relay R to meet the standard reset requirements. Resetting now takes place as usual with N not resetting until td_2 switches off. In the event of an exchange call coming in while the ground keys are controlling DO and l_2 instead of the toggle, auto-switching will not take place (r_4 open) and manual access to the exchange line is impossible. Therefore internal circuits have to be reset first. Since finding out who's at the door normally does not take long this is not too serious. On the other hand when a station is on the exchange line another station may still answer the door through the (vacant) internal circuits. This is possible by q_1 offering an alternative path from the various ground keys to DO though all g_3 contacts. One contact being off and G_2 holding L operated retains access to the toggle through its g_3 and l_1 contacts in spite of td_2 switching the station connected to the exchange line.



Continental new	old
1	11 a
2	13 GK
3	10 b
4	9 EB
5	12 *

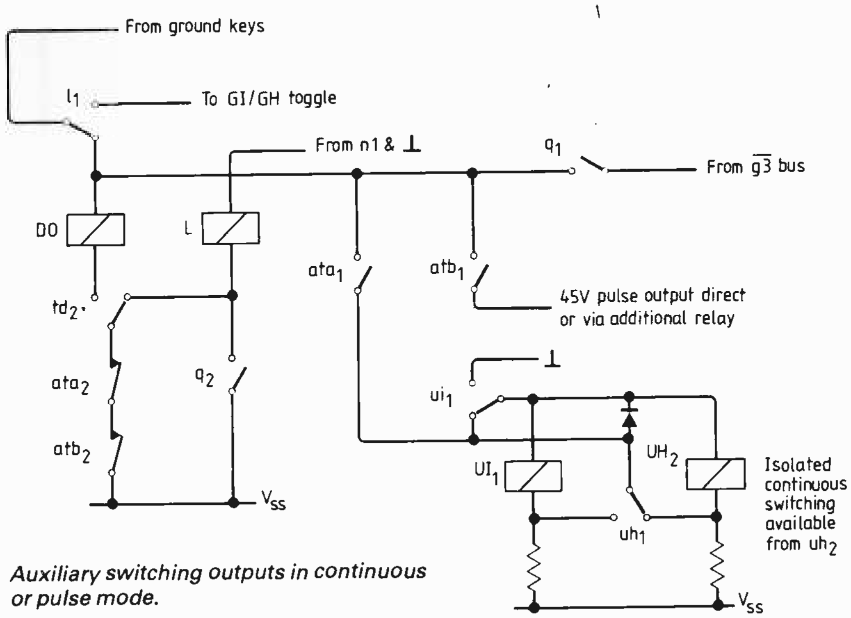
Modifications for connection of UK or Connection to public network for UK (left) and Continental sets. For UK sets, remove straps 5, 6, 17 and 18 in telephone. Change around green/white strap in terminal block and connect blue wire to tag five in telephone. In Continental telephones, change green wire from point two to point five and connect 'a' to the socket ground strap.



Test circuit for determination of rg value. Connect to line interface and select rg for $V_1=V_2$. Impedance is 600 ohms ±20%.

One person transfer

As mentioned in the description of call transfer, there are two ways of returning to the exchange line when in hold mode. The second method is used here so after having put the caller on hold put the handset down which among other things resets all q contacts as well as the G relay. Then go to the station where continuation of the conversation is required, lift the handset and operate the ground key. This procedure saves walking between two stations or



Auxiliary switching outputs in continuous or pulse mode.

the aid of someone who has to take the call first. Remember, leaving the original station off-hook prevents internal reset and thus further internal calling until that handset is replaced.

Switching auxiliary equipment

The above action once again involves use of the ground key section. If permanent switching of for instance a lamp is required, a toggle and auxiliary terminator relay, AT must be added. For momentary operation in pulse mode only an auxiliary terminator relay is required.

Circuit changes to the boxed door-opener section are shown in a separate diagram. Basically all outputs are taken from l_1 normally closed contacts through auxiliary normally open t contacts of which two are shown – ata_1 for permament action and atb_1 for pulse mode. Additional normally-closed auxiliary t contacts are required in series between td_2 and Vss. These are specified as ata_2 and atb_2 respectively. Various auxiliary T relay coil designated ATA, ATB, etc., are assigned a number and connected to the proper terminator-driver outputs. As each auxiliary circuit requires a connection in the terminator fewer stations can be hooked up since the total number is restricted to 16.

Upon dialling of the correct number, ringing tone will be heard as usual. Operating the ground key will now switch the auxiliary toggle to keep the output at l_1 normally-closed contacts at V+ as long as the key is held down. Toggled outputs may be dialled later and reset by once again operating the ground key. The isolated contact uh_2 may be used to switch a lamp or whatever appliance requiring continuous power. If total isolation of equipment connected to a momentary output is necessary an intermittent relay should be connected, its contact providing the desired isolation.

After the required switching action, resetting of the internal circuitry is as if no-reply has been obtained as no contact has been made to operate reply relay R. Operating conditions with respect to a possible exchange call being in progress are as for operation of the door opener section.

Switching of the relay contacts will also be as outlined for the door opener, with auxiliary terminator contacts 1 establishing the path for the ground key while contacts two will switch L with l_2 now preventing incorrect automatic switching of incoming calls.

Paging and self test

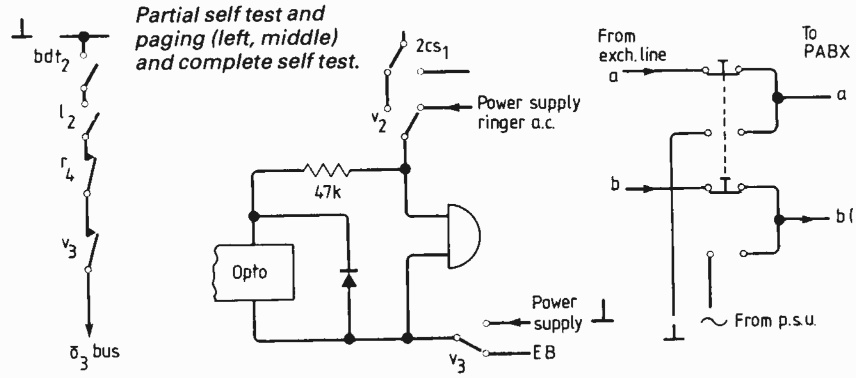
A sensible application for a momentary-pulse output as described in the last section would be connection of a V relay with three-pole change-over contacts. These contacts would power the external ringer in the line interface and simultaneously prevent a bell-detector pulse from incorrectly operating the circuits. When a caller is on hold, by operating the ground key a series of ringer pulses may be given to page a person who is not answering at his usual extension. Alternatively correct operation of the ringer and BDT may be checked if required. A separate diagram gives the details for inclusion of the three contacts. Variations such as switching the bell only are of course possible. If it is desired to test the entire line interface a local dp change-over pushbutton in the a and b exchange line is required. This should not be used for paging as operation disconnects the exchange line and therefore a local switch rather than a relay is used.

Note that with a caller on hold after having given a paging signal, re-access to the exchange line can now only be obtained by replacing the handset, picking it up again and then operating the ground key to reconnect the exchange line. The reason for this is that when in the hold mode all Q relays as well as the one G relay are off. After having dialled the number assigned to the paging output, L remains firmly off and re-operating the ground key immediately after now only produces another paging signal. Therefore resetting has to be initiated the alternative way before further action can be taken.

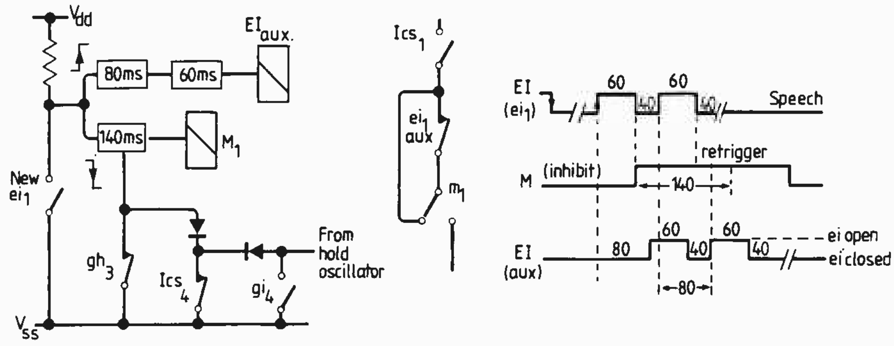
Two further points regarding equipment-status signalling are worth noting. When an outside call is in progress an internal call between two other stations may be made at the same time. When dialling the station having the outside conversation though, a busy signal will be returned to the caller. This happens because the engaged station T relay operates and since its g is already on, coil 2ENG will energize through g_1 and t_2. The audible signal is sent to the caller from $2eng_2$ now operating and the caller's o_2 on and g_2 contacts being off. Contact $2eng_1$ will start the engaged oscillator. Also when dialling one's own number an engaged signal will be produced as coil 2ENG powers through ir_1, the stations o_1, the diode and t_2. Contact $2eng_2$ blocks the ringing tone and instead connects the busy signal to o_2. Although T_1 connected ringer current from ri_1, o_2 blocks it from the telephone.

Connection to the public network

In addition to demands made regarding loading of the network, output levels and frequency range it is also required that the network must always remain accessible as they must in the event of power cuts or faults in privately owned equipment. This is accomplished by leaving the originally installed telephone in circuit so that it operates independently of the p.a.b.x. To avoid 'bell-tinkle', which might cause incorrect operation and is therefore not allowed, some re-wiring in accordance with BTT plan 1A is required. Both Continental and UK variants are shown. In a UK connection bells are connected in series and correct wiring requires the removal of straps between terminals five and six as well as 17 and 18 in the set and in the block terminal the b-EB strap between the green and white wire (if fitted) has to be turned. As the visual indication should remain operative when using a timer to disconnect the ringers, the opto-isolator has to be connected in parallel through the blue wire to tag five in the telephone. If one ringer in the original telephone is sufficient a wire-link has to be inserted in the



Partial self test and paging (left, middle) and complete self test.



Circuit changes in line interface and timing diagram for delayed dial pulse and muting sequence.

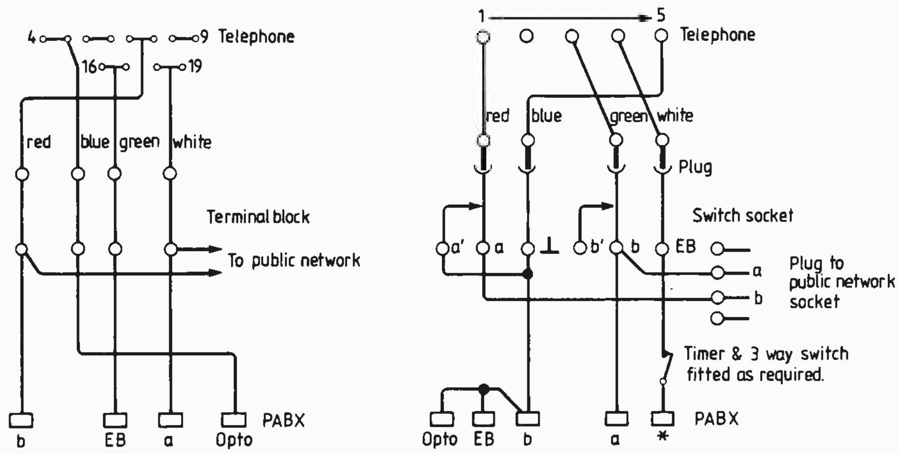
line interface in lieu of the bell. Thus when making a call either through the switchboard or directly from the original phone any ringer will be disconnected by one of the cradle switches operating.

In Continental sets on the other hand bells are connected in parallel and as in UK systems the unused speech circuit remains disconnected. Continental sets have an additional switch at terminal five in the line interface designated $2cs_2$. If in this case the additional ringer is not required it is simply not fitted. On the other hand the timer switch now requires an additional contact and the three-way switch has to be double-pole. Both have to be connected in the output from the p.a.b.x to the yellow wire, if two bells are fitted (asterisk on diagram).

Additionally the common use of four-prong plugs and switched sockets makes connection simple and it is sensible to simply add one of each and wire-up according to instructions in the diagram. In the telephone, the green wire has to be connected to tag five (or terminal 12 in old sets) and a wire-link has to be made between the points a and ground in the socket. Now plug the original telephone into the new socket and the cable with plug fitted from the p.a.b.x into the network socket. Unplugging the set connects a to a' and b to b' and vice versa. Plugging the telephone back into its original socket renders it operative as before without the need to change the green wire in the telephone back to terminal 2. If permament wiring has to be made, connect terminals a, b, ground and EB tags, ignoring the a' to ground wire-link. Connecting US sets is different again as in these instruments b and EB are internally connected and only a red and green wire appear, so extensive modification will probably be required. This was found to be true in particular when adding a memory dialler which required cutting of p.c.b. track to separate the bell wire.

Resistors R_e and R_f on the internal side of the line-isolating transformer are selected to provide balance and good audibility. Initially R_e should have a value roughly equal to a telephone, as if answering an internal call, and R_f is taken as approximately the coil value of the reply relay, both properly rated to dissipate the power.

As mentioned in the line-hold section, the frequency range of prerecorded music should be limited between 300 and 3400Hz. At 11kHz roll-off of around 30dB is required, and output level within the sound frequency band should not exceed $1V_{pk-pk}$. This level is measured across a 600Ω resistor (±1%) temporarily fitted between terminals a and b of the line interface. Adapting values of R_e and R_f should satisfy this requirement. Network loading has to be 600Ω ±20%. A test circuit for the determination of the required value of R_g (use a 1W type) is given. Measured values of V_1 and V_2 have to be equal in which case $z=R_g$. As the various results turned out to be more or less interdepen-



Connection to public network for UK (left) and Continental sets. For UK sets, remove straps 5, 6, 17 and 18 in telephone. Change around green/white strap in terminal block and connect blue wire to tag five in telephone. In Continental telephones, change green wire from the point two to point five and connect 'a' to the socket ground strap.

dent these tests should be repeated until all values are within their specifications.

Regulations for connection of equipment to the public-switched network vary from country to country. Most countries do not allow connection of any uncertified equipment to the network. BT plan 1A mentioned here no longer applies.

Construction tips conclude this article.

Non-destructive m-i-m breakdown

Breakdown voltages of metal-insulator-metal junctions are measured to obtain the contact potential difference between two dissimilar metals, which in turn yields the difference in work functions, but methods previously used have been destructive.

Measurements can be made by breaking the junction down in one direction then removing the bias so that the junction recovers in a certain time[1]. Reverse bias is then applied and the breakdown voltage measured in the other direction. In a two-junction method[2], breakdown voltage measurement caused breakdown of the junction in each case. Bhattacharya et al reported[3] that the junction may be made to recover immediately after breakdown if a reverse bias is applied after causing breakdown in one direction. Breakdown voltage is then measured in the other direction and the difference between the two is related to their work functions by

$$V_1-V_2=\delta\ V=2(\phi_1-\phi_1)/e$$

where ϕ_1 and ϕ_2 are the work functions and e is electron charge.

To investigate the contact potential difference of several noble metals relative to that of aluminium, tunnel junctions were prepared in our laboratory by first evaporating a 150mm-thick strip of aluminium about 2mm wide and 8cm long. The strips were oxidized in air for between 24 and 72 hours then a counter-electrode of one of the metals under investigation was evaporated to form the usual cross-shaped tunnel junction. However, during measurements, the junctions almost always broke down destructively.

Dr Ijaz-ur-Rahma, working at Makerere University, Kampala, while on leave of absence from Quaid-e-Azam University, Islamabad, has designed a circuit which overcomes this problem by switching off the supply less than 5μs after breakdown (Circuit Ideas, December issue, page 44), and allows repeated measurements of the same junction, so the method yields more accurate values of breakdown voltage than is possible by other techniques.

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1. A. Roy Bandham, P. C. Srivastava & D. L. Bhattachraya, *International Journal of Physics*, prob. 1975.
2. J. G. Simmons, *Physics Review Letters*, vol. 10, 1963, p.10.
3. A. Roy Bardham, P. C. Srivastava and D. L. Bhattacharya, *Thin Solid Films*, vol. 28, 1975, pp.237-242.

Sampling frequency meter

Battery-powered frequency meter with memory is based on a 6805 microprocessor and monitors physical quantities such as windspeed in remote locations over periods of up to twelve months

by N. A. Lockerbie, B.Sc., Ph.D.

Physical quantities such as windspeed, temperature, humidity, often need to be monitored over extended periods in areas remote from a supply of mains electricity. When the information sought is merely the average value of a quantity, or just its distribution, commercially available battery-powered data-loggers can be an expensive solution. They are frequently too powerful for the task.

This article describes a low-cost solution to the problem in the form of a battery-powered instrument based on the c-mos Motorola MC146805 E2P microprocessor. In this instrument the input is sampled repetitively and compared with a table of values stored in memory, so that over time, a distribution of the sampled input is built up in 21 internal memory channels (20 channels+1 'over-range' channel). The program controlling the microprocessor can be adapted to suit different needs by simply changing the values stored in this table, and/or by changing the measuring period. This again is selected in software. Besides its distribution, the maximum value attained by the input during the measuring period is also stored in memory. To extract these data from memory after an extended period of sampling, the instrument can be interrogated on site via two key-switches and an eight-digit liquid-crystal display. When not being interrogated the average value of the input during the previous ten-second measurement period is displayed. The total current-drain of the circuit is 1mA, implying an operational life in the field of 12 months from three alkaline D-cells.

Operation

Only certain type types of transducers produce a variable-frequency output that is related to the physical input being measured: anemometers of the slotted-disc and light-beam variety are a good example. Nevertheless most can be adapted to do so, either by using voltage-to-frequency converters (on the output of a strain-gauge amplifier, perhaps) or in certain cases by employing the transducer as the resistive element in an RC oscillator, e.g. when measuring temperature with thermistors. As signals of this kind have inherently good noise immunity for transmission over long cables, the circuit was designed to accept this type of input.

The instrument is essentially a free-running frequency meter, with (as programmed) a fixed measuring period of ten seconds. Every ten seconds its display is updated with a new five-digit reading, the reading being the number of input pulses counted during the previous ten seconds. Because a 16-bit counter has been used in the circuit, this number must lie in the range 0-65,535 and although that clearly limits the average input frequency to a maximum of 6.55kHz with this measuring period, it has not proved to be a serious limitation. Besides being displayed, each count is also compared with a table of 20 values stored in eprom, starting with the lowest value. These numbers, arranged in ascending order, serve as the channel delimiters and divide the range 0-65,535 into the 21 channels that are used to synthesize the distribution of the input. If these 20

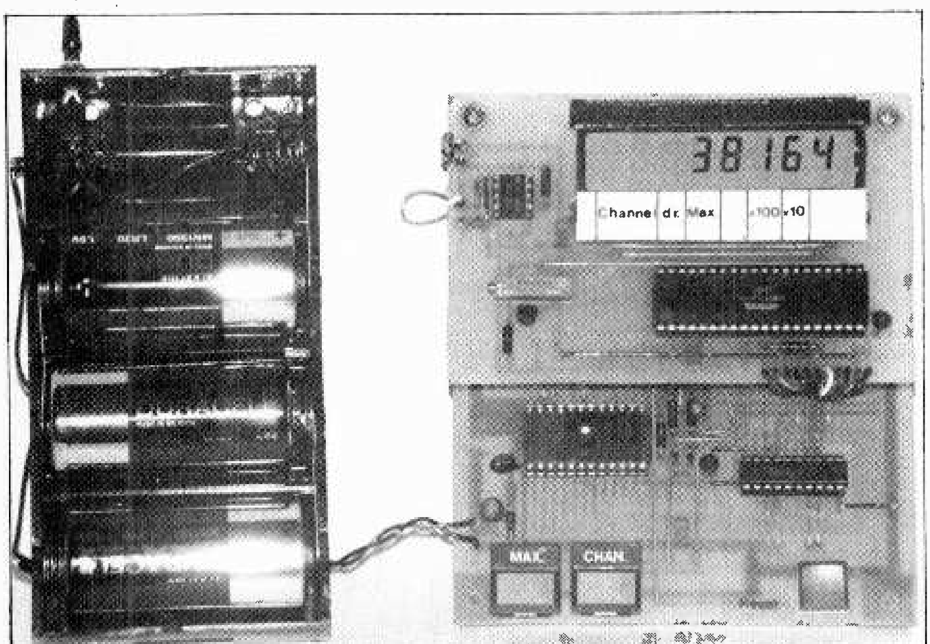

Fig. 1. Microprocessor-based sampling frequency meter. If the number of pulses counted in the ten-second measuring interval is greater than 65,535 "HI – – – – –" is displayed. The i.c. to the left of the display (not included in the circuit diagram) is a small test oscillator, feeding pulses to the input of the circuit.

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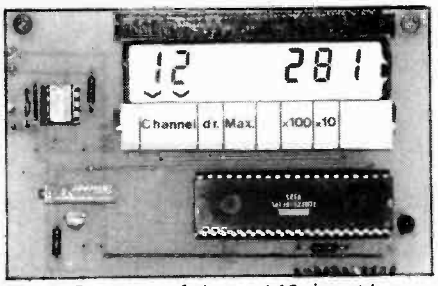


Fig. 2. Contents of channel 12: input has spent 281 units of ten seconds in the range of channel 12 – 36,000-38,999 in this case. Channel contents rise from 0 to 99,999, after which 10,000 is displayed, with the arrowed annunciator pointing to × 1.0, etc.

numbers are labelled N_0, N_1, N_2, N_3, . . .N_{19}, then channel 0 extends from 0 to N_0-1, channel 1 from N_0 to N_1-1, channel 2 from N_1 to N_2-1 etc., up to channel 19, which covers the range N_{18} to $N_{19}-1$. The remaining interval of $N_{19}-65{,}535$ becomes the over-range extension channel.

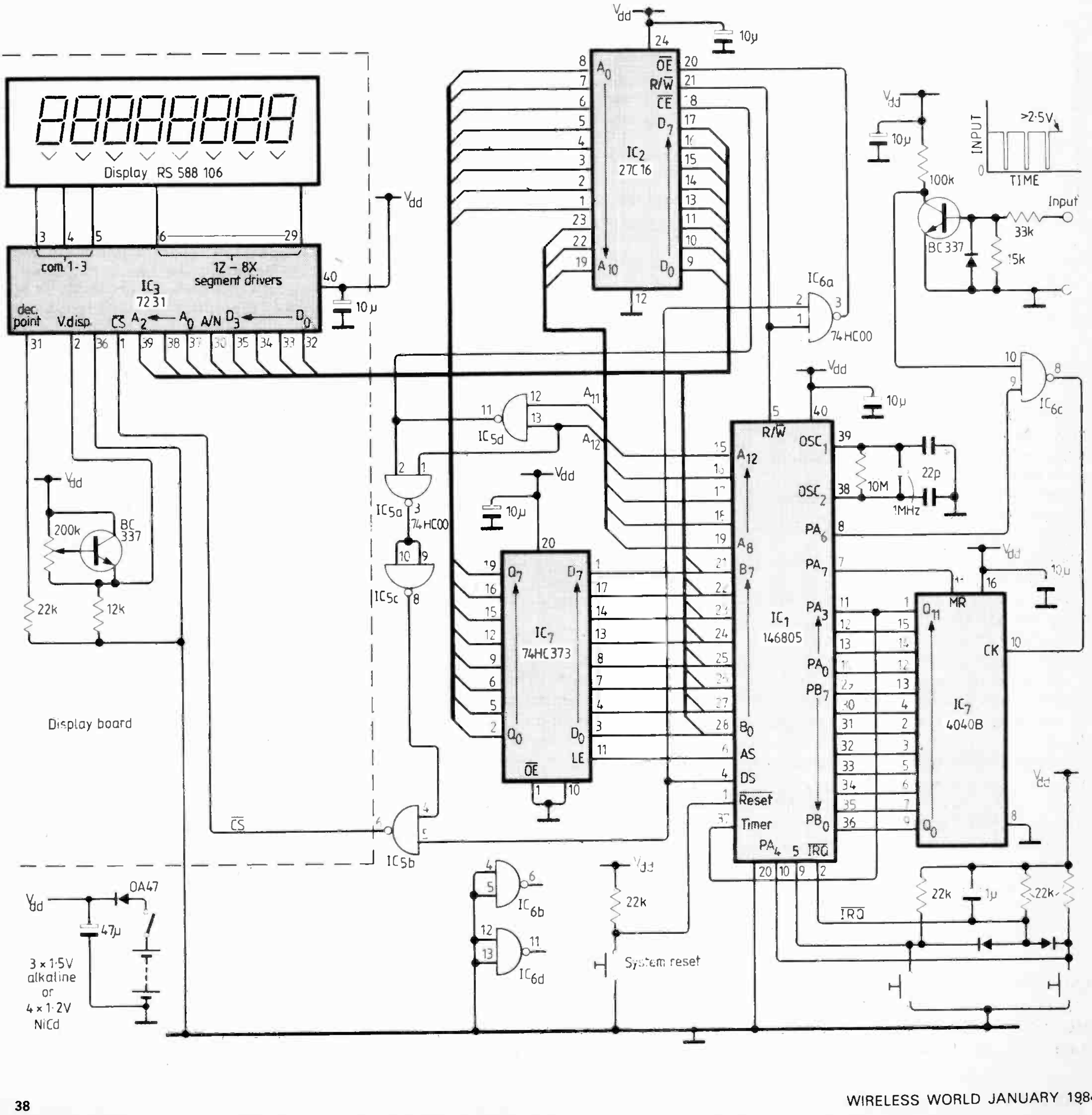
The sequential comparison of the pulse-count with this table terminates when the count is found to be less than N_I (I=0 to 19), N_I being the number with which it is currently being compared. For example, suppose the count was found to be less than N_2 (and by implication, $\geq N_1$, then the count would lie in the range of channel 2. At this point channel 2 – in reality just a counter (in ram) – would be incremented by one unit of time, where the unit of time is ten seconds. In this fashion, the distribution of the input signal is slowly built up by the 21 channels, in the form of the amount of time the input spends in each count (and therefore frequency) range.

As the comparison table is held in eprom, different eproms can easily be substituted to suit different transducers. Moreover, non-linear transfer characteristics for the transducers can be ironed-out by judicious choice of values in the table. For example, each channel can be made to be exactly one unit of windspeed wide: or else the channels can be given deliberately different widths in the physical variable to emphasize certain regions. Channels can be made only one count wide if desired.

In addition to building up the distribution, each count as it is acquired is compared with the maximum value measured to date and the larger of the two is retained in ram as the current maximum value.

When the channel and maximum data have been accumulating for some time in ram, they can be read out by pressing one of the instrument's two key-switches. Pressing either switch generates an interrupt, and temporarily suspends the normal sampling action of the instrument. On receipt of the interrupt the two switches are polled to see which of them was pressed and the corresponding sequence follows: either the maximum value is displayed for six seconds as a five-digit

Fig. 3. Complete circuit diagram of the c-mos microprocessor-based sampling frequency meter.



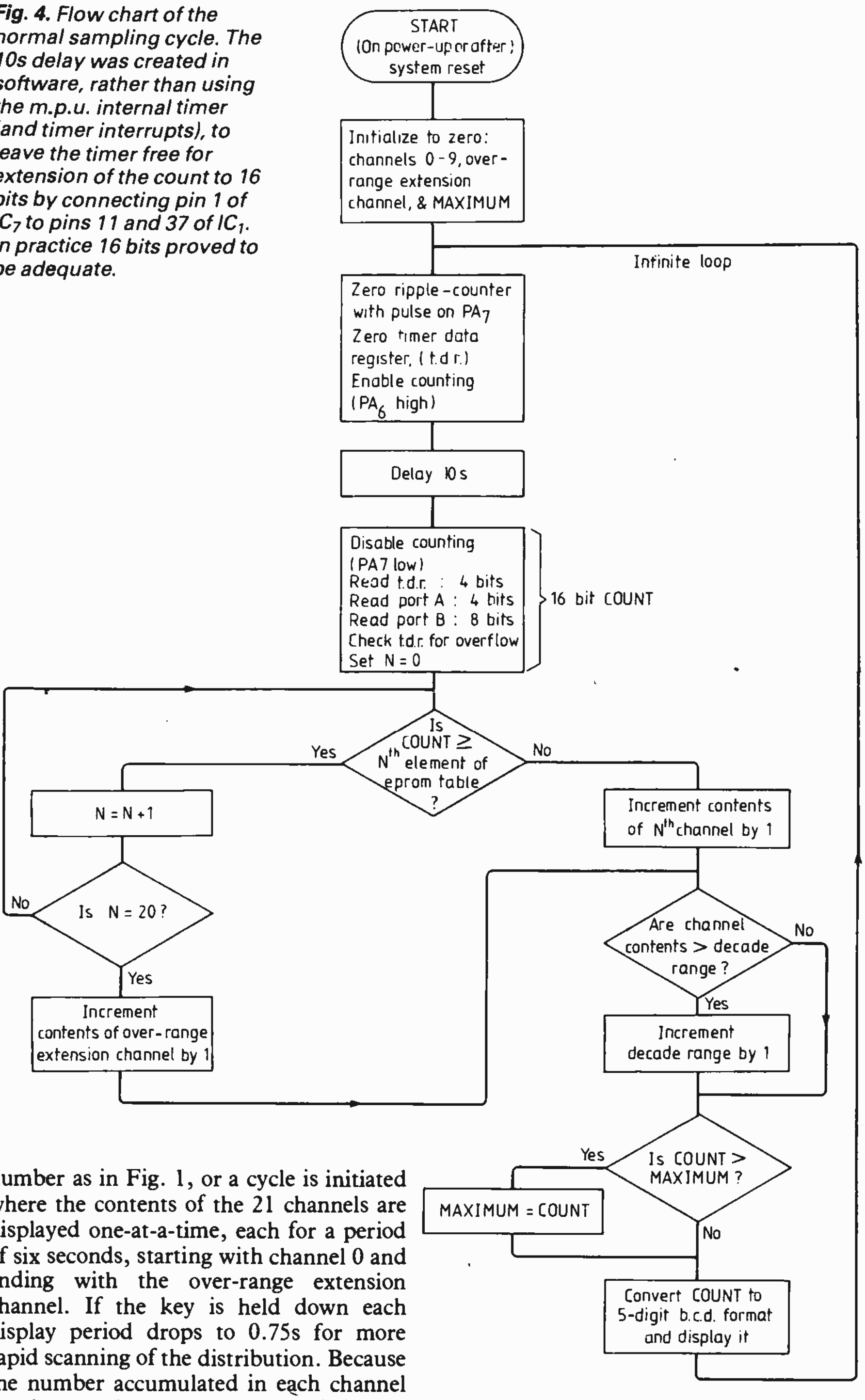


Fig. 4. Flow chart of the normal sampling cycle. The 10s delay was created in software, rather than using the m.p.u. internal timer (and timer interrupts), to leave the timer free for extension of the count to 16 bits by connecting pin 1 of IC_7 to pins 11 and 37 of IC_1. In practice 16 bits proved to be adequate.

number as in Fig. 1, or a cycle is initiated where the contents of the 21 channels are displayed one-at-a-time, each for a period of six seconds, starting with channel 0 and ending with the over-range extension channel. If the key is held down each display period drops to 0.75s for more rapid scanning of the distribution. Because the number accumulated in each channel can become large over an extended sampling period, the channel contents are displayed with a resolution of five digits, together with an arrowed annunciator that is the power of ten by which the reading should be multiplied. It is kept the same for all channels, effectively normalizing the distribution to its peak value. Channel number is always displayed simultaneously with the contents of that channel, as in Fig. 2. If the 'channel' key is held down immediately after pressing the 'maximum' key, then the 20-channel delimiter values are reviewed in a manner similar to that for the channel contents. When either sequence terminates, control is passed back to the normal sampling routine, which continues as before.

Circuit description

The heart of the circuit see Fig. 3, is an MC146805 E2P c-mos microprocessor running at a 1MHz clock frequency. It has 112 ram locations that are used for storage of the system stack, data, and program variables. Each channel for example uses three of these locations. For further information and another implementation using this m.p.u., see the article by T. D. Forrester[1]. Port lines PA_5, PA_4, PA_3-PA_0 and PB_7-PB_0 are configured as inputs and lines PA_6 and PA_7 as outputs. For communication with the peripheral chips, the m.p.u. is connected to the inputs of display driver IC_3, and the data outputs of IC_2 via an eight-bit bidirectional multiplexed address/data bus. As the data and low-order memory address bits are multiplexed on the same bus the address bits have to be latched and high-speed c-mos octal latch IC_4 fulfils this function. Address strobe line AS (IC_1 pin 6) generates the necessary demultiplexing latch-enable pulse. Lines A_{10}-A_8 of IC_1 provide the remaining three bits of the 11-bit eprom addresses.

The main controlling program for the microprocessor and the all-important look-up table are stored in the eprom, IC_2, a National Semiconductor NMC27C16 QE-65 (or -55, or -45), which is a c-mos version of the popular n-mos 2716 2k-by-8 eprom. Note that using the more common n-mos 2716 increases the total current drain of the circuit by a factor of typically 30! The 20 numbers which form the look-up table can be programmed separately into 40 memory locations set aside for this purpose, in an otherwise programmed eprom (the channel delimiters are all 16-bit numbers requiring two memory locations each).

In the circuit, the m.p.u. is connected so that it can both reset and read the binary-coded parallel output lines of IC_7, and via IC_{6c} it controls the gating of pulses through to the clock input of IC_7 (pin 10). This arrangement is similar in principle to that described by J. L. Gordon[2]. The most-significant output of IC_7, a c-mos 4040B 12-stage binary ripple-counter, is fed into the 'timer' (actually a counter) input of the m.p.u., extending the ripple counter by a further eight bits. In this application, however, only the first 16 bits of the composite 20-bit ripple counter are used for counting input pulses, the remaining four being used for headroom, thereby guarding against the possibility of an overflow wrapping around and then counting up through zero again. The four highest timer bits are monitored in software to detect overflows from this 16-bit counter. Unlike the relatively low-speed 12-stage ripple-counter, nand-gates IC_6 and IC_5, which provide gating and address decoding, are high-speed c-mos types.

The signal input to the instrument coming from the transducer must consist of a constant positive voltage level of between +2.5 and +30V w.r.t. circuit ground, interrupted by negative pulses which should fall below +1.5V for correct operation. This signal is conditioned by the level-shifting n.p.n. input transistor before being applied (now inverted) to pin 10 of the nand-gate IC_{6c}.

Mounted for convenience on a separate board from the main circuit is the eight-digit display and driver. The liquid crystal display of the seven-segment type with a decimal-point (unused) and an arrow annunciator beneath each digit. A 7231B, IC_3, drives the display in a triplexed mode via three common lines and 24 segment lines. It has a code-B font of characters. To create a digit in one of the eight positions on the display, first the digit position (0-7, 0 being the right-most digit) and its value (0-9 or −, E, H, L, P, (blank) . . . coded A-F in hexadecimal) have to be presented, in parallel binary form, to IC_3's address and data inputs: IC_3 inputs A_2-A_0, and D_3-D_0. If the annunciator for this position has to be on, a high level is applied to the AN input of IC_3. A strobe pulse is then sent to IC_3 chip select input (pin 1) and that latches the digit (and annunciator) in place on the display. Address, data, and annunciator bits are assembled in software into a

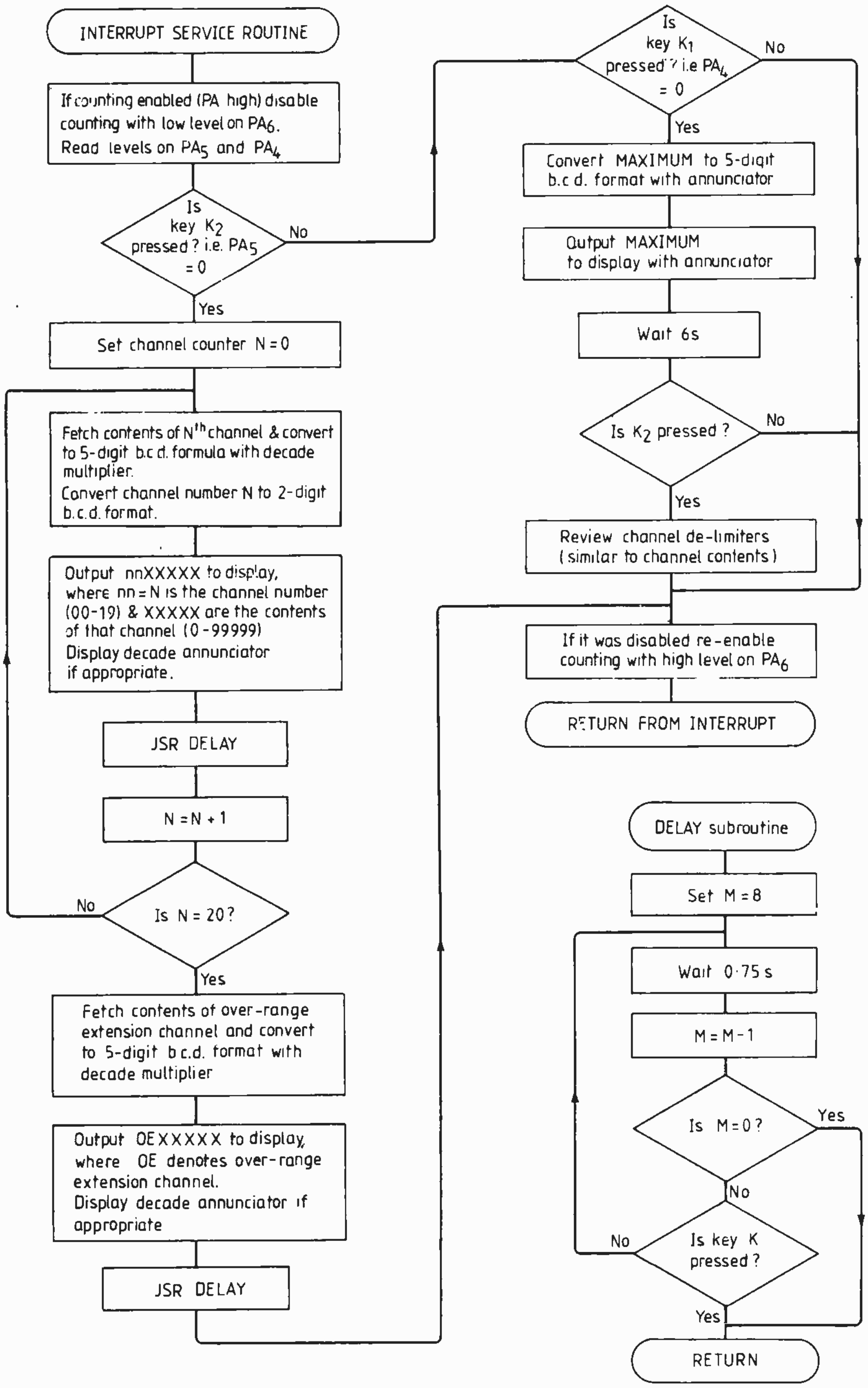


***Fig. 5.** Flow chart of interrogation mode of operation. Key switches K1 and K2 are diode or-ed to the m.p.u. interrupt request line. If K1 is closed, the maximum input value is displayed briefly. Closure of K2 initiates a cycle through all 21 channels, displaying briefly the contents of each. Holding K2 closed accelerates the scan. Note that an interrupt can be pending, even though neither switch is closed.*

single byte, and it is this which is sent to IC_3, by the m.p.u., on the data bus. By writing these data to the correct address, the latching $\overline{CS}$ pulse to IC_3 is generated automatically. The circuit around the n.p.n. transistor connected to pin 2 of IC_3 varies the display contrast via the 200kΩ Cermet pot.

Address decoding for i.cs 2 and 3 is carried out by nand-gates IC_{5d} and IC_{6a}, and IC_5, respectively, which generate the $\overline{CS}$ signal for IC_3, and the chip and output enable signals $\overline{CE}$ and $\overline{OE}$ for the eprom. Thus the eprom is mapped into address range IFFF-1800, whilst the display is mapped into 17FF-1000.

Power is supplied to the circuit via a protective germanium diode by three 1.5V alkaline D-cells, resulting in a supply voltage of typically 4.3V. Although i.cs 2 and 3 are nominally 5V parts (all the rest are 3 to 6V), in practice the complete circuit functions correctly down to a supply voltage of 2.5V.

As regards the operating temperature range for the circuit, intended as it was for field use in Northern climes, the instrument functioned satisfactorily down to a temperature of −25°C, at which point the l.c.d. ceased displaying (temporarily). The rest of the circuit still functioned at −30°C, however.

Detailed operation of the circuit as a whole can best be understood with the aid of the flow diagram in Fig. 4 for normal sampling operation, and with that of Fig. 5 for the interrogation mode.

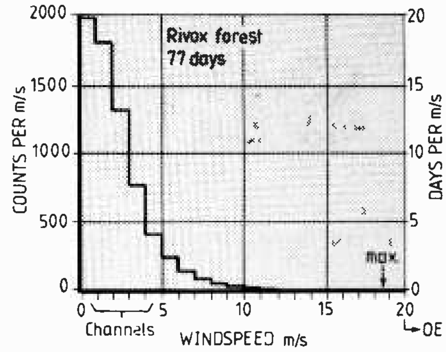


***Fig. 6.** Results from 11 weeks of windspeed measurement at Rivox Forest (see text).*

Construction

Although wire links could be used on the component side of the printed circuit board, as in the instrument shown in Figs 1 and 2, a double-sided board greatly simplifies construction, and foil patterns for both sides of the board are avoidable (see below), and together with a component overlay assembly is straightforward. As in Figs 1 and 2, the display part of the board can be separated from the processor board to produce a more compact instrument. In this case the 11-way ribbon cable connecting it to the processor board should not exceed 30cm in length. For improved immunity to electrical interference (e.g. from lightning) the p.c.b. should be mounted close to a conducting surface, itself connected to the circuit common line.

Four versions of the instrument have now been built, and one of these has been used for monitoring windspeed 2 metres above the forest canopy in the centre of Rivox forest, near Dumfries. The results of 11 weeks of sampling during mixed weather, with mostly light winds and several thunderstorms, are shown in Fig. 6. The circuit itself was mounted in a small waterproof plastics box with a transparent lid (RS 507-977) and reed switches, operated with a small magnet from outside the enclosure, were used for K1 and K2.

I should like to thank all those at Strathclyde who have been involved in any way with this work, and in particular Dr C. R. Lloyd from the University of the South Pacific, Fiji.

Printed circuit boards, programmed eproms (except for the look-up table in the first 40 memory locations) and a program listing can be obtained from D. Smith, CII, Strathclyde University, 100 Montrose Street, Glasgow G4 0LZ.

References

1. Forrester, T. D., *Wireless World*, March 1983, pp. 39-42.
2. Gordon, J. L., *Wireless World*, May 1981, pp. 42-44.

WW

Static Z80 simulator

Static faults that manifest themselves as obscure bugs dynamically or that prevent the processor from running can be tedious to find. This tool simulates Z80 signals for design proving and prototype fault finding.

by Colin Walls

When designing microprocessor-based equipment, engineers generally concern themselves with the dynamic properties and problems of the circuit. This is reflected in their armoury of instruments: logic probes, oscilloscopes, logic analysers, signature analysers, and so forth. This approach is naturally carried forward to the development of firmware, where in-circuit emulation of the processor or prom is common.

The tool described enables the engineer to quickly solve the purely static design and implementation problems before the processor or even all the active components have been installed. Problems often manifest themselves as obscure bugs in a dynamic environment (e.g. a floating interrupt line) or may prevent the processor from running at all (e.g. an address line shorted to earth). Such faults tend to be very tedious to find using conventional "bussing" of the wiring.

The circuit is designed to simulate most, but not quite all (see 'Limitations'), of the functions of a Z80 microprocessor in a static manner. The choice of the Z80 is purely arbitrary and the same principles may be applied to any device. Necessary changes are indicated, where possible. Physically, the simulation is achieved by bringing all the signals to a 40-pin header plug, which is plugged into the circuit in place of the microprocessor.

Circuit description

The circuit is shown in Figs 1 to 4 and each group of pins is described separately below. The Z80 pin connections are summarized in the Table.

Address lines. There are 16 address lines, A_0 to A_{15}, connected to pins 30-40 & 1-5 (Fig. 1). These lines are output only and always active. They are held at logic 1 by a mild pull-up resistor (10kΩ) and switched to logic 0 by shorting to 0V. Red l.e.ds indicate the state of each line and any shorted to 0V can quickly be detected. For processors with multiplexed address and data lines, tri-state buffers would be needed for the address lines, enabled by the appropriate control signal ($\overline{ALE}$).

Control and status output lines. There are eight control and status output lines (Fig. 2):

- $\overline{IORQ}$ – input/output data transfer, pin 20
- $\overline{MEMRQ}$ – memory data transfer, pin 19
- $\overline{HALT}$ – processor halted status, pin 18
- $\overline{M1}$ – machine cycle 1, pin 27
- $\overline{RD}$ – input data transfer, pin 21
- $\overline{WR}$ output data transfer, pin 22
- $\overline{RFSH}$ – dynamic ram refresh cycle, pin 28
- $\overline{BUSAK}$ – bus ownership acknowledge, pin 23

The $\overline{IORQ}$, $\overline{MEMRQ}$, $\overline{HALT}$, $\overline{M1}$, $\overline{RD}$ and $\overline{WR}$ signals are de-bounced using an S-R latch implemented by means of two cross-coupled nand gates. The top normally high output provides the active-low signals. The complementary output of $\overline{RD}$ (i.e. RD) is also used to clock data input (see 'Data lines'). Green l.e.ds indicate the inverted signals. The $\overline{RFSH}$ and $\overline{BUSAK}$ are not implemented (see 'Limitations') and are held high by a mild pull-up (10kΩ).

Control and status input lines. There are eight control and status input lines (Fig. 3):

- $\overline{INT}$ – maskable interrupt, pin 16
- $\overline{NMI}$ – non-maskable interrupt, pin 17
- $\overline{RESET}$ – system reset, pin 26
- ϕ – clock, pin 6
- $\overline{BUSRQ}$ – bus ownership request, pin 25
- $\overline{WAIT}$ – wait state request, pin 24
- V_{cc} – 5V supply input, pin 11
- Gnd – 0V supply input, pin 29

The $\overline{INT}$, $\overline{NMI}$ and $\overline{RESET}$ signals drive green l.e.d. indicators. ϕ and $\overline{BUSRQ}$ signals are not supported and are left unconnected (see 'Limitations'). Lines V_{cc} and Gnd may be used to supply power to the circuit under test (separate supply leads being provided to the simulator) or to take power from the circuit to power the simulator. An alternative would be to provide a common ground, but separate 5V supply to the simulator. The supply is confirmed by a yellow l.e.d. The $\overline{WAIT}$ signal is stretched by the 555 monostable to catch short pulses from peripheral devices. The inverted signal is displayed on a green diode.

Data lines. There are eight data lines, D_0-D_7, connected to pins 14, 15, 12, 8, 7, 9, 10 & 13, Fig. 4. These lines are bidirectional and may be tristated. The input (read) facility is provided by an octal latch IC_{10} driving eight red l.e.ds, clocked by the inverted $\overline{RD}$ signal (RD). The output (write) facility is provided by a tristate buffer IC_{11}, enabled by the $\overline{WR}$ signal. The circuit enables either, neither or both read and write to be performed at any one time (see 'Operation').

Construction

The prototype simulator was built on a piece of veroboard 81 holes long by 18 strips wide. A diagram showing the board layout can be obtained from the WW editorial office. The board was fitted into a plastics box with an aluminium front panel. The 40-pin d.i.l. header plug used as the probe was a solder lug type, to which 38 wires were connected (pins 6 & 25 not connected), bound together to form a flexible lead. An insulation-displacement type header plug could be used but ribbon cable, though neater, is less flexible.

Operation

The simulator may be used as soon as the prototype microprocessor board is available. Initially, before any i.cs are installed, the board may be checked for any shorted control or bus lines. If lines are buffered, the buffers should be shorted out for this testing phase.

The next stage is to check the address decoding and signal routing in conjunction with a logic probe. The final stage of static testing is to perform read and write operations to memory and i/o devices. A read operation is comprised of the following stages:

Colin Walls graduated from Bath University in 1979 and is now a senior systems programmer at Westcode Systems of Wokingham.

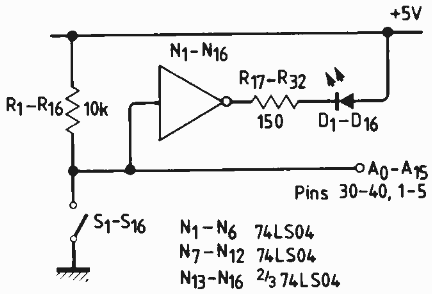


Fig. 1

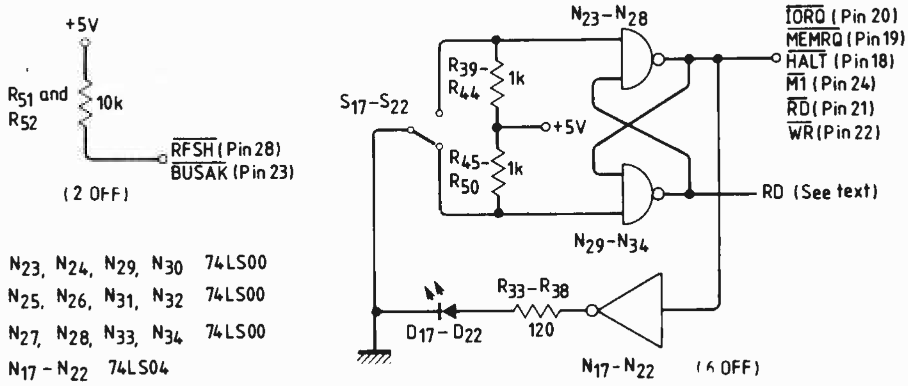


Fig. 2

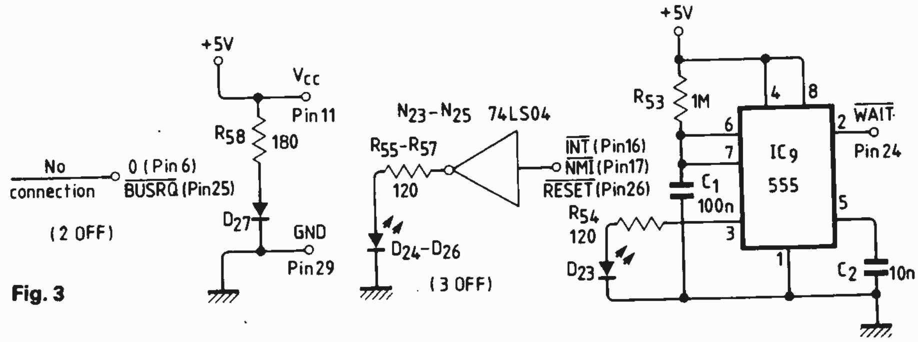


Fig. 3

Components

IC_1 to IC_3	74LS04
IC_4 to IC_6	74LS00
IC_7, IC_8	74LS04
IC_9	NE555
IC_{10}	74LS373
IC_{11}	81LS95
D_1 to D_{16}	5mm red
D_{17} to D_{26}	5mm green
D_{27}	5mm yellow
D_{28} to D_{35}	5mm red
R_1 to R_{16}	10kΩ
R_{17} to R_{32}	150Ω
R_{33} to R_{38}	120Ω
R_{39} R_{50}	1kΩ
R_{51}, R_{52}	10kΩ
R_{53}	1MΩ
R_{54} to R_{57}	120Ω
R_{58} to R_{66}	180Ω
R_{67} to R_{74}	10kΩ
S_1 to S_{16},	s.p.s.t.
S_{17} to S_{22},	s.p.d.t.
S_{23} to S_{30}	s.p.d.t.
C_1	100nF
C_2	10nF

Veroboard 81 by 18 holes, case, 40-pin d.i.l. header plug

Z80 pinouts

Pin	Signal	Pin	Signal
1	A11	21	$\overline{\text{RD}}$
2	A12	22	$\overline{\text{WR}}$
3	A13	23	$\overline{\text{BUSAK}}$
4	A14	24	$\overline{\text{WAIT}}$
5	A15	25	$\overline{\text{BUSRQ}}$
6	φ – clock	26	$\overline{\text{RESET}}$
7	D4	27	$\overline{\text{M1}}$
8	D3	28	$\overline{\text{RFSH}}$
9	D5	29	0V
10	D6	30	A0
11	V_{cc} – 5V	31	A1
12	D2	32	A2
13	D7	33	A3
14	D0	34	A4
15	D1	35	A5
16	$\overline{\text{INT}}$	36	A6
17	$\overline{\text{NMI}}$	37	A7
18	$\overline{\text{HALT}}$	38	A8
19	$\overline{\text{EMRQ}}$	39	A9
20	$\overline{\text{IORQ}}$	40	A10

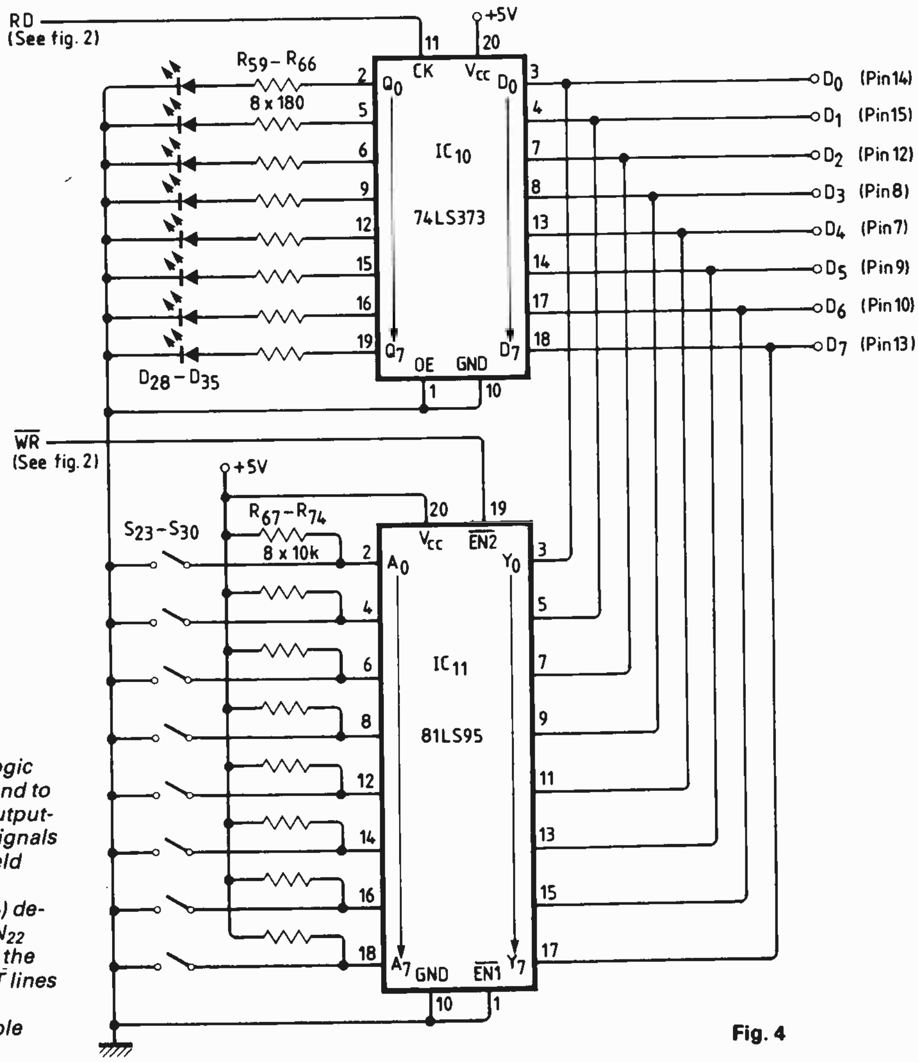


Fig. 4

Each of 16 address-line drive circuits, Fig. 1, provides a logical 0 or 1 on the address pins. Inverters (N_1 to N_{16}) drive l.e.ds to monitor logic levels (on≡1), enabling lines shorted to ground to be easily noticed. In the control and status output-line drive circuits, Fig. 2, RFSH and BUSAK signals are not implemented, hence their pins are held high by pull-up resistors. The other control signals are generated by switches (S_{17} to S_{22}) de-bounced by an SR flip-flop. Inverters N_{17} to N_{22} drive l.e.ds to monitor logic levels (on≡0). In the indicator circuits, Fig. 3, $\overline{\text{INT}}$, $\overline{\text{NMI}}$ and $\overline{\text{RESET}}$ lines are monitored by l.e.ds driven by inverters (on≡0). $\overline{\text{WAIT}}$ line is monitored by monostable circuit and hence pulses are stretched and displayed by D_{23}. In data-line drive and indicator circuits, Fig. 4, input is performed by octal latch IC_{10} clocked by inverted RD signal.

Output is by octal triatste buffer IC_{11} enabled by $\overline{\text{WR}}$ signal. Logic levels set on the switches are thus placed on the data bus.

– Set up a valid address on the address bus switches; the number of switches (up to 16 for memory and up to eight for i/o) varies according to the decoding scheme in use.
– Select memory ($\overline{MEMRQ}$) or input/output ($\overline{IORQ}$) access.
– Select input ($\overline{RD}$).
– Data read is displayed and latched on the data bus l.e.ds.

A write operation is comprised of the following stages:
– Set up the address.
– Set up the required data on the data bus switches.
– Select memory or i/o access.
– Select output ($\overline{WR}$).

A thorough execution of these three testing phases enables the microprocessor itself to be installed with a high degree of confidence that it will run.

Limitations

The functional simulation of the Z80 microprocessor is incomplete in three respects. The $\overline{RFSH}$ signal is not implemented, as dynamic ram would require more sophisticated circuitry to perform refresh cycles. The clock signal is not monitored; this signal could be divided down and used to drive an l.e.d. to flash at a visible rate. And the $\overline{BUSRQ}$ and $\overline{BUSAK}$ signals are not implemented. These could be added in a similar manner to the other control signals. Additionally, tristate buffers, enabled by $\overline{BUSAK}$, would be needed on the address lines and control signals to free the buses completely.

Enhancements

In addition to the functional enhancements listed the simulator lends itself to an improved user interface. A hexadecimal display could be connected to the data and address bus outputs in addition to, rather than instead of, the single l.e.ds. Similarly, a hexadecimal keypad could be used to enter addresses and data values.

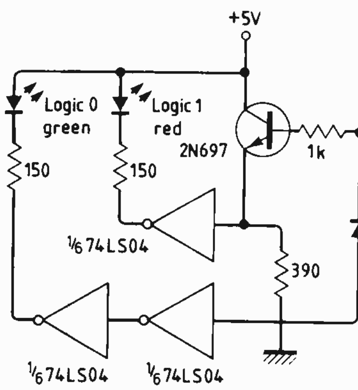


Fig. 5

A basic logic probe circuit also could be incorporated into the simulator. A suggested circuit is shown in Fig. 5, the required gates being available in IC_8. WW

BOOKS

Einstein's Error by A. M. Winterflood, 2nd edition, 72 pages, £3 paper cover, from H. K. Lewis & Co, 136 Gower Street, London WC1E 6BS. The author of this second edition says it could perhaps settle the long dispute over the validity or non-validity of Special Relativity. Previous critics have used logic and commonsense to attack Einstein's theory, but A. H. Winterflood argues that its physics and its mathematics are both wrong.

According to the author, the physics error which Einstein made is one which most of us habitually make, namely, the (wrong) assumption that *speed* is merely length divided by time. The mathematical error was one of omission; he failed to enter his 'p-rinciple of relativity' into the general transformation formulae for Maxwell's spherical wave equation.

The author produces these general transformation formulae and shows that they reduce to Lorentz's equations when certain assumptions are made. Lorentz's transform is therefore valid. However, when Einstein's principle of relativity is fed into the general transformation formulae, Lorentz's transform is no longer obtained. Einstein's use of Lorentz's transform is thus invalid.

Computer-Controlled Testing and Instrumentation by Martin Colloms, 160 pages. Pentech Press, £12.50, hard cover.

Now that most new professional measuring instruments are designed to be compatible with the IEEE 488/IEC 625 bus and there is an increasing number of small computers available as bus controllers, more and more electronics firms will be considering the advantages of testing their products automatically. This book is a good, clear introduction to the GPIB standard and test systems based on it, written by an engineer who has used this bus to set up his own automated testing system for electroacoustic products.

Its practical approach is enhanced by examples of actual test set-ups, program listings and problems that may arise. Currently available equipment is discussed and illustrated. One may question the rather large proportion of reference information (about a fifth of the text) and more guidance on the economics of using the GPIB system relative to traditional methods of testing would have been helpful. But the book is good value for money and can be recommended as achieving its stated purpose – of providing a comprehensive introduction to the bus and answering questions that may arise when it is being used to set up a test system.

Principles of Digital Data Transmission, 2nd edition by A. P. Clark, 310 pages. Pentech Press, £16 hard cover, £8.95 papercover.

This textbook, by an academic with industrial experience, is on the branch of communication systems engineering resulting from the increasing use of voice-frequency channels for digital data transmission. It is the second edition of a work originally published in 1976 and has been revised, expanded and reset to take account of the changes that have occurred in data transmission systems over the intervening years – new modulation and detection processes, for example.

The first eleven chapters of the book survey the characteristics of telephone circuit and h.f. radio link v.f. channels, while the remaining five chapters are given to a theoretical analysis of the various signals that can be used for transmitting digital data. If the author has extracted even the conclusions of the 519 references presented on 23 pages at the back of the book he has saved the student an enormous workload of reading in this expanding subject. The level is suitable for final year undergraduates or first-year postgraduates.

Advanced User Guide for the BBC Micro by A. C. Bray, A. C. Dickens and M. A. Holmes, 510 pages. Cambridge Microcomputer Centre, £12.95, ring bound. The British Broadcasting Corporation microcomputer has acquired a wide reputation as a low-cost machine for workshop and laboratory uses; and for applications such as these, as well as for advanced programming or other kinds, this new guide is an essential reference book. Produced in the same style as Acorn's own User Guide, and with Acorn's blessing, it supplies a great deal of practical information which was not previously available.

Index and binding

The index for Volume 88 (1982) of *Wireless World* is now available, price £1 including postage, from the General Sales Department, Electrical-Electronic Press, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.

Our publishers also offer a service of binding volumes of *Wireless World*, each complete with the appropriate index. If you wish to use this service send your copies to Press Binders Ltd, 4-4a Iliffe Yard, Crampton Street, London SE17 3QA with your name and address enclosed. Confirm your order to the General Sales Department (address above) and with this letter to Quadrant House send remittance of £13.80 for each volume (price includes v.a.t. and index).

In both cases cheques should be made payable to Business Press International Ltd.

NEWS

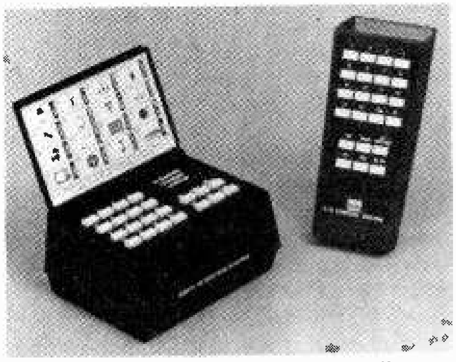
BSR clambers out of depression

After some disastrous years, culminating in a loss of £36m last year, BSR are coming back from the brink and have already reported an interim profit of £3.2M for the first half of this year. They owe their success in a great part to the appointment of a new Chairman, Bill Wyllie, who has gained a reputation in the Far East for rescuing ailing companies (BSR is registered in the UK but its headquarters are in Hong Kong, and Mr Wiley was formerly head of the BSR subsidiary Astec, itself a Hong Kong-based company). He has enthusiastically made a clean sweep. BSR, historically has been made up of a very wide diversity of companies some of which were acquired because, for example, they supplied BSR with components. The new regime has rationalized many of the company's operations and sold off many of the accretions.

The new management has put much accent on New Technology. One product was mentioned in this column last month, the Entropo Microwafer, a mass storage cartridge tape drive for computer memory.

Always known for record changer decks, they are now mass-producing an electronically-controlled linear tracking turntable for the o.e.m. market which they will also sell themselves under their ADC label.

In the home computer field they are producing many products for other manufacturers. An interesting technique is being used in the cartridge games roms, produced for the Sinclair ZX Spectrum; They have found a method of connecting the naked chip directly to the p.c.b. without any packaging except a blob of resin to encapsulate it after it is in place. They have called this CB for Chip on Board. Another



BSR X-10 can control lighting or appliances all over a house and is itself ultrasonically remote-controlled.

technique they are developing is surface-mounted components combined with single-sided p.c.bs, to eliminate any drilling or hole plating.

Computer control of the household is possible with the BSR X.10 Control unit which is programmed through a home computer. The system enables lighting or appliances to be switched from a central unit which sends coded f.m. pulses through the normal house wiring to decoders plugged in series with the appliance. Once programmed the computer is unplugged and is only needed if the unit is to be re-programmed.

The dbx branch of the company has produced a new model 224 noise reduction unit, which can simultaneously encode and decode. They have also produced a neat little playback decoder, battery operated, for use with headphone cassette players for both dbx and Dolby B decoding.

Another area for success has been the mass-production of switched-mode power supplies, produced for the o.e.m. market and for use in their own products. BSR is still a vast organization with products as diverse as Swan brand electric kettles and Frazer & Glass plastics pressings for cars; but they now seem to be heading back to success.

Transputer unveiled

Inmos have at last revealed the details of their first microprocessor, the Transputer; a 32-bit device that is capable of processing 10mips (million instructions per second). It uses a 'reduced instruction set' (fewer instructions to process, compensated by the very high speed) but has a number of mathematical functions to make it even faster and more efficient. In addition to the processor itself there is 4Kbytes of read/write memory with 80Mbytes/s data rate, and a number of interfaces. The memory interface is a multiplexed 32-bit system which can directly address up to 4Gbytes at a data rate of 25Mbytes/s. There is also a peripheral interface, which can access all industry-standard devices at a rate of 4Mbytes/s, and finally four special Inmos links for connecting the Transputer to four others. Such a combination would constitute a very impressive computer. One Transputer offers something like the equivalent power of 100 home computers, all networked together. Two Transputers linked could cope with 20mips.

Transputers will be able to be programmed in the standard high level languages but a lot of work has gone into the development of Occam, the Inmos language that can operate on different instruction concurrently. Occam has been used by them to design the Transputer.

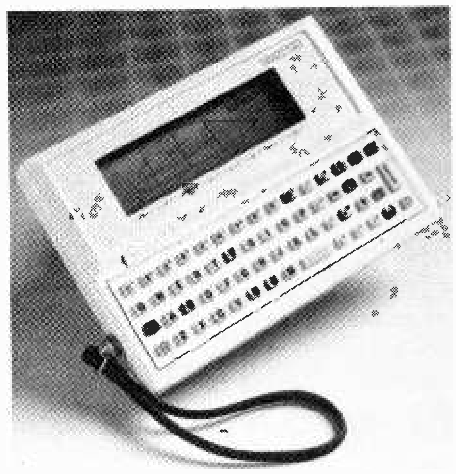
So far, Inmos have built the processor, the memory and the communications interfaces on separate chips. When they are combined (it is thought that samples will be available in the third quarter of the year) there will be the equivalent of 250000 active components on a 6.3mm (0.25″) square chip of silicon.

Hunter takes a bow

A new British handheld microcomputer, claimed to be the smallest, most powerful and rugged of its type in the world, has been announced. Called Husky Hunter and designed and manufactured in Coventry by Husky Computers, it is very tough and may be used in almost any environment, even under water. It is about the size of an average book, weighs 1k and is powered by rechargeable batteries with a fail-safe system consisting of a second set of NiCid batteries which are charged from the main cells and provide an additional life of 50 hours if main set is discharged.

Where the Hunter scores over other similar portables, is in its operating system, which is rom-based CP/M compatible; and in its memory capacity, with options of 80K, 144K and 280K. Extended Basic is the resident language and other languages may be downloaded through the CP/M-compatible system or may be installed internally. These include Cobol, Fortran, Forth, Ada, Lisp, C, Pascal and MBasic. File management and a 'virtual disc' system are included. This operates on sections of memory as if they were discs.

Data communication is through an



Husky Hunter a robust portable computer with a massive memory which can run CP/M programs.

RS232/V24, 25-pin standard connector at a data transfer rate up to 4800 baud asynchronous. A wide range of protocol formats are provided including communication with IBM mainframes.

The Husky Hunter uses an NSC800-4 microprocessor, which executes the Z80 instruction set, operating at 4MHz.

The liquid crystal display is organized as eight lines of 40 characters but is also dot-addressable for graphics and can display graphs, charts and even simple pictures. Graphics commands for lines, boxes, circles and points are included in the Basic. Five different sizes of character may be added to graphic displays. The display can also be used as a 'window' to be scrolled over a much larger display in such applications as spreadsheet calculations.

The Hunter is thought to have applications in many harsh environments; in the construction industry, exploration (its predecessor the Husky has been used in the Antarctic), for transport and delivery records and for portable data recording in many fields. The makers are keen to point out that it makes a neat desk-top computer as well. Prices lie on either side of £1000 depending on the version selected. Husky claim that if you use the pounds-per-K criterion, then the Hunter is well below the price of any competitors.

IEEE Futurebus uses Eurocard

The proposed IEEE standard for Futurebus – an advanced 32bit backplane bus for multiprocessor systems – was announced last month in London. Produced by the IEEE microprocessor standards committee working group P896, the draft specification was approved at its November meeting and presented 'hot off the press' at a colloquium organised by the IEEE's own backplane working party on November 29. But ironically there was not one American contribution to the meeting, which included discussion of P896 protocols, its arbitration scheme, system event and control, reliability and testing, and applications, as well as detailed electrical and mechanical specifications.

Discounting any suggestion of resentment over choice of venue or even of the strong European influence, one UK member of the IEEE working group put this down simply to a lack of American funding (for travelling expenses), either because employers wouldn't pay or because committee members couldn't be spared from their usual jobs for this kind of standards work. UK members of the 34-strong working group are financed by the Department of Industry for two years, which has meant that two or three delegates have been able to attend regular meetings in the USA.

The specification is expected to create a large international market for equipment and systems, according to the colloquium's chairman, Peter Fergus of AERE. "Wide UK public awareness of the specification is essential" he said "if UK industry is to gain early access to this market". The UK was deliberately chosen as venue for the meeting, explained Paul Borrill of University College and chairman of the IEEE P896 working group, so that manufacturers could be alerted to the market – one in which we could expect to see products "within six months to a year".

A key feature of the draft is the inclusion of mechanical specifications, unusual in IEEE standards, and something which the Europeans regard as a breakthrough. It is, of course, the absence of mechanical standardization that has led to a proliferation of differing assemblies in the USA, with no compatibility between them, where buyers get locked-in to particular manufacturers as a result. In P896 the mechanical spec. is based on Eurokit, with the preferred board size being a triple-size Eurocard 280mm deep, and a 96-way DIN/IEC connector, with the possibility of interface with smaller Eurocard sub-systems such as VME. Thus existing European makers have a built-in advantage, "though this will erode" one observer puts it "as soon as the Americans realise the benefits of standardization".

Shortly after the IEEE microprocessor standards committee set about developing specifications for the 696 (S100) and 796 (Multibus) standards it became clear that they did not offer the capability of satisfying future systems, particularly of the multiprocessor kind and, in recognition, the future bus investigations achieved independent status. That was in 1979, and since then the P896 working group has been through almost as many chairmen as drafts produced! But the result, draft 6.2, is now considered 'hard' and though now available for public comment it will be revised only if practical problems are encountered.

The objectives for the bus have made it a significant step forward in both facilities and performance available to designers. With system-architecture independance it allows distributed bus control and is software-system and processor-independent, it is optimized for 32-bit transfers at a burst rate of greater than 10 million per second, supports fault-tolerant systems, is achievable with 1983 technology and has a ten-year design lifetime, and meets IEC mechanical standards in addition to a number of other system requirements. One of the many innovations in the proposal is the specification of new interface drive devices to meet the low capacitance needed for transmission line driving; existing t.t.l. devices do not have the drive capability. Other features include technology-independent dual-edge handshake, fully handshaken broadcast and broadcall modes, provision for protocol extension, and an arbitration scheme that governs transfer of bus control amongst the 32 devices or sub-systems that may be connected to the bus.

News at Compec

With 500 exhibitors, Compec is establishing itself as the major showcase for professional mini and microcomputer systems. Following on from our computer survey, we present some of the new products that fit into an industrial, research or educational environment, rather than purely office/business.

Computers

A British company, Almarc, started by importing American computers but now manufactures its own range of Spirit S-100 bus computers. New to the range is the Spirit 1, based around a 68000 16-bit processor and capable of running under the Unix operating system. Based on plug-in units, a variety of configurations, including multiprocessor computing are possible, and there is a wide selection of plug-in modules for a-to-d/d-to-a converters, extra memory or interfaces.

The Nohalt fail-safe computer is actually two computers running in tandem with an uninterruptable power supply. The system uses distributed processors and duplicates everything so that if, for example, a disc drive fails, a back-up is available. The system is expandable up to 32-bits, with networking for up to 64 terminals. It is distributed in the UK through BCU Computers (GB) Ltd.

These computers are typical of the newer generation of computers that bridge the gap between micro and minicomputers and are not one computer but systems which may be configured from many options. Similarly, Cromenco Ltd are offering a desktop micro, the C-10 which is an enhanced version of their earlier model. It is available with C-Net, a local area network and distributed networked processing.

Digital have announced the Vaxstation 100 graphics terminal for use with a Vax minicomputer running c.a.d./c.a.m. software. It supports high resolution graphics design but also acts as a text workstation and may be used as a general-purpose terminal linked to the host computer by an optical cable up to 500 metres long.

Local data collection and processing, testing, diagnosis and controlling of systems in the field as well as normal terminal functions are possible with the 42C hand-held computer/terminal from G.R. Electronics. The unit is fully user-programmable even down to the character set and keyboard functions. Up to 64K ram is available and its contents may be retained by a lithium back-up battery. Applications may be programmed in machine code, in an interpreted high-level language or downloaded from a host computer via a serial interface. The interface can be configured as an RS232, RS422 or a 20mA loop. The 40-character display supports a full ASCII character set and user-definable symbols. A bar-code reader wand may be used.

The Merlin portable computer is an Apple IIe with a miniature 5in display screen and two disc drives which fits neatly into a carrying case. Put together by Xcalibur Computers with Apple approval, it is expected to have many applications in laboratories, industrial and other harsh environments.

Communications

Advanced Network Communications Systems point out that the Cambridge ring is still the "only viable form of real-time local-area network in existence in the world". The company, founded a year ago with the specific purpose of promoting a British solution to network communications, had on show their 10MHz open local network. The system conforms to the CR82 Standard as specified by the SERC Joint Network Team. Ring driver software for most popular minicomputers is available.

An electronic matrix switch, the MS2000, replaces the traditional electromechanical switch system with electronic control for analogue and digital communication. It allows central test equipment to monitor any part of a network, and maintain comprehensive error reporting to supplement additional test equipment. The switch was introduced by General Audio and Data Communications Ltd, who were also displaying their new remote line monitoring system, RLM2000. This is a low-cost solution to remote site problems by controlling the analysis of all data from the central unit. A master/slave system costing about £2,000 is claimed to replace currently available systems costing ten times as much.

Camtec Electronics launch their JNT-mini pad, a 4-to-10 port version of the JNT-PAD. Packet assembler/disassemblers (pads) form the basis of a range of data communications products for both wide-area (X-25) and local-area (Cambridge ring, Ethernet) networks. The JNT (for Joint Network Team) PAD provides all the functions for connecting up to 16 asynchronous character terminals to X25 networks and is approved for connecting to the BT Packet Switch Service.

A modem giving 2400bit/s synchronous working for £350 is claimed to be half the price of its rivals. It is fully compatible with the BT 2412 V26 modem and auto-dial, auto-answer and rack mounting are all low cost options from Jaguar Communications Ltd.

Memories are made of . . .

. . . flexible discs say Altek, who were proudly displaying the Mitsubishi 2Mbyte 5.25in drive. Using m.f.m. storage the drives are low height, provide storage at 11844bits/inch at a track density of 96 track/in. Access time is up to 94ms.

. . . cartridge discs, say APS Microsystems who have designed and developed a disc drive which, they say, combines the best features of flexible and fixed disc drives without the disadvantages of either. The Alpha 10+10 is a 20Mbyte disc system which can be used with the IBM PC and most of the more expensive personal computers. It costs £3,400.

. . . tape cartridges, according to Feedback Data Ltd, who have produced a range of quadruple density (6400b/in) drives in two models, the first of which is for data collection from non-intelligent sources, or if the data are in a continuous format where it may be used for file back-up or program storage. Both models have RS232 interfaces operating at 50 to 38,400 baud with current loop option. They feature automatic formatting, read-after-write checking and may have up to 16K buffer storage.

. . . microdiscs, according to Sony and Tabor, their American rivals. Both of them were displaying double-sided 3.25in flexible disc drive with capacities of 1Mbyte. Both seem to be compatible with each other as they both claim to be plug-compatible with 80-track 5.25in drives. The Sony standard has been accepted by the Public Services Working Party as a suitable standard for equipment used in UK public services.

. . . drums, says Vermont Research, who have introduced a 10Mbyte memory system. This is actually a return to an old idea when each of several magnetic heads covered a single track on a drum revolving at high speed. According to computer historians, this system was a precursor of the multilayer disc pack used by most mainframe systems. The drums were often very large, weighed tons and took days to slow down if ever the system was 'powered down'. The Vermont drum is not so vast and fits neatly into a standard rack. It has an m.b.t.f. of over 25,000h with an expected lifetime of 10 years.

On the periphery

At the cheap end there were a number of 80-column printers with a variety of typefaces and facilities selling for around £200. Closer inspection showed that many of them, including the Walters Microsystems' WM80, Mannesmann Tally MT80, Lucas LX80 and Sun SX80 were all the same machine with very slight differences in case and style. At the top end of the market is a Swiss (Wenger 4/1) printer with 136 columns and an 18-needle printhead. It can print 'letter-quality' text (i.e. you can't see the dots) at 110 characters/s and data output quality, where you can just see the dots if you look hard, at a staggering 400 char/s. It has every imaginable interface and many mainframe protocols built in. All for £4,000.

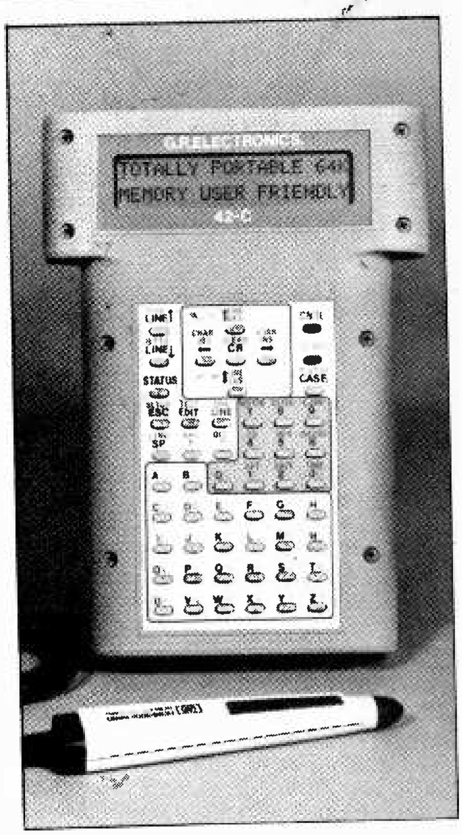
For £14,000 you can buy one of CalComps' 107X plotters which can draw on paper from a roll or on single cut sheets, has a plotting speed of up to 1320mm/s and an addressable resolution of 0.0125mm.

An all-purpose interface adaptor, called the XC50 Cross Communications Adaptor, is made by Walters Microsystems. It includes a 52K memory buffer for spooling data being output to a printer, it can convert serial-to-parallel data streams and parallel-to-serial, and convert the data speed on input and output to different data rates. An internal eprom can be programmed to meet specific protocols, such as converting ASCII code to EBCDIC.

A low-cost graphics tablet enables the user to input drawings and diagrams to a BBC micro. It can be used as a pressure-sensitive keyboard or for cursor control. The Grafpad from British Micro has a program for c.a.d. enabling it to draw circles, squares and rectangles automatically and any design or picture can be saved or dumped to a printer. It costs £125.

Applications are many for the Data and Research Services' Optical Scanner, which can read pencil marks on a pre-printed form and convert them into data for input to a computer. Typical examples are experimental results, meter readings, time control cards. The Open University uses them to mark their assignments when multi-choice questions are answered by pencilling marks onto a form.

A sample-and-hold data acquisition system for the IBM Personal Computer has been added to several other enhancements for the PC to convert it to industrial and scientific applications. The DT2818 is made by Data Translation in Slough. It provides multichannel simultaneous analogue input and output as well as digital i/o and clock functions. Suggested applications include physiological and speed research, multiparameter materials testing and any other applications where auto- and cross-correlation is required.



Nominally a hand-held terminal, the 42-C from G.R. Electronics has many inbuilt functions associated with a portable computer.
(See News at Compec)

News in brief

The dangers of excessive sound level in headphones have been bothering Koss, the American headphone manufacturer. Noise-induced deafness is the most insidious as it does not become apparent until later in life and there is no cure for it; hearing aids just magnify unintelligible noises. Koss have come up with a sound pressure level indicator called the Safelite which is to be incorporated into all their personal stereo products. Research has shown that the harmful level of sound pressure is 95dBA and it is at this level that the Safelite, used in conjunction with headphones, triggers an amber warning light. The first product to incorporate this will be the Koss Music Box, a combined radio and stereo cassette player.

Practical subwoofer design

We regret that in B.J. Sokol's article in the December issue proofs went inadvertently unchecked. The variable resistor designations were left as p_1 and p_2 on page 41; these correspond to the upper and lower variable resistors in Fig. 2, designated R_1 and R_2 in the caption. Potentiometer p_4 referred to on page 43 is the 10kΩ component in the upper diagram on page 42, which diagram should have been labelled Fig. 4. Also in this diagram the input polarity of the upper right op-amp should be transposed. In the transfer functions on page 41 parameter A is ω/Q (=sign omitted), and the sum should of course have read $H_0+k_1H_1+k_2H_2$. In Fig. 1 V is the a.c. voltmeter reading. Apologies to Dr Sokol, who tells us that for consistency he should have shown a 200kΩ feedback resistor around the upper op-amp in Fig. 2.

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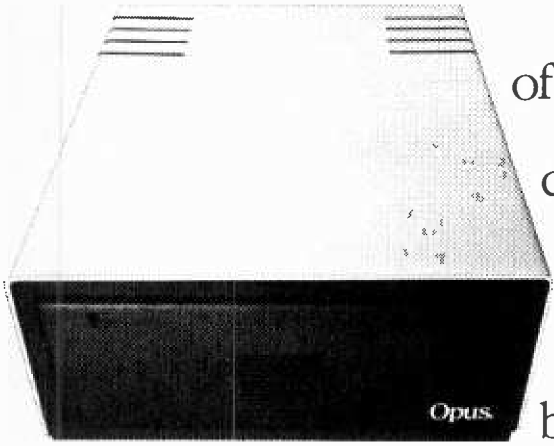

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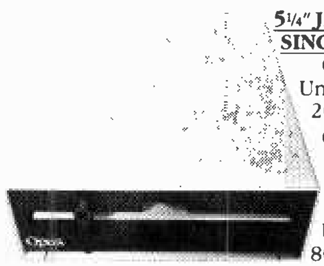

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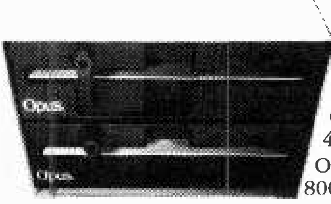

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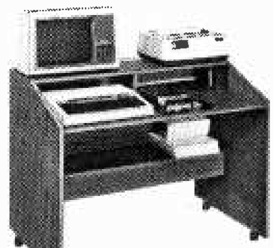

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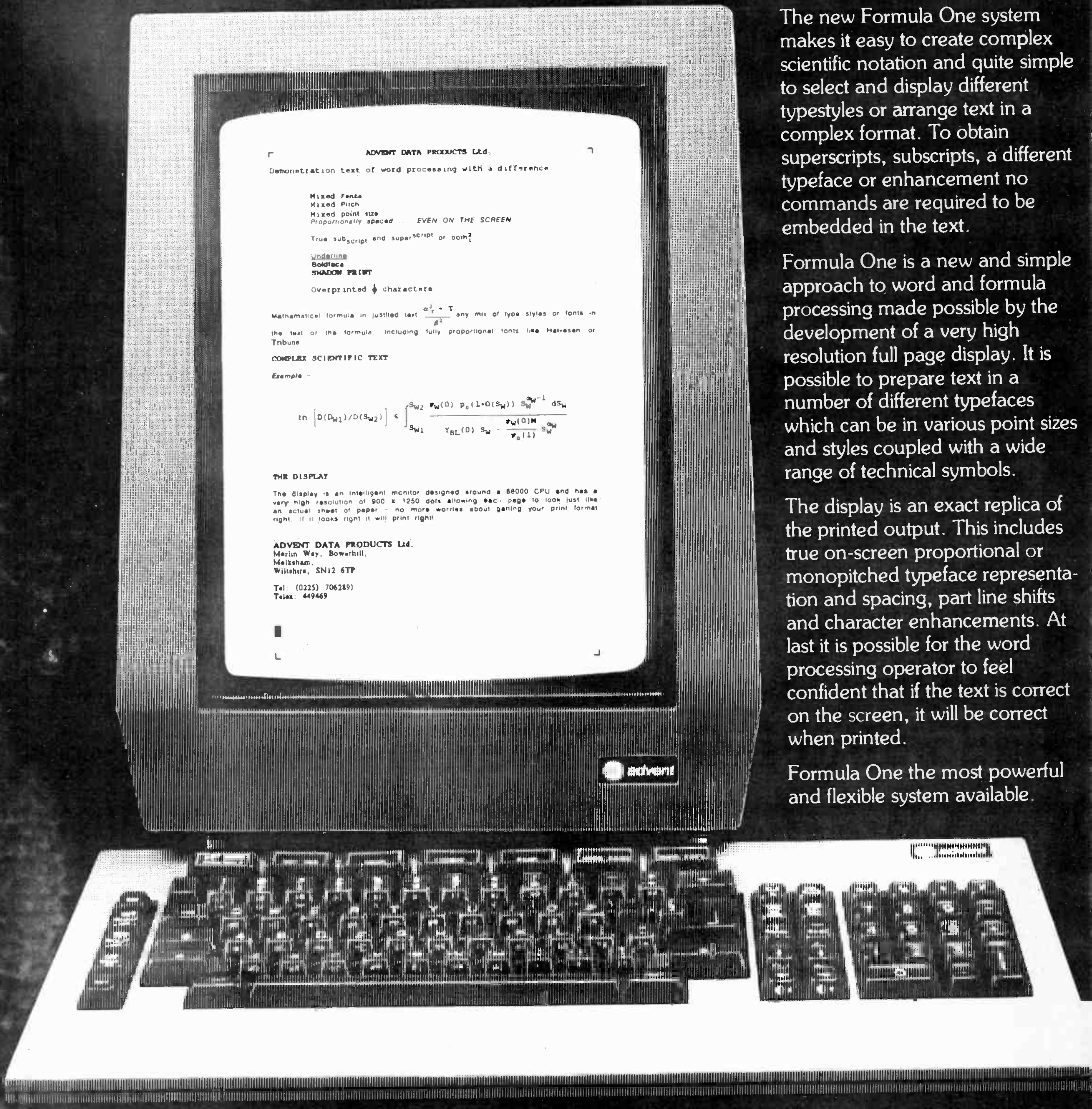

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LETTERS

WORLD TIMING

Your readers may be interested in some background to your recent article about radio time signals and their apparent errors (R. C. V. Macario and G. R. Munro, October 1983).

For very many years the time service of the Royal Greenwich Observatory has maintained accurate scales of both Earth-rotation time and atomic time, primarily for astronomical purposes, and has regularly monitored the errors of selected radio time signals. The results have been distributed to surveyors and others who need accurate time and can compensate in arrears for the effects of known timing errors. Nowadays the primary time signals that disseminate UTC (the internationally accepted version of GMT) from dedicated transmitters are all co-ordinated, and are so tightly controlled at source that, at least in the h.f. bands, propagation and reception errors are usually dominant; consequently there is now little need to monitor their reception. We still distribute the results of observation relating to Earthy rotation and to reception of the other signals that are now used for the most accurate work.

In contrast, the techniques of programme switching and distribution that are used by the broadcasting authorities may introduce inpredictable delays in time signals included in general broadcasts. This makes such signals inherently unsuitable for purposes needing high accuracy and, partly as a result of this, there may be little interest in ensuring that the controlling clock is accurately set.

The six-pips signal used by the BBC orginates at the Royal Greenwich Observatory in Sussex in equipment which is adjusted to keep the signal emitted from Droitwich within about 5ms of UTC; this accuracy is poor in comparison with the 1μs or so that is available from our clocks, but it seems to be adequate for the users of this particular service and it does not seriously limit the operational flexibility of the BBC. Some other broadcasting authorities apparently have weaker links with the international time services, whose operations are co-ordinated by the Bureau International de l'Heure.

J. D. H. Pilkington
Head of Time Department
Royal Greenwich Observatory
Herstmonceux Castle
East Sussex

CAREERS

I refer to Ron Slater's article entitled 'Careers in Electronics' November 1983. In the last section of this article the writer mentions the 'scarcity' of qualified r.f. engineers. I recall being told, by my then employer, the same thing a decade or so ago. One occasionally reads the same sentiments in r.f. related journals.

Based on our experience, over the last few years in this establishment, the numbers of students pursuing telecommunication specializations in their final undergraduate year this must indeed be the case.

The fact remains, however, that the salaries being offered for new graduates *and* experienced engineers in this field do not reflect their much quoted rarity value.

If one believes in the supply/demand system and that the salaries offered are geared to this relationship, then one is forced to the conclusion that in reality the demand for r.f. engineers which is, and has been, fairly constant over the years is still being met by the supply and that their 'scarcity' is a relative term employed in this instance in relation to microprocessor and software engineers.

In the near future the undoubted surplus of the latter may significantly effect the situation?

Dr I. J. Dilworth
University of Essex
Colchester

The article by R. C. Slater in the November 1983 issue of *Wireless World* is most useful and informative. However I would like to raise one point.

Mr Slater suggests that the normal method of application for registration by the Engineering Council is through the institutions. The Engineering Council does, however, provide a means of registration direct to it, without the necessity for membership of an institution. The representation within the Council and the fees charged by the Council leave a lot to be desired for these registrants. Since non-institution members form a large proportion of the engineering workforce it seems strange that the Engineering Council is about to make second class citizens of them.

P. H. Milne
Fareham
Hants

SPEED OR VELOCITY?

I am repeatedly bemused by references in your letters pages to the postulation of a "constant velocity for light in vacuo". We know light travels in different directions, so "constant speed" may, just, be worth discussing. If you'll excuse the pun "constant velocity" is a non-starter!

Simon Pengelly
Tonbridge
Kent

WAVE MOTION

Following Mr W. M. Dalton's letter in November, by all means let us stop, but before starting again the following thoughts on wave motion may be interesting.

Waves are only visible on surfaces which may wobble about their mean stationary norm. Such surfaces include water/air surfaces and cross-sections, both of which are actually interfaces. Without a surface of this kind no wave can be apparent, though pressure changes of something approaching a sinusoidal character, sensed here and there in the medium, may allow the apparency of a wave to be deduced in exactly the same way that the existence of energy is deduced from any other change, that is from behaviour. Given such a surface, the apparency of a wave is produced.

Now, one may cut a cross-section of any medium in any plane one desires, and if that medium contains rotational motion the apparency of a wave will be provided so long as the cut is not precisely through the axis of rotation. The process is analogous to deriving a sinusoid from a circle.

Thus there are two distinct kinds of waves, firstly the apparency provided by what I have just said, and the linear pressure-wave: however, the latter can always be resolved as being caused ultimately by rotational motion, for instance by a piston operated through a connecting rod by a crank, in which case, a "quantum" of its energy might well be a function of one rotation of the crank, and dependent upon its mass and its velocity of rotation when in free motion.

Thus in the end, all wave motion *in a continuum* (i.e., devoid of a surface) must perhaps of necessity be a function of circular motion, that is, spin. This is a delightful thought to me because it means that if there is an energy gradient in space, which I tried to show might be the function of gravitation in my own letter of November, the Planck Quantum would not be constant but would merely tend to constancy in any locality, being a function of spin energy. This in turn may affect one's thinking upon the speed of light and Doppler, and indeed upon the nature of the space-time continuum.

When considering a microcosm, the thing is so small that any conceivable "point" (which is essentially large by comparison) may contain randomly orientated spins of many-sub-massive building blocks, i.e. a non-polarised state of energy, and it seems that from that "point" one may derive probably everything, including the Laws of Physics, passing Abstract Law on the way as one descends the pyramid.

Conceiving a "point", i.e. a tiny static volume in space-time, is a very different matter to conceiving a dynamic function and mentally reducing the scale of it so that many such functions may be contained within the point conceived: the point must be contained within an agglomerations of quite large brain cells at a given instant of time; however, if one then zooms down the function with the lens of the mind's eye one can conceive the quark, the absolute microcosm, a sub-massive (non-apparent), sub-energetic (in wave terms) and sub-informational (non-provable) entity. It is a game of leap-frog, each leap being a leap of scale ending in unity: call it repeated differentiation, the thought process at work, the function of comparison through time, imagination, call it what you will, but it is the fount of analysis and creativity, the functions which lie behind every tiny act of man-made providence.

Having long been doubtful of the sagacity behind the planar apparency which is a surface device, shallow and superficial, I am now driven to the conclusion that wave believers are not too far removed from flat-earthers, who not only suffer from the disease of planar apparency but who seem to wobbulate about their stationary norm in space-time! In short, casual analysis always invokes evolution which is essentially a space-time function, and somewhat more dynamic.

J. A. MacHarg
Wooler
Northumbria

FORTH COMPUTER

Brian Woodroffe is not the first to suggest that the coding of 'Next' is the most important part of a Forth interpreter (*Wireless World*, Nov. 83). However, we need only look at the number of 'U's that appear in his examples of primitives, to see that access to the data stack is far more critical. This is where the 6809 shines. It can read or write to anywhere on the data stack, directly manipulate the data stack pointer, and push or pull any number of registers with just one instruction. Its quick 'Next' and efficient return stack follow in importance.

But we mustn't let our enthusiasm colour the facts. J. O'Connor's first suggestion for '+' on

LETTERS

Table 1 – *Clock cycles taken to execute some Forth primitives by the Z80 and 6809.*

Primitive	Z80	6809
+	75	32
MINUS (NEGATE)	85	28
@	78	27
!	94	33
DUP	65	26
OVER	90	27
SWAP	73	39
DROP	64	19
Total	624	231

the 8088 will certainly run correctly. This is because the result of ADD (BP), AX is written directly back to memory. (However, my 8086 data sheet implies that this method would be slower than the one suggested by Mr Woodroffe).

My own interpreter for the Z80 takes acount of this processors strengths and limitations and improves on the FIG model. In Table 1, I have compared the number of clock cycles taken by my Z80 and Brian Woodroffe's 6809, to execute several Forth primitives. From the totals we can presume that a Z80 will have to run for 624 clock cycles to approximately equal 231 on a 6809, or about 2.70 to 1. Now the ratio of clock speeds between a 4MHz Z80A and a 1.5MHz 68A09 is 2.67 to 1. So they will run Forth at nearly the same speed. Also, since it is vectored, I can quickly change 'Next' to perform error checking, single stepping, or for fast interrupt handling. The Z80A will of course need faster eproms, but the difference is not as great as Mr Woodroffe suggests. The memory access time of the 68A09 is given from 'address lines stable' and at 1.5MHz is 440ns. The equivalent figure for the Z80A at 4MHz is 340ns, whilst the time from the falling edge of $\overline{MREQ}$ is 240ns. Incidentally, these times do not vary in direct proportion to clock speed, so Brian Woodroffe's calculations of 'performance factors' hold little weight.

In his hardware design, the chip select lines of the eproms and peripherals are decoded directly from the address lines, A12 through A15, with no validation signal. Consequently the chip selects will glitch whenever tow or more of these address lines change simultaneously. Also, by subtracting delays of 32ns and 38ns for the decoders, from the processors access time, we are left with 370ns. I can only leave it to Mr Woodroffe to explain why he is using 450ns eproms

James Kidd
Warrington
Cheshire

ELECTRIC CHARGE FROM A RADIO WAVE

May I come to the support of Professor Jennison, and suggest that his analogue model of a rotating waveguide differs from the real thing only in degree and not in kind?

My justification for this claim is that the model may be smoothly transformed into the waveguide via the following stages.

1. Take Professor Jennison's model and reduce the losses in the phase shift networks, simultaneously reducing the gain of the amplifiers appropriately.

2. When the losses reach zero, the amplifiers will have unity gain and may be replaced by pieces of wire.

3. Successively replace each inductor by two inductors with half the number of turns in each, until each inductor consists of half a turn only. The ring of inductors now consists of a continuous circle of wire, with the capacitors connected at intervals.

4. Reduce the value of each capacitor, thereby increasing the speed of the wave around the ring until each capacitor consists of a single pair of rectangular plates separated by an air gap.

5. Reduce the length of the wire connecting the inductors to the capacitors until the inductors and the "live" plates of the capacitors are merged.

6. Join the "earthed" plates of the capacitors end to end, and curve them in a cylinder around the inductor.

The original phase shift oscillator has been transformed into a ring of coaxial waveguide, through six stages which do not, as far as I can see, include a discontuity.

If Messrs Parton and Freeborn (Letters, October and November) agree with me, could they or other readers point out where I have made an unjustified assumption in the transformation?

Peter Hesketh
Chepstow
Gwent

WAVES IN SPACE

I would like to make one comment on T. C. Webb's letter in the August issue. My co-author Malcolm Davidson experimented with sending data (highs and lows for 1s and 0s) in both directions down a 1 kilometre length of twisted pair. He found that the losses experienced by the signals travelling in one direction were less when pulses were being sent in the other direction.

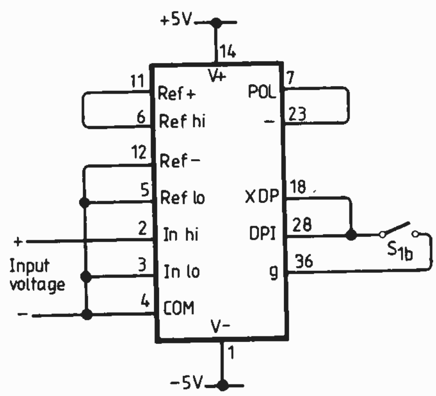
Conventional theory would say that during the time when one positive pulse passes through another going the other way in a transmission line, the i^2R losses drop to zero. The total current is zero during this time.

Ivor Catt
St Albans
Herts

ELECTRONIC WEIGH SCALE

I am grateful to Mr Wyre of Lascar Electronics for his comments on the use of the Lascar digital panel meter in my electronic weighing scale. (*WW* October, 1983).

It had not been my wish in the description of this instrument to commit any potential constructor to the use of a d.p.m. unit of any specific commercial origin, since there are a number of suitable units, and I am not in a position to arbitrate between their respective merits.



The circuit details, with reference to the d.p.m. employed, in my instrument circuit diagram were, therefore, deliberately left in outline form only, in the expectation that the would-be user would follow the particular recommendations of the manufacturer of the unit he had selected.

If the Lascar unit is to be employed, the precise connections needed are as shown below.

J. L. Linsley Hood
West Monkton
Taunton
Somerset

DESIGN COMPETITION

With reference to a letter from Mr Cohen (September 1983 issue) regarding distress alarms for the disabled, such a system was developed and marketed early in the 1970s. It consisted of a v.h.f. transmitter and receiver system. The lightweight transmitter could be easily carried or worn on the person and the receiver, situated in a near neighbours home or in the warden room of an old people's home, could identify a number of individual transmitters. The system was in fact purchased by a number of Social Services departments. At that time cuts in the Social Services budget occurred and as a consequence widespread use of the system did not occur.

The cost of such a system is, of course, directly proportional to the market volume. Unless it is clear that the financial as well as the social commitment for such systems is both present and of reasonable longevity then however socially desirable such a product may be manufacturers will not invest the necessarily large capital to allow consumer development and marketing to proceed – at least for an attractive sale price.

The cynic may be tempted into thinking that if a volume market existed our far-eastern competitors could produce such systems much cheaper than UK based manufacturers. The net result being that the use of such devices would be at the expense of yet another net outflow of UK based money.

Perhaps if the Social Services department is convinced of the necessity of such a distress alarm it should partially fund UK development and marketing of such a product.

Dr I. J. Dilworth
University of Essex
Colchester

In his article and letter in November *Wireless World* Mr Woodroffe is less scrupulous than the Intel benchmark report that he obliquely criticises. This report, which compares the 68B09 with the 8088, can only really be faulted on the grounds that no allowance is made for code frequency in averaging out relative execution times and code sizes. It indicates, quite correctly, that re-entrancy is handled faster by the 6809.

By contrast, the table presented in his article by Mr Woodroffe can be faulted on several grounds. First, it omits the Texas 9995 processor, which competes in the same market sector as the 6809 (64k address, nonsegmented). I wonder why? The 9995 has a non-multiplexed bus and fast 16-bit parallel onboard ram; for 450ns access time its bus cycle is 670ns, versus 800 for the 8088 and 1000 for the 6809. It also makes use of prefetch.

Second, and more serious, some funny arithmetic occurs before the bottom line. The relative speeds for the 6809 and the 8088 are given as 4.11 and 3.19 respectively although the 8088 actually executes its code faster. This is derived from this "speed for 450 nanosecond access memory." I have news for Mr Woodroffe; in the real world it is not desirable to run a processor with a bus cycle allowing 695ns access at a speed which gives 450ns access. It tends not to work. In the real world the 8088 is faster by nearly 30%. Of course it would be perfectly practical to use a faster 6809 – the 68A or B 09 options – but then he should say so. If he is not actually using these faster devices in his own computer, he should tell us what access time his hardware actually requires, and recalculate his last line on that basis.

The third objection, however, is that in reality the 8088 programmer is unlikely to use the "JMP NEXT", as this requires that NEXT be within 127 bytes, necessitating numerous NEXTs scattered throughout the code rather like Underground stations (I nearly wrote public conveniences) in London. He or she will accept the 9-byte inline code (typical 6809 code is twice as long as typical 8088 code), losing 15 clocks and giving 8.6 microseconds. This execution time is slightly less than for the 6809 running at 1.5MHz with a comparable memory access time. The point, surely, is that the 8088 is the more expensive device, and the time and effort required to use features like segmentation mean that they are likely to be wasted in a small domestic microcomputer. There is no point in buying unused silicon.

The comments about code usage I agree with, except as regards the very arbitrary 80/20 ratio, seen quoted elsewhere as 75/25, ⅓/⅔ – it is true that in most high level languages most of the time is spent pushing garbage to keep the system happy. This is why high level languages waste silicon and time while keeping programmers employed. However, the picture can change dramatically as soon as real arithmetic starts to happen, especially when trigonometry is involved. The makers of home computers assume, generally correctly, that most users will never stretch the resources of the mathematics. I would have thought, however, that electronic engineers differed in this respect; in the days when I was limited to a programmable calculator I remember calculations that exercised the poor little thing for hours on end, leading me to wish a bleeper had been fitted to announce the result. For this reason I would have thought that, again, the TMS9995 would have been a strong contender for a CPU because of its ability to handle 16 bit signed and unsigned multiplication and division in the instruction set.

Perhaps I should add that I am in no way connected with any semiconductor manufacturer.
Martin D. Bacon
Taunton
Somerset

SINE WAVES

Roy Hartkopf's letter in the November issue under the heading "Sine waves, harmonics and sidebands", will invite comment from many quarters. May I put forward mine? First of all, the type of modulation discussed by him appears to be that of amplitude. As we all know, this involves the variation of an r.f. carrier (usually) in amplitude by another waveform impressed by intelligence (hopefully!)

This operation is a multiplicative one, in general, so if the instantaneous voltage be presented by $e_c = A \sin \omega_c t$, and the mod. instantaneous voltage by $1 + m \sin \omega_m t$ where A = carrier amplitude and ω_c and ω_m are the carrier and modulating angular frequencies respectively, multiplying these two expressions and expanding the result gives: $e_c\, e_m = A \sin \omega_c t + \frac{1}{2} mA \cos(\omega_c + \omega_m) + \frac{1}{2} mA \cos(\omega_c - \omega_m)\, t$, where m is the percentage modulation.

No sign of harmonics here, Roy. In fact, the two sidebands $\omega_c + \omega_m$ and $\omega_c - \omega_m$ have harmonic relationship only under the particular condition mentioned when $\omega_c = \omega_m$. Here the lower sideband vanishes and becomes a d.c. voltage of value mA/2, since cos 0 = 1. The upper sideband becomes $\frac{1}{2} mA \cos 2\omega_c t$, which is the second harmonic of the carrier frequency. The statement therefore that sidebands and harmonics are the same would appear to be true only in this one instance.

Another thing, notice that in the process of amplitude modulation, the carrier remains at the same amplitude: this fact borne out by rectified carrier d.c. used for a.g.c. purposes etc., which, when properly filtered, remains constant with constant carrier, irrespective of modulation depth. Where then is the distortion of the varying sine wave?

Of course, harmonics appear as a result of system non-linearity, but that's another story. So until Roy explains convincingly his proposition it will remain in the "r.m.s. watt" file.

In conclusion, I would gently point out to Roy that the derivative of a sine function is not another sine function but a cosine function. Yes, the waveform is similar, but, in calculation if 1 were inserted instead of 0 . . . !
A. B. Pidgeon
St. John's
Worcester

PREFERRED VALUES

D. R. Watson (November) should realise that it is not true that "the preferred values (the 20% range) are the rounded approximations of

$$1, r, r^2, r^3, r^4, r^5, r^6$$

where r is determined by the requirement that $r^6 = 10$, and equals 1.468 to 3 decimal places", as a simple test will show.

Sequence	value*	Rounded value	Preferred value
1	1	1	1
r	1.468	1.5	1.5
r^2	2.155	2.2	2.2
r^3	3.164	3.2	3.3*
r^4	4.645	4.6	4.7*
r^5	6.819	6.8	6.8
r^6	10.010	10.0	10.0

* Value is rounded to 3 decimal places. This rounded value is then multiplied by 1.468 for the next stage of the calculation.

There are two wrong answers; 3.3 should be 3.2 and 4.7 should be 4.6. But perhaps when the list of preferred values was drawn up, one preferred value was used to calculate the next one by multiplying say, 4.7 by 1.468 to get 6.900, which was then rounded to give a new preferred value of 6.9. But no, that can't be right; the new preferred value is 6.8.

I wonder how 6.900 was rounded to give 6.8. Teacher never explained that one to me.

If D. R. Watson cares to try he will find the same standard of arithmetic in the 10% and 5% ranges, and for all I know, in the other ranges as well. Surely the "Preferred Range of Values" is the radio industry's "camel" in the permanent exhibition of "horses designed by committe".
W. Scott
London

PRECISION PREAMPLIFIER

In your October issue, D. Self presents a design for a most elegant preamplifier. My only reservations are his comments on the reasons for the inclusion of tone controls and his lack of enthusiasm for non-electrolytic capacitors.

First of all, the inclusion of tone control these days, particularly of the Baxandall type, can only be regarded as a sop to convention and perceived desires, rather than actual needs. I never use them, finding their advantages in, for example, increasing the bass, completely outweighed by their effect on other portions of the spectrum. Therefore, as a convenience to those of us who can get along without tone controls, it would be a delight if Mr Self could present a design omitting the controls, while at the same time keeping the non-inversion of phase and the lovely balance control.

Second, the use of electrolytic capacitors as coupling elements, whilst on the surface appearing completely acceptable, ignores some of their operating parameters. It is, for example, not a good idea to reverse bias an electrolytic, and yet I cannot see any provision made to place a standing bias on the coupling electrolytics in order to ensure that the negative portions of the audio signal do not reverse bias the capacitors, however momentarily. Since op-amps are commonly used with d.c. feedback, they usually incorporate some method internally for reducing their output d.c. offset or they would quickly saturate. It is precisely this apparent lack of d.c. bias on the coupling electrolytics which worries me; further, the low-impedance design of the unit means that coupling values are relatively high in order to reduce their reactive effect. Consequently, film capacitors are not a ready alternative due to cost.

To overcome this nuisance, many preamps use non-polarized coupling electrolytics in their split-rail designs. Pure Class A designs can easily overcome the problem due to the single rail. Even using non-polar electrolytics does not overcome their distortion at zero volts, the same as a regular electrolytic. Perhaps this point has not been overlooked by Mr Self, but it would be nice to have it confirmed. From what I can see, bypassing the electrolytics with film capacitors will not help; the electrolytic characteristics will surmount those of the much smaller (presumably) capacity film unit at zero volts, if not elsewhere.

Since my profession is one of electrical engineer at an electric supply authority, I think it instructive to note that capacitors used on the power system are, these days, almost entirely film types utilizing polypropylene dielectric. We don't like 3rd harmonic generation, terrible dissipation factor and high internal losses – presumably that is why electrolytics have not penetrated the market! My opinion is that if Mr Self lashed out and bought the film capacitor, ditched the electrolytics, and listened, he would indeed hear the difference.

As for the use of decent connectors that don't tarnish, I will use gold plated units myself. Everyone else can do what they want. I only suggest reference to power system usage of continuing low resistance connections. Meanwhile I would appreciate hearing Mr Self's rebuttal to my remarks and for him to generate a design without tone controls.
W. M. B. Armstrong
Halifax
Nova Scotia
Canada

Improving colour television decoding

This Pal modifier, which switches the V-axis signal for decoding across adjacent lines, results in full luminance bandwidth and a sharp picture, although to some it may appear busy with aliasing dot crawl. But when an adaptive notch is added, continuous high-band luminance and its associated aliasing is filtered out, large-area 'business' is removed as well as horizontal dot crawl.

by D. C. A. Read
B.Sc. (Eng.), M.I.E.E.

To keep costs down a decoding technique involving only one chroma line was investigated. By using adjacent lines from the field, both spatial and temporal errors are reduced to a minimum because field-length or picture-length delays are not involved. If a delay of exactly 64μs is used the information is vertically coherent, although comb filtering by addition or subtraction across adjacent lines, as illustrated in Fig. 11 (a) left-hand side, results only in unwanted products because the two chroma components are mutually at right angles. On line N, V is vertical, On N+1 it is horizontal. The U signal behaves similarly.

Fig. 15 (a) and 15 (b) show the signals into and out of one-line delay (64 μs) with its PAL modifier. The PAL modifier removes the V-axis phase reversal and the phase setting of the $2f_{sc}$ signal (driving the carrier input of the modifier/modulator) rotates the vectors. Referring to the left side of Fig. 11 (a) and taking line N at the input to the 64μs delay line operated on by the modifier it emerges as in Fig. 15 (a) and 16 (b), which shows that the V-axis has been switched. Adjacent lines in the field can now be subtracted to cancel the chrominance to obtain luminance, but there is some luminance aliasing, shown as −Y in Fig. 15 (b).

Although the delay line used in a chrominance circuit is a quarter-cycle of the subcarrier short, to enhance U and V for feeding the chroma demodulators, in the luminance channel the delays are adjusted to be exactly 64μs between subcarrier inputs. The modifier can rotate all the vectors, removing the $\frac{1}{4}f_{sc}$ signal offset to the balanced modulator carrier input. The basic expression for PAL-coded video, Fig. 16 (a), defines the effect of the PAL modifier in mathematical terms, indicating that the ± signs are reversed to show the V-axis reversal by the modifier. Fundamentally, the spectral distribution of the V signal is asymmetrically disposed with respect to the subcarrier frequency, and this asymmetry reverses on alternate lines, Fig. 4. The effect of the modifier is to counteract this reversal.

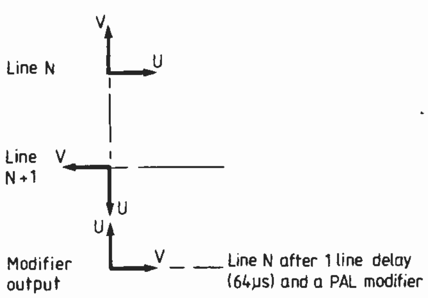
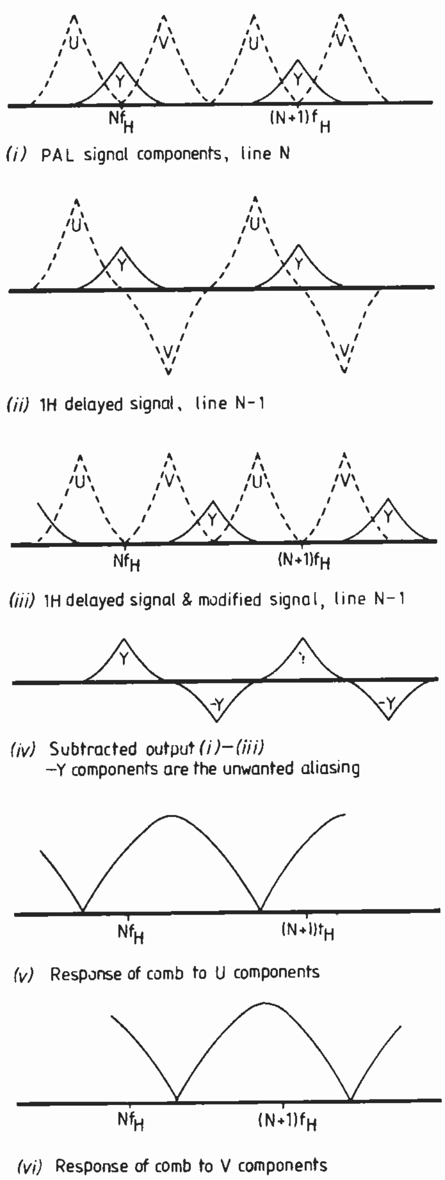


Fig. 15. PAL modifier chroma phase relationships (above) for line N+1 and line N emerging (at time of N+1) from line delay and modifier. Phase of $2f_{sc}$ feed sets output phase of modifier. (b) shows improved methods of decoding PAL signals using a modifier in the comb (right).



In the line sweep waveform of Fig. 17 (a) the upper trace is the notch, used when the comb filter breaks down, and the lower trace is the output of the modifier comb. The test signal frequency at the beginning of the line sweep test signal is approximately 0.5MHz, while at the end of the line it is nearly 6.5MHz. The effect of the modifier on the luminance channel response in the subcarrier area is thus shown.

The increase in signal amplitude shows that high-band luminance energy is passing through the modifier and is being modulated. This is an unwanted aliasing, not shown in the mathematical analysis, representing high-band luminance energy with a chroma subcarrier dot crawl, which effect is similar to viewing a saturated colour area on a monochrome set with no notch in the luminance path. In addition to this effect the lower trace shows that the modifier output extends to twice the amplitude of the original luminance signal, Figs 17 (a) and (c). Notice the increased bandwidth over which the comb is working compared to the sharp notch. This not only allows more of the chroma sidebands to be removed when comb filtering for clean luminance, but also reduces cross-luminance interference with less dot crawl on vertical chrome edges.

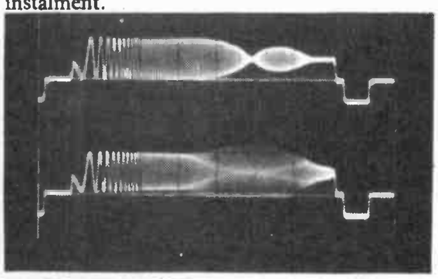
Subjectively the effect of luminance aliasing on pictures is not serious, so that when viewing with the chrominance circuit turned off and paying close attention to fine detail in the picture, the effect is only disturbing on high-detail, high-contrast signals. This is more than offset by the improved sharpness and freedom from notch rings.

A test signal which shows up the cross-luminance, notch and cross-colour effects particularly is a skew sweep, in which the video (sinewave) frequency is constant over the duration of each line but stepped up in frequency on each succsssive line, with the start-of-line phase maintained. This forms a field sweep. Fig. 17 (b) shows the test signal passing through the luminance notch, and (c) is the comb filter decoder with PAL modifier, showing the resulting alias (luminance channel only). Fig. 17 (d) shows the typical shape of the comb teeth when using two lines only for the comb filter.

Colour print 2* shows that the cross-colour from the diagonal luminance is far more serious than the alias introduced by the modifier. Fig. 12 (c) showed a three-line comb for obtaining clean luminance; there was no aliasing because a modifier wasn't used. But colour print 3 shows that luminance diagonal detail is lost where no cross-colour is present.

Because the comb filter method of decoding breaks down on horizontal colour transitions from line-to-line an adaptive detection technique is required to prevent horizontal colour changes producing high dot-crawl, comprising a notch filter which is automatically switched in or out of circuit. Such a scheme will also act when luminance detail produces a high level of aliasing via the modifier. The notch will switch in and reduce the aliasing visibility, unfortunately with a loss of luminance resolution because the notch reduces all the signal energy at 4.43MHz±600kHz (3dB points). Normally, adaptive detection recognizes the presence of non-correlation between adjacent lines of the chrominance circuits, but for simplicity the adaptive notch used detects the presence of energy at 4.43MHz in the luminance channel and therefore fulfils a dual role – horizontal colour change and high aliasing. The method of controlling an adaptive notch will depend on the type of encoder used; but as broadcasters would be unwilling to add a comb at the encoder (to reduce cross-colour and high aliasing), because of the large number installed in studios around the country, the simple solution is an adaptive notch, and this is developed later.

*Colour prints will be included in a subsequent instalment.



Pal modifier for switching V axis component

The modulated coded video signal is

$$E_m = E_y + E_u \sin\omega t \pm E_v \cos\omega t$$

Using the MC1596 modulator i.c. the signal is multiplied by $-2\cos 2\omega t$, that is the PAL modifier operation. Considering the chroma components only, the modifier output is therefore

$$E_m = E_y + 2(-E_u \sin\omega t \cos 2\omega t \mp E_v \cos\omega t \cos 2\omega t)$$

$$= E_y - E_u(\sin(\omega t + 2\omega t) + \sin(\omega t - 2\omega t)) \mp E_v(\cos(\omega t + 2\omega t) + \cos(\omega t - 2\omega t))$$

$$= E_y + (-E_u \sin(-\omega t) \mp E_v \cos(-\omega t))$$

$$= E_y + (-E_u \sin\omega t \mp E_v \cos\omega t)$$

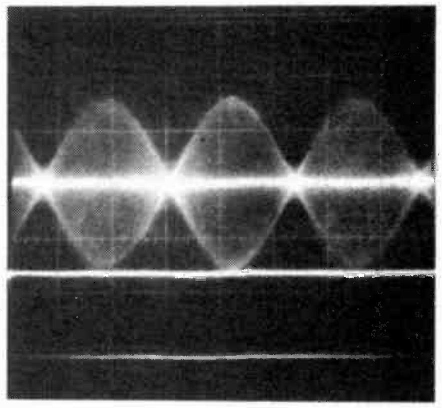
where ∓ sign indicates V signal inversion. The 3ωt components will be removed by the output filters.

Fig. 16. From the PAL colour television CCIR System I specification as drawn up by the BBC and IBA the equation for the complete colour television signal is as shown above. The modulation equals E_Y (luminance) plus $E_u \sin\omega t$ (B-Y weighted colour difference signal) $\pm E_v \cos\omega t$ (R-Y weighted colour different signal), where ωt represents the 4.43MHz subcarrier, and the sine and cosine terms signify quadrature modulation.

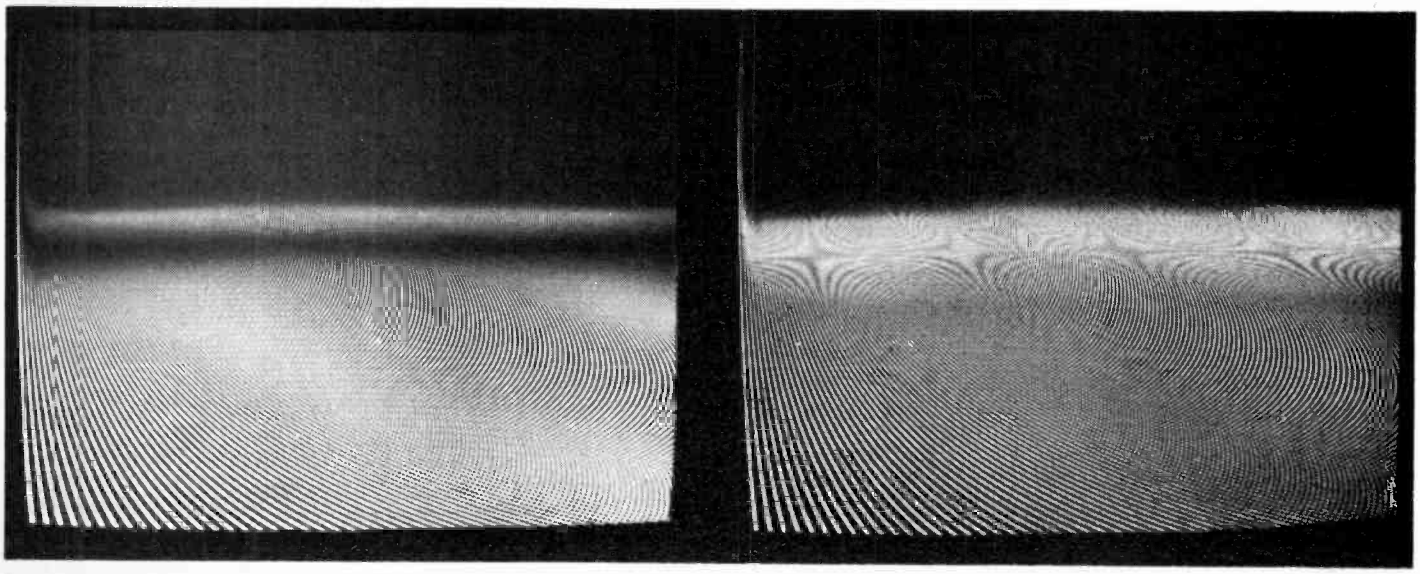
PAL modifier using balanced modulator

In the MC1596 balanced modulator used for the modifier, Fig. 18, the $2f_{sc}$ feed is normally obtained from the low impedance output pin on the PAL decoder i.c. assuming a $2f_{sc}$ oscillator. Alternatively, a crystal oscillator running at $2f_{sc}$ under the control of a phase-locked loop could be employed. Two divide-by-two circuits triggered by the negative or positive-going zero crossings of the 8.8MHz sinewave provide the U and V 4.43MHz demodulating carriers in quadrature directly, without involving delay techniques.

Fig. 17. Traces taken using a tv line sweep test signal (a), left. Video frequency starts at about ½MHz increasing to 6-7MHz at the end. TV screen photographs show the effects of notch and comb on a field sweep signal (below). Notch causes information loss and the comb results in aliasing. With this signal the top tv line is about 10MHz and the frequency steps down to 800kHz on the bottom line. In the subcarrier region the luminance diagonal detail sweeps from near-vertical to near-horizontal. Trace on right shows the shape of comb teeth using two adjacent lines from a field (d).



The top trace in Fig. 19 is the gaussian-filtered U and V modulated by the coder with some of the upper sideband removed by the output filter, as developed across the bases of the lower long-tailed pair of Fig. 18. The second trace is the carrier input at $2f_{sc}$ balanced on pins 7 and 8 of the MC1596 modulator. The final trace is the output, the carrier having been suppressed by balancing at pins 7 and 8 with a potentiometer (in the circuit to be shown later). The final diagram also shows how the spectral energy has been reversed, with added energy at $3f_{sc}$ which is later removed by the luminance filter, also to be shown in



the final circuit of the revised PAL decoder.

In the receivers which have been modified it was found easier to introduce a separate chroma delay line, as it is normal practice to use the chroma delay line present in the decoder chroma circuit for addition and subtraction enhancing of the U and V components. As a result it is difficult to extract the chroma part of the PAL signal at the output of the chroma length line; because these delay lines are fairly cheap (£2-£3) a separate chroma length delay line as shown in Fig. 20 was used. Also the chroma bandpass filter was improved to form a symmetrical gaussian filter with good group delay performance (i.e. linear phase) that is symmetrical about the subcarrier. Details of the filter are shown later.

Notice the broken line from the output of the chroma bandpassfilter in Fig. 20. This, and a signal of equal amplitude from the modifier output, are fed to the two inverting inputs of the summing circuit (both at half level) so that, when subtracted from the direct signal on the non-inverting input, the circuit will maintain a constant luminance amplitude sweep but the apparent luminance detail in the subcarrier region will be halved when viewed on the picture.

Also shown in broken line on this circuit at the output of the summer is a 'tee-ed off' subcarrier detecting circuit. This simple tuned circuit detects the high-energy 4.43MHz components and modifies one part of the output filter to introduce a notch at 4.43MHz. The output filter has phase equalization which represents several hundred nanoseconds of delay. The delay equalization is placed first in the circuit and the last filter element is the part that is modified to form a notch by the 4.43MHz detector circuit. The notch therefore is switched in before the actual luminance components that are to be removed reach the end of this circuit, having passed through the group delay equalization and the earlier section of the filter.

With horizontal colour bars fed in and the subcarrier-detecting adaptive notch circuit turned off (by lifting one end of the capacitor in the series resonant circuit), Fig. 21 shows that an on each horizontal transition the subcarrier is no longer subtracting since the colour has changed across the adjacent lines. On subtraction large components of unattenuated subcarrier appear.

A field where both luminance level and colour have changed is shown in Fig. 22 (a), top trace. The middle trace shows the luminance output with the adaptive notch working. Observe at the beginning of the line that a small pip occurs where a part cycle of subcarrier is visible because the time taken for the notch to operate is not fully compensated by the delay of the early part of the filter (plus its group delay equalizer). The bottom trace is the direct control voltage on the fet used to add a capacitor in the filter bringing a section to resonance at 4.43MHz. The long delay on the trailing edge is found to be advantageous on the picture using electronic graphics and printing. For example, the top of a letter T will bring the notch on, and if the tops of Os and other rounded letters appear on the same tv line, the notch will still be on and dot crawl will not occur around these edges although the amount of energy associated with a rounded top surface would not have been

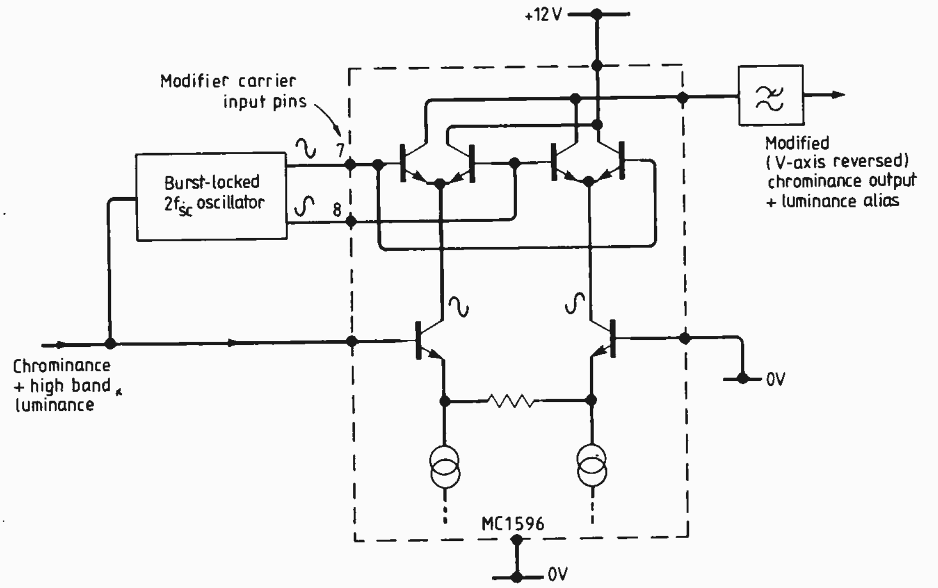


Fig. 18. Pal chrominance modifier with $2f_{sc}$ oscillator locked to incoming burst using MC1596 i.c.

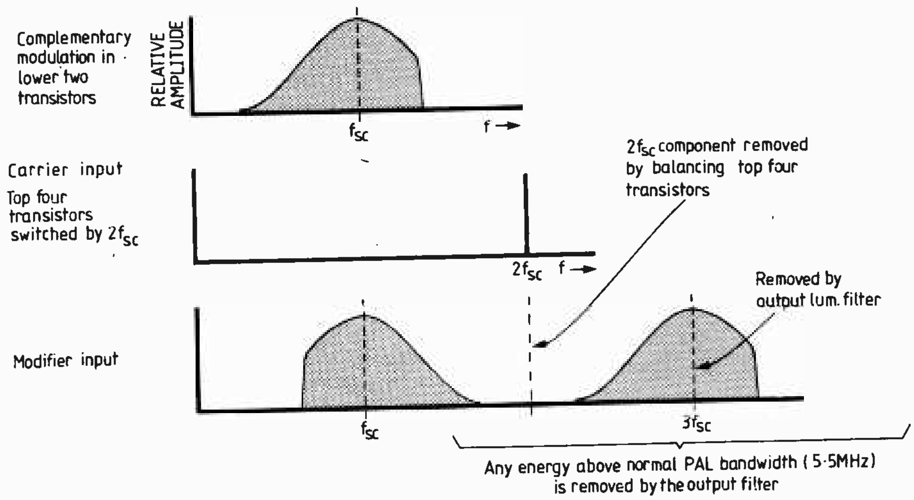


Fig. 19. Modifier chrominance signal envelopes show reversing of the sidebands as the carrier input is high w.r.t. the video signal.

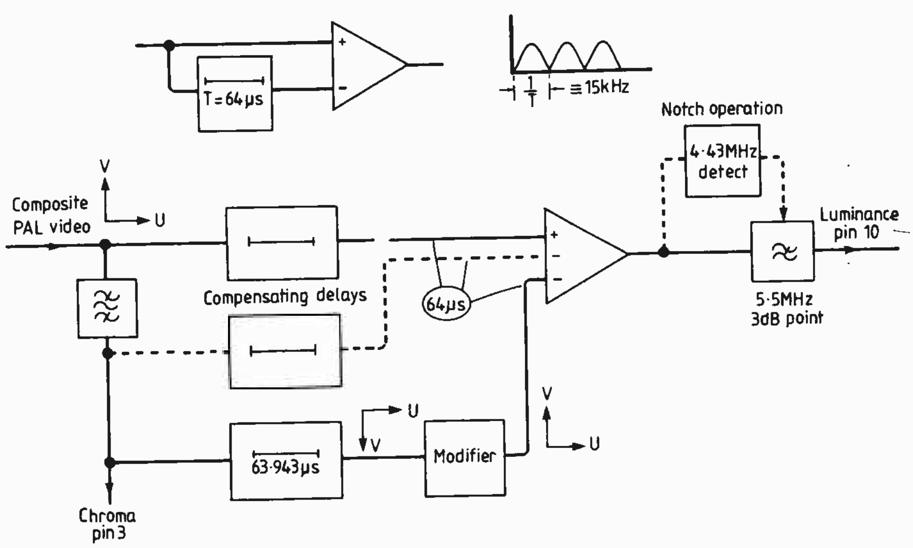
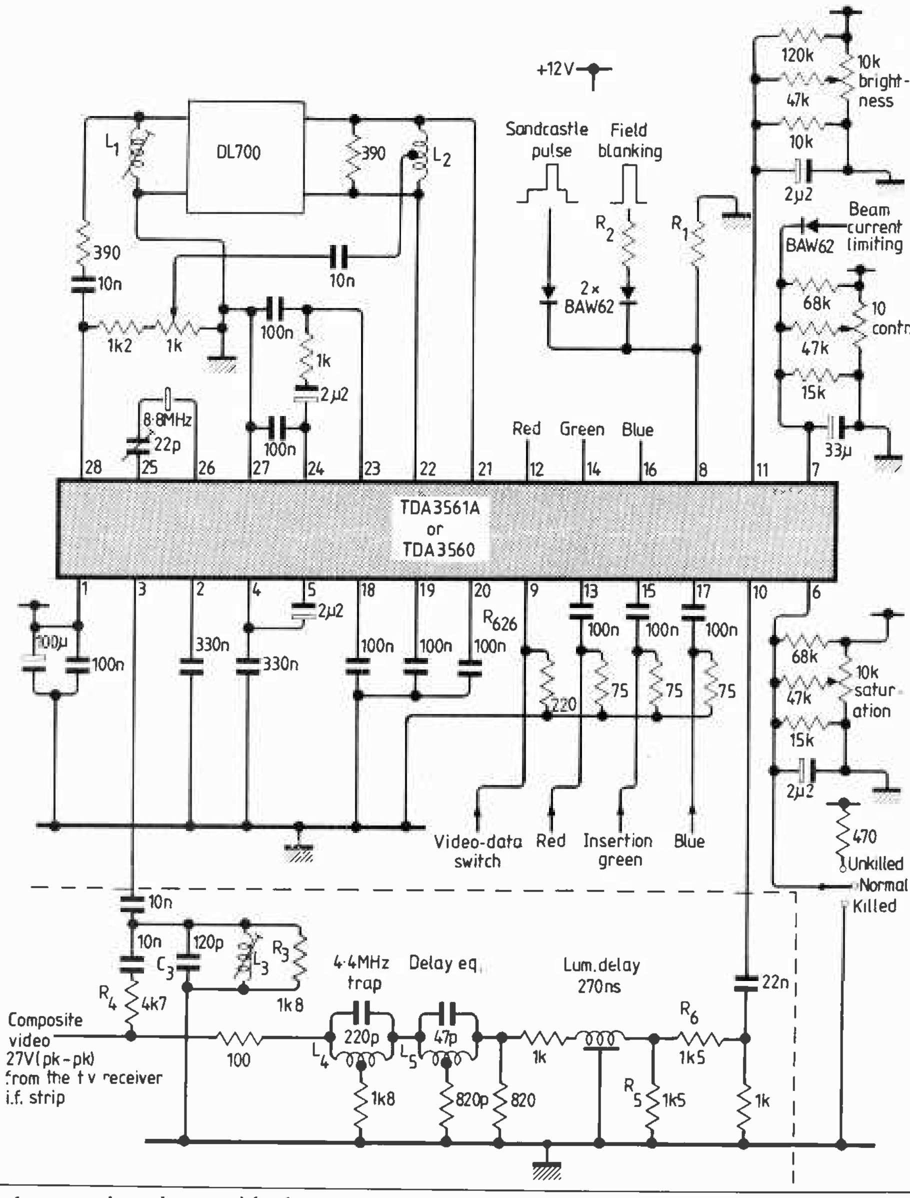


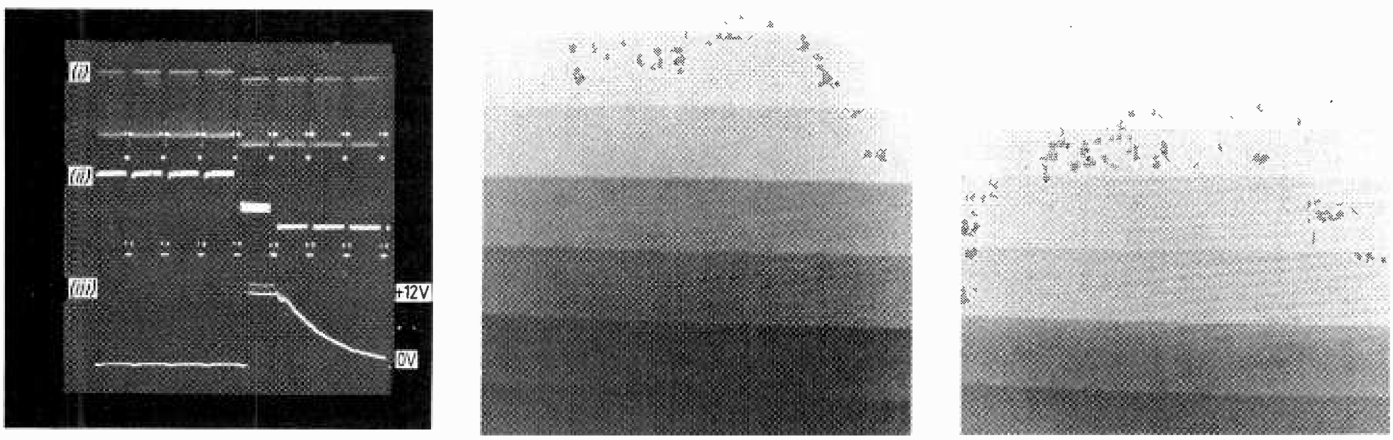
Fig. 20. Combing across adjacent lines with the aid of the PAL decoder (page 54, bottom). Block diagram of the PAL decoder is for Mullard one-chip decoder TDA3561A (or 3560). Components within broken-line area are replaced by diagram on p.54; pin 10 is luminance input, pin 3 chroma input.



sufficient to bring the notch in. The notch effectively stays in for approximately half a line once it has been switched in by a strong component at 4.43MHz. Fig. 22 (b) and (c) show pictures of the television screen (testing signal, 100% horizontal colour bars) without and with the adaptive notch.

The middle trace of Fig. 23 (a) shows the luminance output for 100% vertical colour bars, with the cross luminance at transitions much reduced. Also, during the burst period at the beginning of the line, there is little evidence of colour subcarrier in the black level. The bottom trace is the original notch decoder which shows the greater residual subcarrier; (b) and (c) show the resulting pictures. The zone-plate test signal of figure (d) provides a luminance sweep at all radial angles, with (e) showing the response of a notch decoder and (f) the modifier comb with aliasing. Care must be taken not to allow any circuits to overload as the harmonics produce indecipherable patterning, as shown in colour print 4.

Traces in Fig. 24 (a) show the inverting and non-inverting inputs; the output summing point is shown in the bottom trace of (b). The envelope timing is matched, i.e.



(a) *(i)* Input composite PAL signal
(ii) Comb Y out
(iii) Control voltage to f.e.t. switching in adaptive mode. F.e.t. is fully on at +3V

(b) (c)

Fig. 22. Operation of adaptive notch (a). Screen photographs are taken without (b) and with (c) the adaptive notch in the luminance channel. Notch removes dot crawl on horizontal colour changes where the comb, subtracting across adjacent lines in the field, would otherwise cause large components of subcarrier to appear.

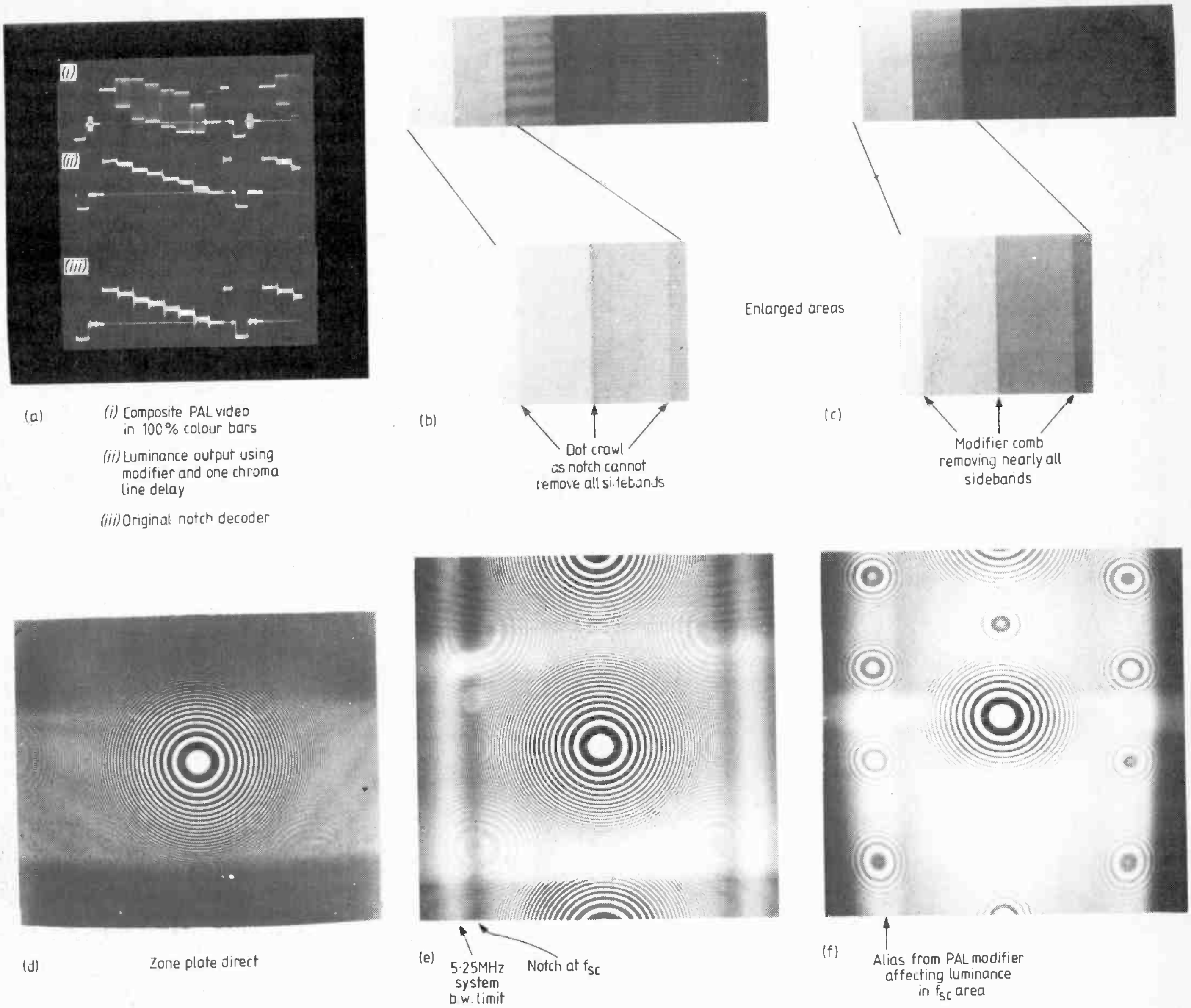


Fig. 23. Oscilloscope photographs show effect of the notch compared with the modifier comb decoder in the luminance channel (a). Horizontal dark bands on (d)-(f) are due to the camera shutter not being synchronized to the tv scanning system, please ignore and accept apologies.

the two traces of (a) are delay-adjusted to obtain the 64μs spacing, and the colour subcarrier phase and amplitude values are also balanced to achieve cancellation. In the top two traces of (b) the carrier frequency has been shifted slightly by removing the 25Hz term and changing ¼ to a ½ in the subcarrier expression, the result being that the subcarrier is now stationary with respect to line timing. You can now see that phase (group delay) in the gaussian chroma bandpass filter and the cheap DL60 chroma delay line, figure (c), reduce the ability to obtain cancellation at the vertical colour transition where the sidebands generated are large. Residual error is shown in the bottom trace, Y-out, (b). Some is also due to the changed rise times of the subtracting chroma transitions due to the reduced bandwidth of the chrominance signal. Comparison of the two traces at (a) shows this rise time difference. Colour print 5 shows the effect of the reduced rise time on the chroma-only display.

To be continued

Fig. 21. Oscilloscope traces show how the comb filter breaks down on horizontal colour transitions. Test signal is 100% horizontal bars. On certain transitions, the subcarrier adds to produce large amplitudes, as shown. See also Fig. 22(a) showing one transition enlarged.

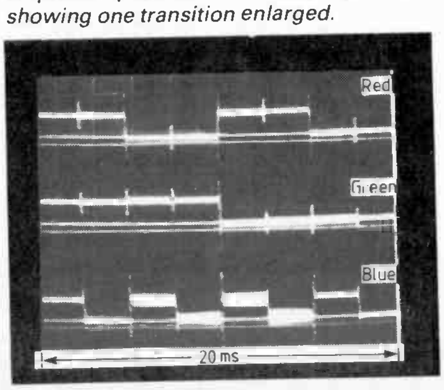


Fig. 24. Bottom trace is the PAL modifier and one-line delay signal which cancels the chroma of the top signal to provide clean luminance. (Top trace is a composite PAL signal of 100% colour bars at the green-magenta transition.)

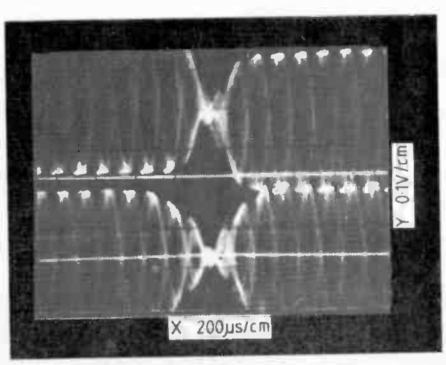
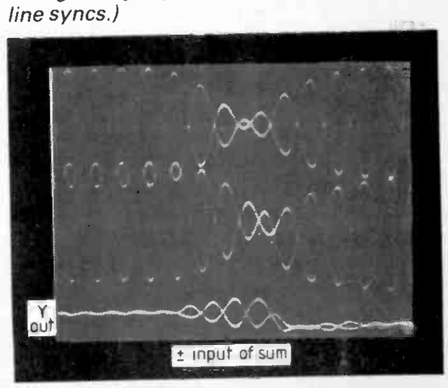


Fig. 25. Group delay errors in the chroma delay line, and changed rise times, detract from the cancellation in the Y output in the bottom trace. Middle trace is the input composite signal. (Subcarrier frequency changed slightly to make it stationary w.r.t. line syncs.)



Constructor's r.f. generator

An a.m. radio chip is the basis of this low-cost design covering 100kHz to 30MHz in five ranges.

By L. Boullart

It is a regrettable fact that there is at present little interest among amateurs for self-built a.m. or f.m. tuners. However, in the last few years an ever increasing range of integrated circuits, coils, ceramic resonators and so on has become available, and it is easier to build a home-made tuner than ever before. Perhaps one of the reasons for the general reticence is the lack of adequate measuring equipment. The present article will deal with a reliable instrument for the alignment of a.m. and f.m. tuners: an r.f. generator.

At the heart of all r.f. signal generators is a variable frequency oscillator or v.f.o. A fet oscillator makes a simple and reliable generator of high frequency sine waves, capable of working over a wide range of frequencies (Fig. 1). However, this simple

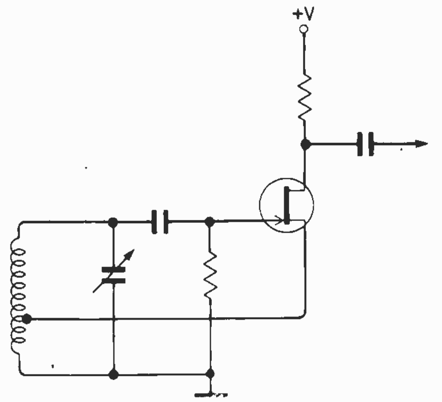


Fig. 1. Output level of this simple oscillator varies with frequency and the tapped coil makes range-switching complicated.

circuit has two major drawbacks:

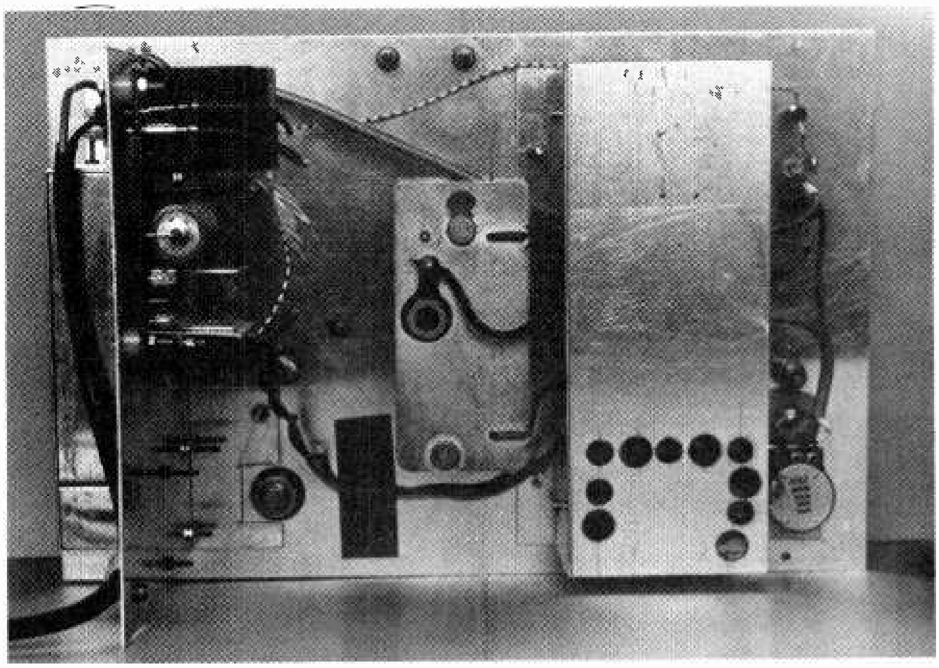
- The r.f. output will not be constant, and will vary substantially between extremes of 100kHz and 30MHz.
- The need for a tap on the coils or a coupling winding greatly complicates the switching arrangement for the different wavebands.

An oscillator with a constant output and a two-pole connection for the oscillator coil is much to be preferred. One such configuration is based on a kind of r.f. multivibrator driving an LC tank circuit in the collector of the first transistor (Fig. 2). Since the circuit is driven by square waves, the output remains virtually constant over a wide frequency range.

The Mullard TDA1072 integrated circuit is ideally suited for this particular application, since it has a buffered oscillator output (Fig. 3). Amplitude modulation could be applied to pin 1 (the i.f. output) via a resistor, but a modulation depth of 16% for 1.2V r.m.s. input is as much as can be achieved in this way. Because the output impedance at pin 10 of the TDA1072 is rather high, separate arrangements must be made to obtain a 50 ohm r.f. output impedance. It is therefore more convenient to apply amplitude modulation elsewhere in the circuitry by means of a dual-gate mosfet in a common-source configuration. The second gate which stands normally at +4V can be used for amplitude modulation up to a depth of 50%. Incidentally, a modulation depth as great as this will result in excessive harmonic distortion: 30%, or even a bit lower, is a better figure to aim for in practice.

A serviceable instrument should also include a calibrated attenuator; and a ladder network consisting of a series of T-attenuators will do the job very nicely. Six independent push-button switches are used: one for 6dB, one for 14d, four for 20dB attenuation. In practice, however, it should be noted that the last 20dB or so (below about 10μV) cannot be relied upon because of reactive coupling and losses. Table 1 gives full details of the attenuator networks.

Lastly we have to consider the audio oscillator for internal modulation. A Wien bridge oscillator based on an operational amplifier with a thermistor in the negative feedback loop for stabilization will deliver 1.2V r.m.s. with 0.01% distortion, but this is far better than required; besides, the thermistor is a rather expensive component.



Rear view of the assembly: the r.f. generator board is enclosed in a screening box and the power supply is fixed to a bracket on the left.

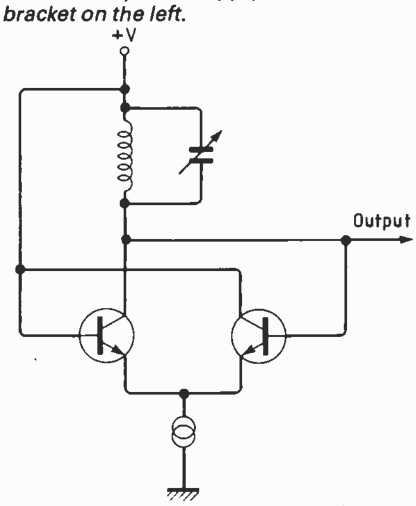


Fig. 2. This more complex design is similar to the oscillator in the TDA1072 i.c.

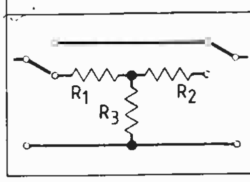
As an alternative, silicon diodes can be used to stabilise the signal amplitude provided the polarising current is kept quite small. With three silicon signal diodes in series, the oscillator shown in Fig. 5 (IC_2 etc.) will yield a 1.2V r.m.s. sine wave with a distortion content of between 0.1 and 1%.

A common emitter transistor (emitter follower) ensures a low impedance output and the R-C low-pass filter in its base reduces the total harmonic distortion to 0.06 to 0.6% for a 0.6V r.m.s. signal amplitude. The lowest distortion will be attained with R_{18} adjusted carefully to the point at which oscillation begins. The output of IC_2 at pin 6 must not be allowed to exceed 1.2V r.m.s.

The full circuit of the signal generator is shown in Fig. 5. The five frequency ranges are selected by the switch S_2, for which only two tuning-scales are necessary: one for ranges 1,3,5 and one for ranges 2,4. Each range can be adjusted individually by means of a trimmer C_{21} (22pF) and the ferrite core of the coil.

The r.f. output at pin 10 of the TDA1072 is approximately 65mVr.m.s., of which 50mV is available at the input to the attenuator. The audio modulation depth can be varied from 0 to 50% with R_1 and external modulation can be selected by S_2.

Table 1. Resistor values for the calibrated attenuator.



Atten.	R1,R2	R3
-6dB	15Ω	68Ω
-14dB	33Ω	22//330Ω
-20dB	39Ω	10// 270Ω

Construction notes

The complete r.f. and a.f. sections are mounted on a single printed circuit board which includes the coils and the range switch S_1. Coil details are given in Table 2. The six push-button switches for the attenuators and their associated resistors are mounted on a separate printed circuit board. The attenuator assembly is divided into six compartments by tin-plate or copper screens soldered to the p.c.b. between the switches. Both boards must be encased in a metal screening can.

The tuning control used in the prototype is a much cherished 1950-vintage dial drive assembly. It is highly unlikely that such an assembly would still be available on the market, and so this aspect of the mechanical construction is left to the ingenuity of the reader. The nearest replacement I have been able to locate is a 70mm scale and reduction drive by Nimi Seiki. A Jackson Brothers SM6 slow motion drive could also be used.

It is advisable to keep more or less to the layout shown in the photograph, with R_1 and S_2 to the left of the main board, the tuning capacitor somewhere in the middle and the attenuator to the right. The attenuator is mounted on a perpendicular aluminium bracket, with the power supply on the other side as far away as possible.

WW

L. Boullart, who lives in Antwerp, became interested in electronics at the age of 12. Since retiring from his career in teaching in 1976, he has concentrated on measuring equipment. Mr Boullart has been a regular contributor for 30 years to periodicals in Belgium, the Netherlands, France and Britain.

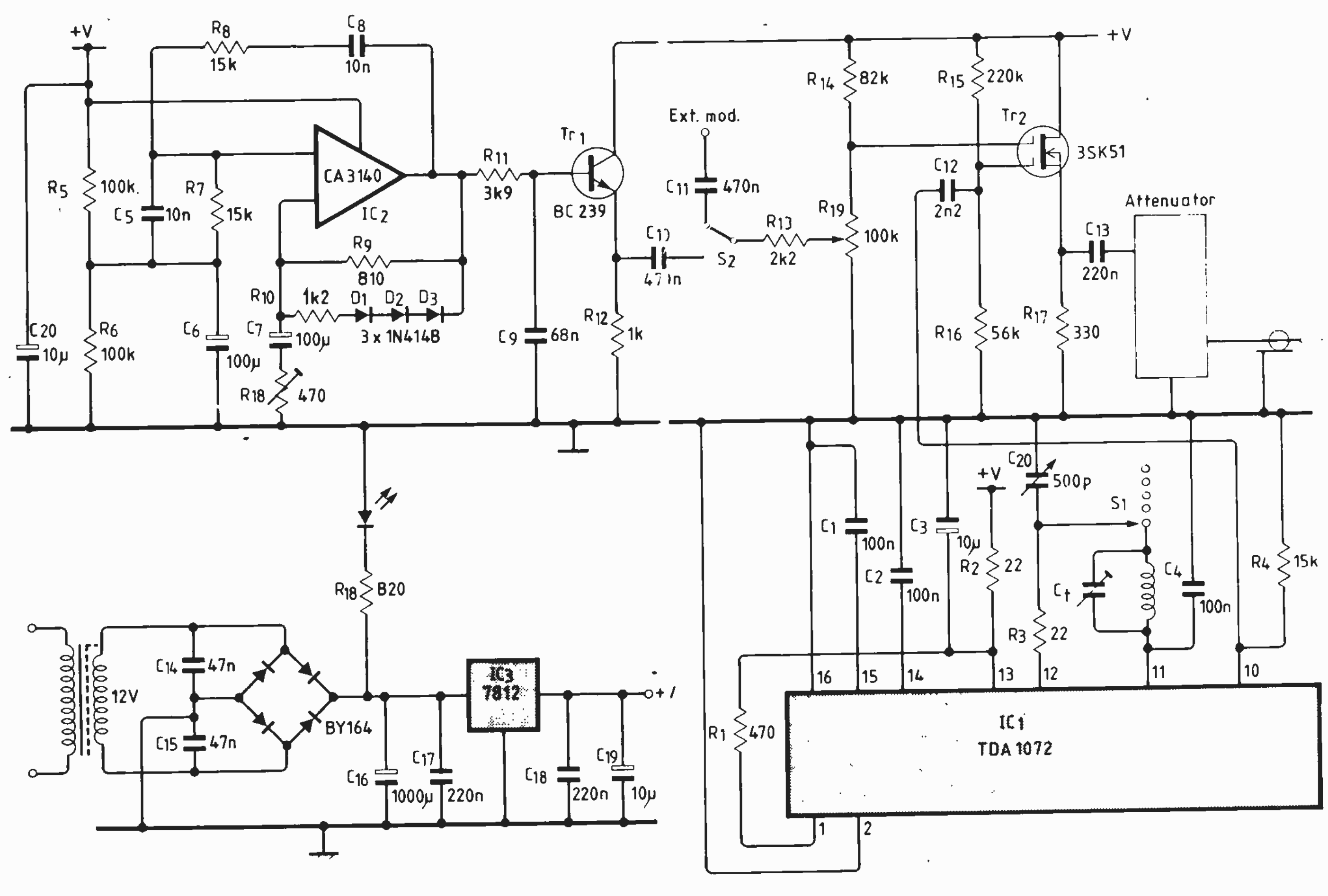
● A set of two ready-drilled glass fibre printed circuit boards is available for this project. The boards, which will accomodate the r.f. generator and the attenuator (though not the 12V power supply) can be obtained by mail order from Combe Martin Electronics, King Street, Combe Martin, Devon EX34 0AD. The price, £6, includes component plans and postage inland or overseas.

Range	Inductance	Toko coils	Base view	Pin connections
1	5mH	CAN 1980 BX	O1 4O O2 O3 6O	2 - 3
2	550µH	YHCS 1A589 R		1 - 3*
3	50µH	154FN 8A6438		1 - 3
4	5·5µH	154FN 8A6439		1 - 3
5	0·5µH	S18 8 ½ turns	----	----

*Remove capacitor

Table 2. Coil details. Pins 4 and 6 must be clipped off with a sharp cutter. Toko coils are stocked by Ambit International.

Fig. 3. Circuit diagram of the signal generator. S_1 selects the range by switching in one of a bank of five coils (see Table 2). Amplitude modulation is provided by IC_2: a modulation depth of up to 50% is possible.



Advance into the past

Ivor Catt looks at the inhibitions imposed on designers of computers by the conventional mythology of devices and architecture.

by Ivor Catt

Rational forward progress in computer technology could only be achieved if a significant proportion of computer scientists had some mastery of most of the technologies and disciplines involved. Unfortunately this is not the case, because the necessary spread of knowledge and understanding – from semiconductor physics at one extreme to complex software and computer applications at the other – is too broad.

Computer scientists habitually assume that the conventional wisdom, or myth, imposed on other specialities than their own, is true. They find it convenient to base their views on the state of the art in other fields on information supplied by amateurs rather than those actually working in them. A specialist in any one field tends to see his professional survival as depending on the stabilization of the conventional-wisdom straight-jacket which at one time or another has been imposed on every other speciality. This is because change in these other fields would make his own speciality too fluid, and he would not survive . . . a point of view which, although usually subconscious, sometimes comes out into the open.

For example, around 1970 it was commonly said, "We are having so much difficulty mastering the software of present computers that it is important, *if we are to progress*, that computer hardware be frozen for a decade or more." Some readers will see the irony implicit in this comment, which was often made by programmers with no knowledge of engineering, which meant virtually all programmers. There followed an explosion of complex software techniques, including list processing, which could have been much more easily achieved by hardware modification; but this option had been outlawed. The result was an increase in the complexity and confusion of already over-complex software, and a deterioration in the overall position.

In general, all other disciplines ganged up on each individual discipline and forced it to remain essentially static, at least in its perceived structure when it interfaced with other disciplines. Examples are:

● The blocking of any blending of memory and processing, any move away from absolute von Neumann, and strict adherence to the 'von Neumann bottleneck', even though at one extreme the technology was demanding it and at the other extreme almost all applications were demanding it.

● The blocking of any deviation from the traditional drift from fully serial machines to fully word-parallel machines, even though (a) the technology demanded a reversal towards serial working, (b) the change in the relative cost of circuit and interconnection demanded it, and, strongest of all, (c) a strong mythology had developed that the computer industry was combining with an avowedly serial industry, telecommunications (citing the appointment of a Minister for Information Technology as evidence). Here we see one myth combating and overcoming another, unfortunately the wrong one, "fully parallel fetishism", being the victor.

● The imposition for all time of the t.t.l. logic signal as industry standard. This occurred even though t.t.l. logic, which came into general use in spite of its weaknesses in design (including the heavy standing current in signal lines, the high signal swing, etc), had given way as the industry standard circuit to c.m.o.s., which had much greater circuit density, in which a very different logic signal standard would have been more efficient.

● The maintenance of a key feature of the thermionic valve – the idea that hermetic seal was necessary to stop the cathode from burning up – well beyond the disappearance of the cathode through drastic changes in the technology towards silicon semiconductor l.s.i. Few computer engineers realise that the 'hermetic seal fetishism' which continues today in v.l.s.i. chips dates back to the danger of allowing oxygen to reach a hot cathode, and has nothing to do with semiconductor technology.

● The inexplicable standardization, without a murmur, on the use of Kovar as the metal for the leads coming from an integrated circuit chip, even though every parameter of Kovar except one is bad in this application. The one good parameter is that Kovar wets to glass, so allowing the formation of a hermetic seal. Kovar's bad features include the following:

– It has rather high electrical resistivity, so degrading performance by creating extra voltage drop in the signals entering a chip.

– It is magnetic, so that signals into a chip are delayed, and energy wasted, while the magnetic field is built up.

– It is not ductile, and work hardens fast, so that there is an unnecessarily large risk of fracture due to bending or vibration.

– Worst of all, it does not wet to solder. In order to make it possible to solder to a Kovar lead, the lead has to be gold plated. However, during the soldering process, the gold dissolves into the solder, creating a brittle alloy and also, should soldering and de-soldering be repeated, the dissolving away of all the gold and the creation of a dry, non-wetted joint between solder and virgin Kovar.

● Microprocessor manufacturers have displayed ignorance of the mechanism of digital signal propagation and voltage decoupling. Placing voltage pins at opposite corners of the package, thus introducing a large single-turn inductor in series with the voltage supply, is the worst possible pin choice, limiting the speed of microprocessors and also making them pattern-sensitive. Although only marginally significant in the old 14 or 16-pin dil integrated circuit, the problem created increases rapidly as the square of the package length, making the large microprocessor chip slow (only 4 MHz), pattern sensitive, and dependent on the layout of the host printed-circuit board in a manner not understood (and so not predicted) by system designers.

● Looking at another aspect of the standard package, I suppose that I should be relieved that the industry did not standardize on the even more absurd IBM SLT package, 1965 vintage, which had a line of pins down all four sides of a square package. When deciding how the pins should exit from an integrated circuit package, the decisive aim should be to minimize the obstruction of printed circuit conductors in the host p.c.b. The two, unrelieved, lines of pins are about as obstructive, and therefore as inefficient, as it is possible to devise (*pace* the IBM SLT). Alternate pins should have been staggered, and this is a simple operation (which would not have created significant problems in the manufacture of i.c. sockets). I only mention this to show how thoughtless and casual developments have been, not to propose change at this late stage.

● The standardization by the industry of t.t.l. with its totem pole (push-pull) output was based on the mistaken idea that the load seen by an i.c. output is capacitive. This was true for thermionic-valve logic gates, with their high impedance, low current outputs, but ceased to be true when we used transistors, at which point the load seen by a fast output became resistive; either a transmission line characteristic impedance (resistance) or a t.t.l. input load (also essentially resistive). Whereas a capacitive load could helpfully be driven push-pull, today a resistive load can perfectly well be driven by one transistor, as is demonstrated by the fact that the fastest existing circuit, 1 ns e.c.l. has a single transistor output.

Speed of logic

Generally, the limiting factor in the speed of logic is not the time taken for a transistor to switch on or off, but rather the time taken thereafter for the switched current to charge or discharge the stray capacitance in the line connecting this transistor to the next. A good measure of the delay involved, i.e. the gate delay, is gained by multiplying the resistance of the drive transistor when switched on by the stray capacitance that it has to drive.

When a bipolar transistor, as used in a t.t.l. circuit, is switched on, its resistance is less than 10 ohms. The capacitance of the line, or wire, on the printed circuit board joining this output to the next logic element is of the order of 20 picofarads. Multiplying these two together gives us a time delay of 200 picoseconds. This shows us that, from this point of view at least, sub-nanosecond logic speeds are possible and we do not pay a speed penalty if our logic signals skip from chip to p.c.b. to chip to p.c.b. and so on.

In stark contrast, the smallest possible unipolar, or mos transistor, when switched on, still has a resistance of 10,000 ohms. If it drives 20 picofarads of capacitance on a printed circuit board, the delay, or signal rise time, resulting would be 20 pico multiplied by 10,000, that is, 200 nanoseconds. So if the physically smallest possible (i.e. square) cmos output transistor has to drive a signal off the chip onto the printed-circuit board, the achievable speed is only 200 nanoseconds, that is, one thousand times slower than bipolar t.t.l. This dire situation can be improved by making the drive transistor bigger and so reducing its resistance. Actually, we might put ten square transistors in parallel to reduce the resistance from 10,000 ohms to 1,000 ohms. However, the price we pay is that these drive transistors have to be made very big, consuming large areas on the surface of the silicon chip. This undermines the reason for using mos which is that an mos circuit takes up less area on the chip than does a bipolar. By the way, if we make the output transistor more beefy, we can make the mos output t.t.l. compatible, and this is usually done.

Let us now consider the situation when a cmos signal on an l.s.i. chip goes from one logic stage to the next without leaving the chip. In this case, the stray capacitance which must be driven is only one tenth of a picofarad, and if the drive transistor is the smallest possible, i.e. 10,000 ohms resistance, the time constant, or delay, is only 1 nanosecond. From this we can deduce that it is not true that cmos is slow. Cmos signals across the chip have a high intrinsic speed, and so inter-chip circuitry should be serial, since this will reduce the amount of circuitry required for each function. (It is ridiculous for operations inside current microprocessor chips to be fully parallel. However, if someone made a serially operating microprocessor chip, probably nobody would buy it because, although its performance might be the same as its parallel competitors, the news would get out that the serial microprocessor contained very little hardware; there would be nothing for the salesmen to boast about.)

Note that if, by increasing the size of an output transistor by putting a number of square transistors in parallel, the output resistance of one bit of a 16-bit bus leaving the chip is brought down to 1000 ohms, so that the speed (rise time) is reduced to 20 nanoseconds, but sixteen such large transistors are needed to handle the sixteen-bit parallel word, using up valuable area on the integrated circuit surface. The same output data rate could be achieved by combining all 160 transistors in parallel to drive the sixteen bits serially down only one wire leaving the chip. In this case, assuming the same amount of chip area for the single drive transistor, a resistance of one sixteenth of 1,000 ohms could be achieved, leading to a bit rate of nearly 1,000 megabits down the single line. The point being made here is that *parallel working does not enhance speed if the circuits used are cmos*. On the other hand, a heavy price is paid when we go fully parallel – extra cost in wiring and extra pins in the i.c. package leading to extra failure (since the main cause of failure is the interconnections) and also far more failure due to pattern sensitivity with parallel data busses. Also, parallel working increases the pysical size of the resulting system, because size is largely dictated by number of interconnecting wires. It also forces us to use extremely complex, expensive test and debugging equipment including logic analysers with their awkward, octopus-like probe pods. By comparison, it is trivially easy to attach a single oscilloscope probe to a point where serial data is passing.

The Nub of computation

The heading of this section is purposedly inappropriate, to illustrate the problem at the very start. The 'computer science' discipline has come to think that its objective is 'computation', 'information processing' or some such. This is not true, or alternatively, if it is true, then 'computer science' is getting in the way of a much more important discipline, which is the application of technology to society's needs.

In our society or culture, certain historical necessities arise. It is usually thought that whether or not a certain development was a historical necessity is proven after the event by whether such a thing in fact came to pass. I think this is wrong. For instance, the wheel and axle was clearly a historical necessity in both Europe and the Americas, and the fact that the natives of the Americas never used the wheel and axle does not prove that it was not a historical necessity. More generally, we can see the extreme cases where a tribe or genus dies out because it evades a step which is a historical necessity.

Our society may well avoid historical necessity in the development of computer science, but that does not in my opinion negate the fact that what follows is a historical necessity.

The proper objective for computer science or digital electronics is to apply technology to meeting human or sociological needs. (This is a quote from my 1969 *New Scientist* article[1]) I would probably limit the broad range of application to physical, not intellectual, needs.

Any physical situation which our technology can usefully be applied to will be a multi-dimensional array of values which need (a) analysis and (b) manipulation. Digital electronics won over analogue twenty years ago, I believe for ever, and so our machinery needs to contain a *digital analogue of reality*, and in fact always does so. One measure of the elegance of our machinery, and probably of its efficiency and simplicity is the ease with which the analogue in our machine maps onto the reality of which it is an analogue. The design of an elegant (and also one suspects efficient) machine requires of the designer knowledge of the physical reality which is the target of our machine; of the nature of data manipulation and computation; and of the physical nature of the machine.

Since the ideal seems to be a machine which can be regarded as a *physical analogue of reality*, and the closeness with which the machine's structure and information mimics the physical reality, the 'computer scientist' must have competence in all fields above.

The problem is that today, programmers, calling themselves computer scientists but having no competence in anything except the second (with perhaps a little competence in the first), think they can usefully contribute to the design and development of our future machines.

A second measure of the elegance of our machinery is the degree to which changes in the physical reality we are mimicking (or recording) in our machine can be easily effected in our machine. This is why a machine is very bad if it does not have content-addressable memory, and in fact it needs more than that. It needs processing capability *in situ* in the memory. This is because values or parameters in physical reality change *in situ*, influenced only by parameters which are physically nearby. This leads to the next requirement of a good machine, which is that since in physical reality there is not action at a distance but all interaction is local, our machine should have superior (or even only) interaction capability between values (vectors, scalars, etc.) which relate to physically close points in the physical reality. Further, it appears that the ability to effect interaction between values which relate to

continued on page 72

Radio activated implant for bladder control

Neurological prosthesis aids patients with spinal cord injuries by stimulating motor nerves

One of the distressing results of injury to the spinal cord is the patient's inability to control the passing of urine in the normal way. As is well known, paraplegics suffer paralysis in varying degrees to the lower part of the body because of the failure of motor nerves, coming from the damaged spinal cord, to innervate the muscles connected to them. Action potentials in these nerves are absent or very weak. Urination is affected by a failure of innervation in two muscles. One is a smooth muscle which surrounds the bladder and applies pressure to empty it – a detrusor muscle. The other, around the neck of the bladder, is a sphincter muscle which opens and closes the outlet for urine.

If the spinal cord has not been severely damaged the patient may regain some measure of reflex control. But many paraplegics have large residual volumes of urine which can cause urinary infections and, in extreme cases, disease of the kidneys. One treatment for this condition is to disable the sphincter muscle by surgery, but this results in permanent incontinence and the need to wear a urine collecting device.

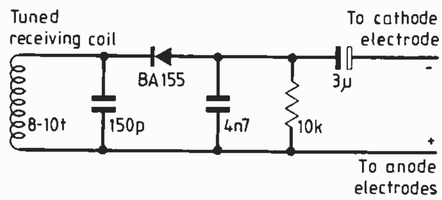
Over the last twenty years or so attempts have been made to give the paraplegic patient a means of voluntary control over bladder emptying by applying electrical stimulation to the appropriate motor

by Tom Ivall

nerves. These techniques have used implanted electronic devices with stimulating electrodes that are attached in some cases to the bladder wall, in others to a part of the spinal cord and in yet others to motor nerves emerging from the spinal cord.

One of the latest and most successful attempts at providing such voluntary control has been made by the Medical Research Council Neurological Prostheses Unit in South London. Based on research by the neurophysiologist Professor G. S. Brindley[1], it has resulted in a practical, near-field radio activated stimulator which is now being manufactured on a small scale* and implanted in a steadily increasing number of patients (26 at the time of writing). Earlier work by the MRC Neurological Prostheses Unit on electronic implants[2,3] has already been reported in *Wireless World*[4,5].

Electrically, the principle of the bladder control prosthesis is fairly simple, as shown in Fig. 1. Stimulating pulses are applied bilaterally to nerves at three levels



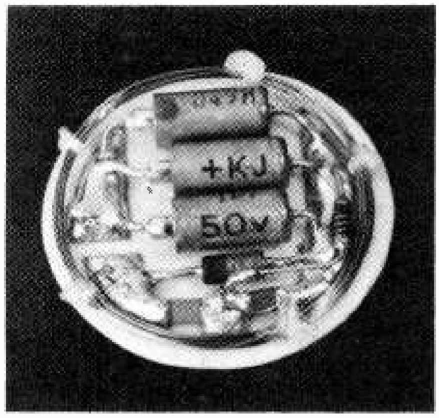


Fig. 2. Circuit (a) and construction (b) of one of the three receivers in the chest implant.

by electrodes fitted inside the outer covering (*dura mater*) of the spinal cord. These electrodes receive current pulses from three miniature radio receivers implanted as a single unit under the skin of the lower front chest wall. The receivers are simple passive circuits with a tuned coil, a semiconductor diode detector, and an RC time constant (Figs 2 and 3).

To apply stimulation the patient switches on a small hand-held unit and holds a three-coil oscillator block to the front of the chest immediately over the implanted receivers. The block generates pulse modulated r.f. power of constant amplitude, giving a combination of pulse frequency, pulse duration and pulse grouping previously determined by stimulation tests on the individual patient. The electromagnetic field passes through the patient's clothing and skin to the receivers, where the r.f. signals are demodulated to produce d.c. pulses. These pulses are carried by an implanted flexible cable to the

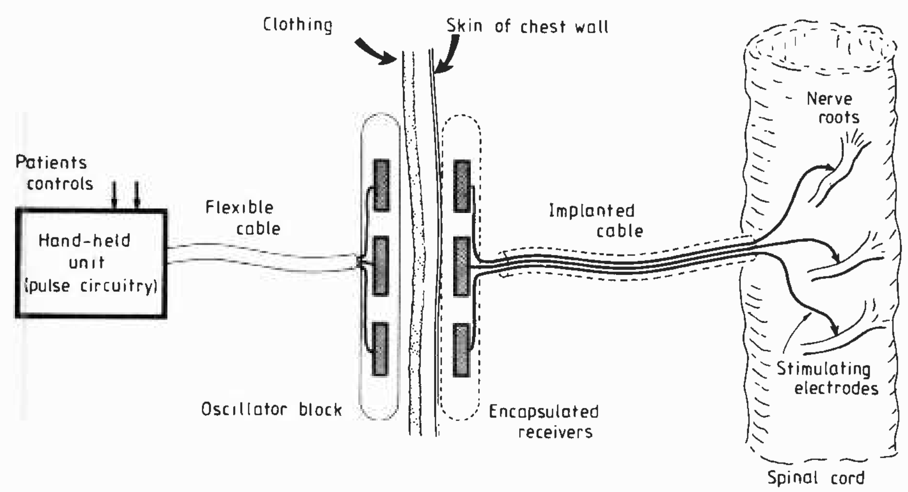


Fig. 1. Schematic showing principle of bladder control prosthesis. The implanted part of the stimulator comprises a receiver unit, a flexible cable and an assembly of stimulating electrodes.

*By Finetech (Engineering) Ltd of Welwyn Garden City, Herts.

stimulating electrodes. All energy is supplied by the transmitter, so there is no need for implanted batteries.

The achievement in developing this electronic implant does not therefore lie in any great originality of the system as a system. On the physiological side the major problem is to find the right pattern of stimuli to innervate the detrusor and sphincter muscles successfully. This varies from patient to patient, depending on individual nerve anatomy and the nature of the spinal injury. On the electronic engineering side the real achievement lies in the techniques of constructing and packaging an implant that will work reliably over a period of years in the extremely difficult environment of the human body.

This environment is a warm, saline vapour produced by the body fluid. It's difficult to think of anything much worse for causing electrical leakage, corrosion and short circuits in the implanted receivers. And within the spinal cord the cable to the electrodes has to pass through a layer or sac of cerebrospinal (CS) fluid between the outer covering and the inner connective tissue of the cord. Fortunately, the MRC team, led by P. E. K. Donaldson, has had long experience, nearly twenty years, of coping with just these conditions.

Nerve root stimulation

Spinal nerves emerge from openings between the vertebrae in the spinal column, roughly at the levels where the associated sensory or motor functions take place in the body – though some of the nerves, of course, then have to travel downwards from the spine. These spinal nerves are trunks containing both sensory and motor nerve fibres. For the bladder the nerves emerge through the sacral vertebrae, a group of five bones fused together in a mass immediately above the four lowest vertebrae (also joined together) forming

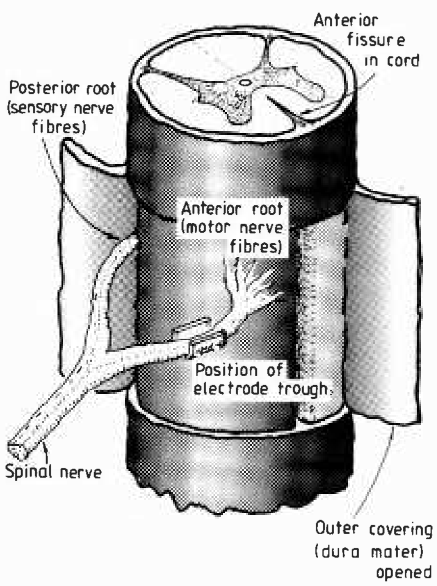


Fig. 4. Greatly simplified diagram of motor (anterior) and sensor (posterior) nerve roots coming from one half of the spinal cord at one level (assume a similar structure for the right-hand side of the fissure). Stimulating currents are applied by electrodes to motor nerve roots.

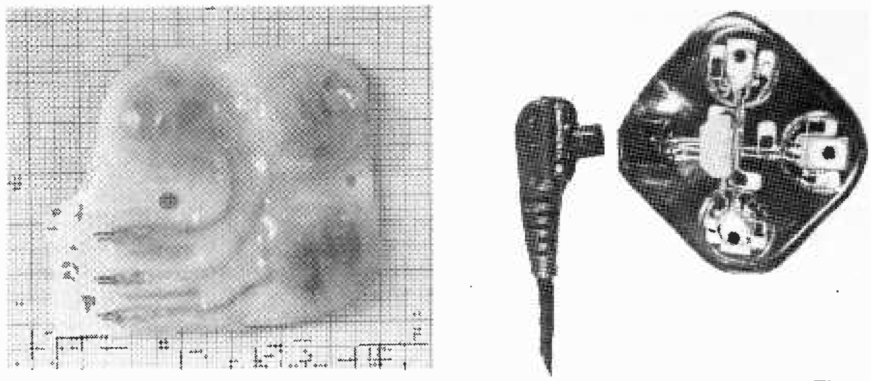


Fig. 3. (a) Complete three-receiver implant after encapsulation in silicone rubber. The three plugs mate with sockets on the implanted cable. (b) The corresponding oscillator block as used by the patient.

the coccyx.

Because the nerves contain both types of fibres, the motor fibres have to be distinguished from the others so that the stimulating electrodes may be attached to these alone. This can only be done at a point along the nerve where the trunk divides into separate sensory and motor nerve roots, which join the spinal cord at different places.

The highly simplified diagram in Fig. 4 shows this at one level and for one half of the cord. Motor nerve fibres arise from roots at the front of the spinal cord – the anterior or ventral roots – while the sensory nerve fibres come from roots at the back of the cord – the posterior or dorsal roots. So the stimulating electrodes must be attached to the anterior roots in the sacrum. These are in fact identified anatomically as the S2, S3 and S4 anterior roots.*

In a surgical operation the dura mater is opened at a point just above and including the top part of the sacrum and the required anterior nerve roots are identified by their size and position. This identification is tested and confirmed by electrical stimulation during the operation. The S2 and S3 roots are large and so can be easily separated into motor and sensory groups of fibres, but the S4 roots are too small to be separated.

Stimulating electrodes for these nerve roots are mounted in small silicone rubber 'troughs', into which the nerve is laid as shown in Fig. 5. Each trough contains three U-shaped platinum foil electrodes and the nerve lies loosely inside them, immersed in the CS fluid. A silicone rubber lid is latched on to the trough to ensure that the nerve is retained. The reason for the use of three electrodes for each motor nerve is to prevent stimulation via the CS fluid of nearby sensory nerves, which might cause the patient to feel pain or other disturbing sensations. The middle electrode is a cathode, while the other two, which are connected together, form an anode. The cathode is connected via the cable to the negative terminal of the receiver's d.c. output and the anode to the positive terminal. As a result of this tripolar structure most of the electric field energy due to the cathode-anode stimulating potential is confined to the spaces between the electrodes, predominantly along the motor nerve. Consequently the stimulating current does not spread outside the trough and affect other nerves.

* Here 'S' stands for *sacrum*, while the numbers identify the particular nerves. Numbering runs from 1 to 5 moving down the spine.

Because the nerve roots to be stimulated are close together the electrodes can be assembled into a unit, as shown in Fig. 6(a). The number of troughs used in the assembly and the disposition of the nerve roots in them depends on the stimulation requirements for a given patient. Details are given in Reference 1. In the Fig. 6(a) assembly there are in fact four sets of cathode-anode electrodes, with one trough extended beyond the others in a stack so that nerve roots at different levels can be stimulated. Fig. 6(b) shows how the S2, S3 and S4 nerve roots, from both halves of the spinal cord, are located in the four troughs.

Once the nerve roots are held in their troughs the dura mater is closed over the assembly. The cable passes through an aperture in the dura mater via flexible grommet or sealing flange which serve to prevent escape of CS fluid from the spinal cord. Of course, the covered electrode assembly makes a bump on the side of the spinal cord and a piece of bone has to be removed from inside the spinal column to make room for it.

Receiver implant and encapsulation

As can be seen from Fig. 3, the three receivers are assembled and encapsulated to form a single implant with miniature plugs for connection to cable sockets. Each receiver is constructed on a platinum-gold thick film circuit with a circular (18mm dia.) alumina substrate. An 8-turn receiving coil runs round its periphery. The BA155 diode is encased in glass and has Kovar leads, while the tuning and reservoir capacitors are leadless chip types. The 3μF electrolytic in the circuit is formed by three 1μF capacitors in parallel – tantalum electrolytics hermetically sealed in glass.

The purpose of this 3μF electrolytic is to prevent a net charge from being accumulated, pulse by pulse, in the capacitance of the stimulating electrodes, as this would eventually lead to gas evolution through elctrolysis. The purpose of the 10kΩ resistor is to complete a circuit, electrodes-capacitor-resistor, to provide a discharge path, in the intervals between pulses, for the small charges resulting from these pulses.

Encapsulation follows a general principle evolved by the MRC Unit over a good many years[2,3,5]. Namely, to prevent water from collecting in places where unwanted conduction or electrolysis could occur it is more effective to displace the water by eliminating voids than to try to set up a barrier against it. This means that all voids between parts must be completely filled, and this in turn means the use of an encapsulant with excellent adhesion to several types of surface.

In the subcutaneous receiver implant the environment is an ionised water vapour. Experience has shown that hybrid microelectronic components will operate successfully in the presence of such vapour – as long as it remains a vapour. An encapsulant will be effective if it prevents the vapour from condensing, molecule by molecule, into a liquid. Hence the need to fill the tiniest voids where the vapour molecules would have space to coalesce.

Epoxy resin encapsulant was found inadequate to meet this condition but the MRC Unit has had considerable success with silicone rubber adhesive. This substance has the apparent disadvantages of high permeability and rapid transmission of water vapour, but against these can be set the considerable advantages, for the present task, of low water absorption, high thermodynamic stability and extremely good adhesion to surfaces.

To ensure effective filling of all spaces between parts the silicone rubber adhesive is painted on, layer by layer, using a fine syringe. This means that the thick film circuit must be constructed so that the syringe needle can be inserted into all spaces. Thin spaces between parts must be designed out. As an example, the leadless chip capacitors are raised on plinths of solder at both ends so that they do not lie practically flat against the ceramic substrate, as in conventional construction.

Another critical factor in construction is the actual shape of the cavities left between the mounted components. In the curing of the rubber adhesive a slight shrinking occurs. Adhesion to two large-area opposite surfaces might continue to be perfect after curing, but the shrinking and consequent deformation might cause the cured rubber to be pulled away from other, differently shaped surfaces. The MRC Unit has made extensive studies of the adhesion behaviour of the rubber when filling various cavities and has found that a useful parameter for evaluating this behaviour is the ratio of the square root of the diameter to the length (e.g. of a 'tunnel' beneath a raised chip capacitor). From these studies it has been possible to design the receiver structure to give cavity shapes that help adhesion.

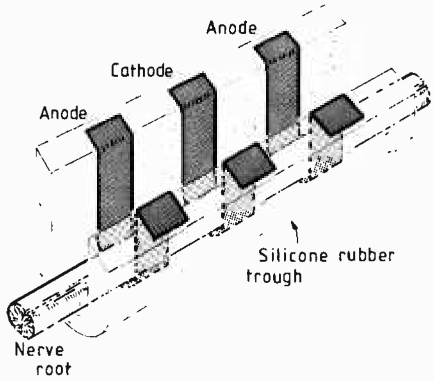


Fig. 5. Construction of electrodes for one nerve root. The middle platinum foil electrode is a cathode while the outer ones (connected together) form an anode.

Before the receivers are encapsulated they are rigorously cleaned to remove any contaminants resulting from construction, handling or atmospheric impurities, as these could dissolve in any condensed vapour from body fluid. The units are first washed in chloroform to remove flux and human hand grease, then in an alkali rinse, then in water which is continuously circulated through a deionizing column. The MRC Unit has built its own washing machine for this purpose. It comprises a bath, water pump and ion exchange column, with continuous electrical monitoring and recording of the water's resistivity as a measure of its purity. Whereas the theoretical ultimate resistivity of completely pure water is 22MΩ-cm, this washing machine runs until the circulating water has a resistivity of 10MΩ-cm after washing the receivers for about ¾ hour. Finally the receivers are dried in a drying cabinet and are then ready for encapsulation.

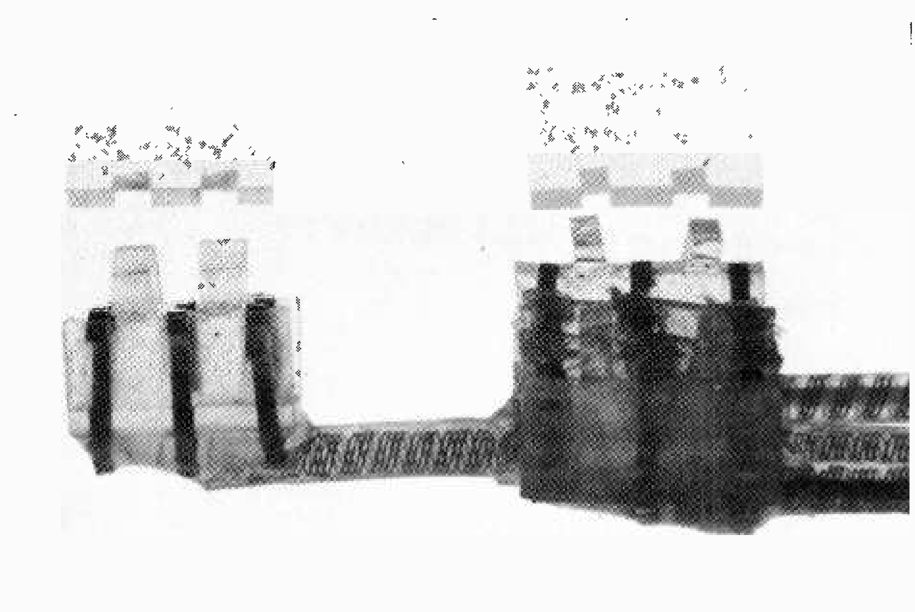
The final silicone rubber coating applied to the whole receiver implant contains an antibiotic powder with a shelf life of 9 months.

Connecting cable

The implanted cable connecting the receiver unit to the stimulating electrodes has been specially designed and made by the MRC Unit to meet some very stringent requirements. Chemically it must be indifferent to body fluid and non-toxic to the patient. Mechanically it must cope with potentially destructive local stresses resulting from deformations – stretching, bending, twisting and crushing – when the patient moves. For the sake of the patient it must have a long life and be sufficiently compliant to adapt to various postures. Electrically it must carry multiple conductors with a resistance low compared with the impedance of the electrode-tissue system. Medically it must withstand autoclaving before the operation.

A structure which fulfils these requirements, and has performed faultlessly in patients for periods of years, is shown in Fig. 7. Developed by J. D. Cooper, now retired from the MRC Unit, it consists of helixes of platinum-iridium wires insulated with polyimide varnish and embedded in silicone rubber. The conductors are 75μm in diameter and have a resistance of 2.2Ω per cm, while the overall diameter of the cable is 2mm.

Full details of the cable, the method of



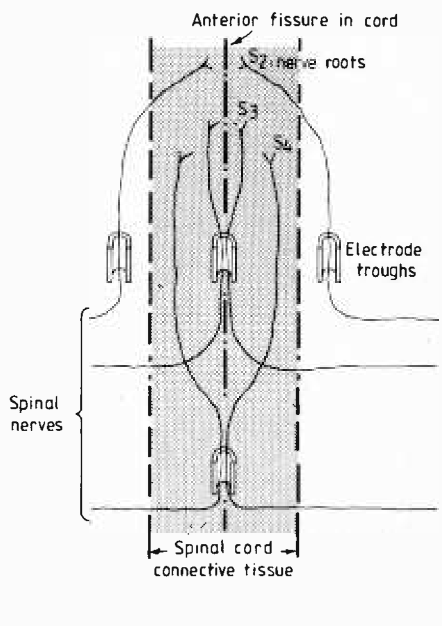


Fig. 6(a). Electrode assembly as implanted under the outer covering of the spinal cord. One set of electrodes is extended beyond the others because the nerve roots are at different levels. (b) Showing diagrammatically how the S2, S3 and S4 nerve roots, from both halves of the spinal cord, pass through the electrode troughs (here sketched as cylinders).

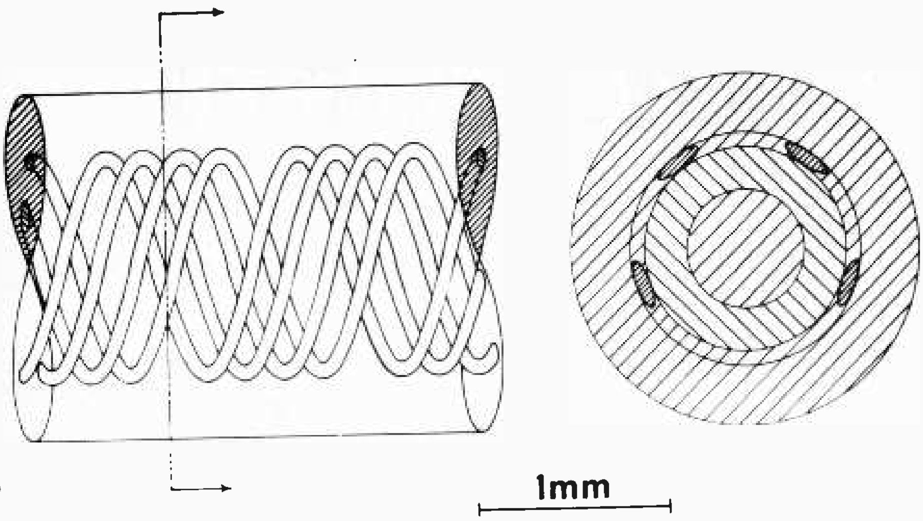


Fig. 7. Construction of connecting cable. The insulated helical conductors are wound on a silicone rubber tube and covered with an outer layer of silicone rubber adhesive.

construction and life testing results can be obtained from Reference 6. Briefly, the helical conductors are not damaged by body movements that stretch, bend or twist the cable, but implantation sites that might result in crushing (e.g. between bone and the skin) are better avoided.

A miniature plug and socket is used at the receiver end of the cable to allow the surgical operation to be done in two stages: first, implantation of the electrodes and cable; then, after about a week, implantation of the receiver.

Transmitter pulse generation

The patient's hand-held transmitter, shown in Fig. 8, is a case containing batteries and pulse circuitry, with an output cable connected to an encapsulated oscillator block of three Hartley r.f. oscillators. The pulse circuitry modulates the oscillators to produce constant amplitude pulses of r.f. at 6 or 8 MHz which are transmitted to the three implanted receiver coils. The modulating, and hence stimulating, pulses have durations of 100µs to 3ms and are generated in bursts (for a reason to be explained) with p.r.fs within these bursts of 30 pulses/s to 300 pulses/s.

For each patient the optimum pulse frequency and strength of stimulation are determined by tests carried out immediately after the implantation surgery[1]. The basic requirement, of course, is to stimulate the motor nerve roots in such a way that the detrusor muscle will apply pressure to the bladder and allow the urine to flow out through the urethra. As in all nerve transmission, the strength of a sensory input or muscle response is shown by the frequency of the action potential pulses travelling along a fibre. (Pulse amplitude is more or less constant as the action potential obtains its electro-chemical energy locally as it travels.) With the bladder, the detrusor muscle applies maximum pressure at stimulation pulse frequencies between 8 pulses/s and 30 pulses/s, depending on the patient.

A characteristic difficulty of the nerve root stimulation in this prosthesis, however, is that the detrusor and sphincter muscles are innervated through the same roots. Consequently root stimulation causes the sphincter muscle to close the neck of the bladder at the same time as the detrusor applies pressure to the bladder to empty it. There are several ways of overcoming this difficulty, but one that has proved successful with a large group of patients is to stimulate strongly with bursts of pulses.

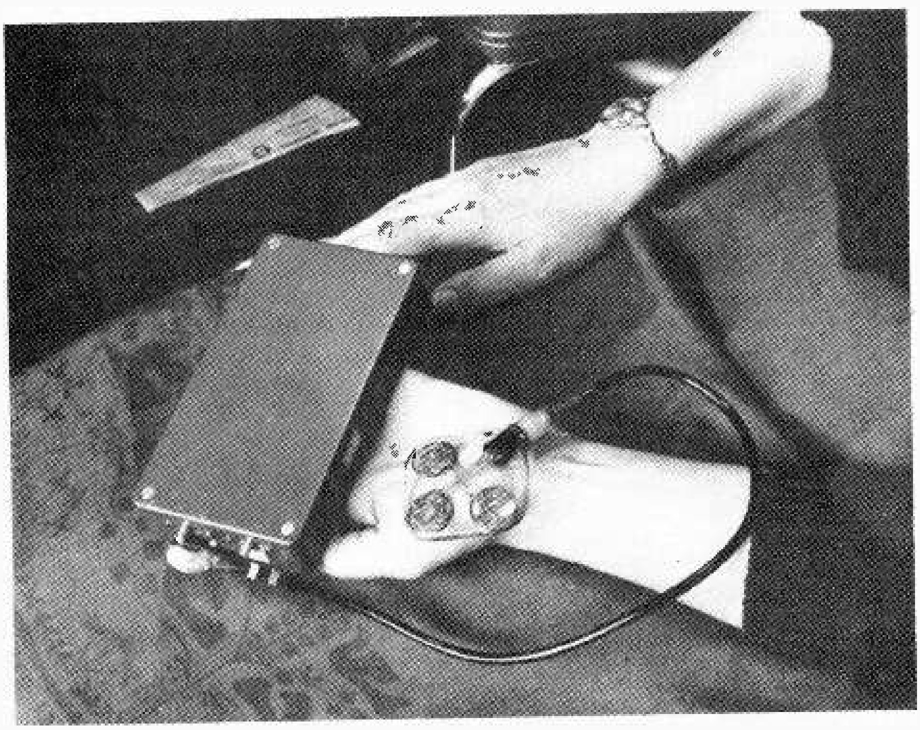
The pulse bursts are typically 1.5s in duration and generated at a frequency of about 14 bursts/minute. They are sufficiently frequent to ensure that the detrusor remains contracted to apply a continuous pressure to the bladder, but the sphincter has a faster response and allows urine to pass in the intervals of about 3s between pulse bursts.

To provide these stimulation requirements the transmitter includes an adjustable pulse generator set at the required p.r.f. for the patient, with its output gated by a burst oscillator that can be adjusted in burst frequency and burst duration. All these functions are provided by cmos integrated circuits and the stimulation parameters are selected by a d.i.l. switch on the circuit board.

Low-level pulses from this circuitry are amplified to about 50V to modulate the r.f. oscillators. The three Hartley oscillators are turned on in sequence by the modulating pulses, through gates operated by a scale-of-three counter. The purpose of this is to smooth the current demand on the batteries. R.f. output power from each oscillator coil is sufficient, at a range of 1 cm, to provide 25V into a 470Ω load at the electrodes.

As well as allowing the patient to control urination at will, the prosthesis can also be used to ensure continence at night during sleep. For this purpose the transmitter coil unit is secured on the lower chest above the receiver implant and the transmitter is set to give a weak continuous stimulation which keeps the sphincter muscle contracted and the neck of the bladder closed. WW

Fig. 8. The transmitter as used by the patient.



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Behind the micro

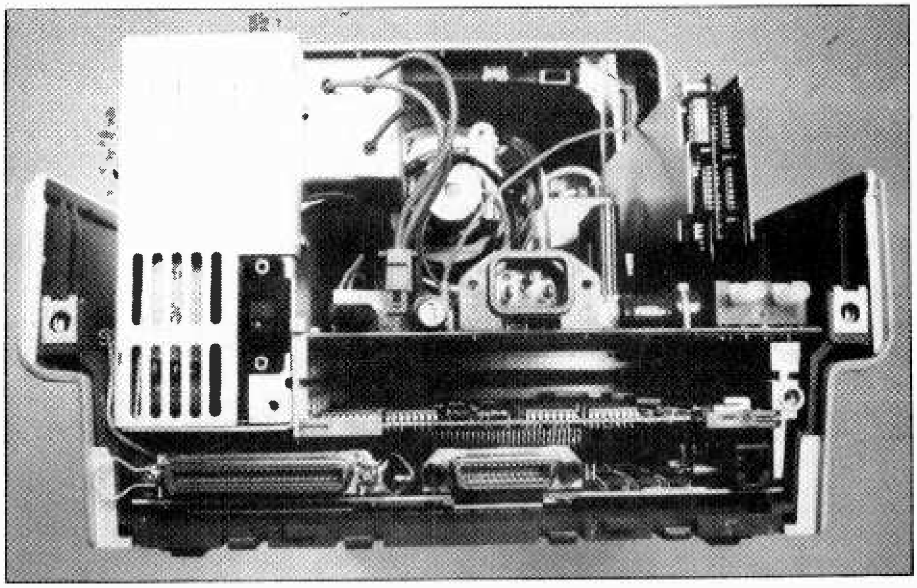
Inventive first-time buyers want to know about the inside of microcomputers but manufacturers usually give little away. This article – supplementing last month's microcomputer guide – will help you find and interpret the information that is available.

There are three main sections to this article. The first includes tips for first-time microcomputer buyers with emphasis on interfacing. Frequently used standard interfaces are briefly discussed. Secondly, a handful of computer boards is described to give you some idea of what they have to offer in comparison to the 'complete' microcomputers detailed last month. Sources of information for all computers and boards mentioned in this feature form the final section.

If you intend adding hardware to your computer, information and circuit diagrams are pf primary importance. It pays to check on how many books describing a computer are available before buying; the least one needs is full details of interface ports and their signal-timing and a description of how the computer is organized internally.

Choosing a computer with an industry-standard interface port is a good idea but such computers are usually expensive, as are the interface boards that connect to them. A port which brings all the processor signals to the outside world and allows address, data and control buses to be isolated from the microprocessor is the most useful feature for the experimenter, but few manufacturers provide one. With this type of port one need not rely on receiving full information from the microcomputer manufacturer, since data sheets from the processor manufacturer provide the finer details. But a sensible bidirectional parallel interface with a full specification suffices for all but the more exotic applications. In fact, most peripheral circuits may be controlled through the slower RS232 serial interface found on many computers, given the right software.

There are a few good microcomputers around for which there isn't a great deal of information. If you choose one of these, make sure that it uses one of the more popular microprocessors. As a designer of interfaces you will soon tire of writing programs in Basic and turn to machine code. There are many books describing machine-code programming for the popular processors which include the Z80, 6502, 6800 and 6809. Few of us can resist making modifications within the computer so a unit with a large physical size can be advantageous – provided it is well designed.



A 68000-based computer with half a megabyte of ram surrounds the c.r.t. in Hewlett Packard's Series 200 Model 16. Basic for this engineering system takes up 277K of memory, but is fast as some compilation takes place when the program is entered.

Computers for the work-bench

In industry, time and money is often saved if an engineer or technician can use an interface-circuit board designed by someone else, and where time is money, the costs of developing software must also be given consideration. Here the choice of a microcomputer is determined not so much by its price but by how many interface and expansion boards are available for it and by which operating systems the computer is compatible with. Popular interfaces will be described later. As far as software is concerned, one of the more popular disc-operating systems* such as CP/M and MS-DOS opens the door to a wealth of programs for design and development, but if one is considering designing microprocessor-based circuits on a regular basis a dedicated microprocessor-development system is the best choice.

Where applications software is more important than computer hardware it pays to look at operating systems rather than computers in the first instance. A list of applications software for the popular operating systems should not be difficult to get hold of. Once you have found the operating system with the most software to suit your needs, study it carefully and compare it against its competitors. Some operating systems are more efficient than others and choosing an efficient one is important, especially if you intend designing your own software. There are computers around that can run more than one operating system, as our list indicates.

Modifying a computer to run a disc-operating system is not always easy. For instance with CP/M – an operating system designed for Z80-based computers – hardware modifications will have to be made on computers not designed to run it and part of the CP/M software has to be modified.

For designers involved with developing software for new interfaces, programs which allow machine-code to be assembled (assemblers) and programs which make machine-code programs from high-level languages such as Basic (compilers) are important. Compiled machine-code programs are often not as efficient as they would be if originally written in machine code or assembly language. Languages such as Forth, which compile the program before it is run, are more suitable for real-time applications than languages such as Basic but they can be more difficult to learn.

Few programs run first time and debugging aids are essential for all but the smallest software projects. Most assemblers will indicate more obvious errors before or while they are assembling.

Eight or 16 bits?

Eight bit data-word processors used in today's microcomputers have 16 address lines allowing them to directly address up

*C. Gooding. Which os to back?. *Software*. June 1983 (origins and aspects of 15 operating systems, particularly useful to the newcomer).

to 64K-bytes (2^{16} eight-bit data words) of read-only and read/write memory (read/write memory is called random-access memory, or ram, but if you try to access it in a random fashion you get good results once in a blue moon). Generally, for computers designed for use without disc drives, between ¼ and ½ of the 64K-byte memory space is taken up by read-only memory (rom), holding the computer's language, which is usually Basic, and software under the vague heading of operating system. Most manufacturers don't differentiate between the operating system and the computer's language unless the operating system does something more than allow one to type in and run a program then jump out of the program again when something goes wrong. If a computer is said to have a large operating system alongside its language it is worthwhile looking into what the operating system does. If the computer language takes up an abnormally large amount of rom it also pays to ask why; it could indicate a versatile operating system, a powerful computer language or just long-winded software writing on the manufacturer's part.

Memory space can be extended above this amount in various ways. Some computers use paged memory in which two or more pages of say 32K-byte memory are switched between by software, and some use virtual memory in which pages of information are transferred between primary (usually semiconductor) and secondary memory (usually disc) by software, preferably without the user realizing it. All methods of extending memory are applied at the expense of something else such as processing speed, but many are very efficient.

Sixteen-bit processors on the other hand are not a problem as far as memory-addressing space is concerned – for the moment at least. Because 16 address lines and 16 data lines use up a lot of pins on the integrated circuit, the two buses are usually multiplexed into one, which might affect the complexity of a computer's interface port. Most 'second-generation' 16-bit devices have more than 16 address lines as shown below (note, there is no such thing as a Z8000 but there are two Z8000 family c.p.us called Z8001 and Z8002).

Processor	Address lines	Directly-addressable memory
68000	24	16M-byte
Z8001	23	8M-byte
Z8002	16	64K-byte
8086	20	1M-byte
LSI11/23	18	256K-byte
NS16000	24	16M-byte

Z8001/2 and 8086 c.p.us have a feature similar to Z80 and 8080 microprocessor which allows them to address 65,536 eight-bit i/o ports in addition to memory addressing.

For most interfacing, experimentation and hardware/software-design applications the increased processing speed offered by 16-bit processors will be far more important than the enhanced direct memory-addressing capability. But unless you need the large memory capacity offered by a 16-bit microcomputer, make sure that you can use the extra processing power and speed. Eight-bit processors are not yet pushed to their limits and there are still many reasons why an eight-bit computer might be the best choice. The computer itself will be much cheaper and so will its interface/expansion boards and peripherals i.cs. And there are large amounts of cheap, efficient and proven software for most popular eight-bit microcomputers. Writing machine-code programs for a 16-bit processor is also more difficult than an eight-bit device.

Clock speed is not always a good yardstick for processing speed when comparing microprocessors from different families. If you intend buying the microcomputer with the best microprocessor, look at the processor's instructions and how it operates rather than at the total number of instructions available, clock speed and the number of bits in the data word.

Peripheral i.cs

These devices, which include real-time clocks, parallel/serial converters and i/o controllers, lessen the burden on the processor leaving it free to concentrate on user programs. All functions carried out by peripheral i.cs can be carried out by the processor and software at the expense of memory space and processing time, so it pays to find out how many of these devices are, or can be fitted. Some computers have sockets for peripheral i.cs so that they may be added as desired. Data books from the microprocessor manufacturer will show which peripheral i.cs are available and what functions they carry out.

Cheap or expensive

It is not always apparent from technical specifications why some computers are cheap and others are expensive. If you find a computer attractive but you think that it is overpriced, ask why the price is so high until you are satisfied. On the other hand, if a computer is abnormally cheap, finding out why is not so easy. There are many ways of making a computer cheap. It may be manufactured in a land where labour is inexpensive. This is sensible and need not detract from the quality of the product, but the buyer should make sure that servicing arrangements are provided. Combining the functions of very many i.cs in a single i.c. called a logic array is another way of cutting costs without cutting quality. Experimenters will normally prefer having the separate i.c.s though, since they are more accessible.

Other methods of cutting costs may detract from quality. Processing power (i.e. electronic components) involves a small proportion of the computer's cost. Keyboards, connectors and printed-circuit boards are normally expensive and it is here where manufacturers often try to save money. For instance, keyboards may have keytops with printed legends as opposed to more expensive 'stick-of-rock' moulded legends and in time the printed types may wear off or be washed away by the wrong cleaning fluid. Many computers use the edge of the p.c.b. as a male connector for interface ports and this is fine provided that the copper on this sector of the p.c.b. is plated with a precious metal. If the computer works when you buy it, not much can go wrong with the p.c.b. but if you are thinking of making modifications inside the computer you may find that the copper tracks peel away from the board when you start soldering. Cheaper computers use few if any i.c. sockets which can also be a bind for the experimenter. There is no practical way of finding out the quality of the p.c.b. before buying but you can inspect the interface connectors and keyboard. Spend wisely, but remember that a computer that doesn't go wrong is worth much more than a guarantee in the long run.

User groups

Finally, find out if there is an independent computer users group for the computer you intend to buy. A good user group can be invaluable and will continue to provide you with information long after the manufacturer has lost interest in you.

Common interfaces and buses

Manufacturers, having designed a product, naturally want to keep buyers attached to them and in the computer field they often attempt to do so by introducing their own expansion bus. For companies like Hewlett-Packard, developer of the IEEE-488 bus, this has worked on a grand scale – the company not only designs computers for controlling the IEEE-488 instrument interface but also produces the measuring instruments controlled by it. But many other buses introduced by computer manufacturers, despite their quality, have not been so widely accepted.

Buying one's first computer is probably the biggest step and in the enthusiasm one will naturally choose the computer with the most impressive technical specification. If time stood still this would be the best buy, but as time goes on, one wants one's computer to do more. Manufacturers disappear and change direction but if you have a computer with a widely used interface it can be updated despite the whims of its manufacturer or the shareholders.

One of the commonest interfaces mentioned in computer specifications is the RS232 serial interface. It is neither fast nor particularly efficient in microprocessor terms but it is widely adopted and one can find many peripherals that suit it. Many microcomputers intended for serious use also have parallel buses but many of these conform to no standard other than the manufacturer's own. Below we describe some of the interfaces most commonly found.

RS232/RS422/RS423/ RS449/EIA

RS232C, defined by the Electronic Industries Association (American EIA) is the most commonly used serial interface standard and is almost identical to the CCITT V.24 interface standard. It will eventually be replaced by a group of three standards – RS449, RS422 and RS423. RS449 defines functional and mechanical characteristics of RS422 and RS423 which are electrical standards for balanced and unbalanced serial interfaces respectively. These new standards allow longer cables and higher data rates.

Only electrical/mechanical characteristics of the interface, functional descriptions of interchange circuits and standard configurations including synchronous and asynchronous communications are defined in RS232C (RS is recommended standard and suffix C indicates revision number). Signal coding is not defined. The standard defines a 25-pin connector but not a type, although a D connector is widely used, and the number of lines used for an 'RS232 interface' varies from computer to computer. Cable lengths of up to 15 metres may be used. In an RS232C signal, logic one is anywhere between −3 to −25V and logic zero is between +3 and +25V; cable loading is also specified as is a maximum data rate of up to 20kbit/s.

For the simplest bidirectional serial interface, only three connections are required; transmit data, receive data and ground. Hand-shaking is possible using a further two signals called clear to send and ready to send (CTS and RTS). Other signals on the 25-pin connector are for modem and terminal control. Many printers may be driven using an RS232 serial interface which means that they may be positioned a long way away from the computer, but circuits required to change from parallel-to-serial and back again add to the price.

Data sent through the RS232 interface may be in any code but ASCII is widely used for communications. A flexible serial interface will have the following options

- 5- to 8-bit data word length
- parity-bit enable/disable
- even or odd parity
- one or two stop bits

which are selected ideally by software but possibly by switches where a hardware serial interface is used. Data rates, normally expressed in baud, should be alterable either by software or by switches. Most modems operate at 300 baud or 75/1200 for Viewdata systems such as Prestel. Binary or b.c.d. words might be used in data-acquisition applications.

Adding a rudimentary serial interface to a computer is simple. If a parallel port is available, one may convert parallel words to serial and vice-versa in software and convey the serial words through one bit of the data bus to and from the outside world using suitable buffers. But this means quite a lot of work for the processor. Addition of a universal-asynchronous receiver/transmitter (uart) takes the job of timing and parallel/serial conversion away from the processor and allows selection of bits/word, parity checking, etc. Software for controlling such an interface may be simple; it becomes a little more difficult if you want programs interrupted on receipt of data. Efficient software for fully controlling a telephone modem can be difficult to write.

Communications interface

This term applies to an RS232 interface with a full set of modem and terminal control signals, as opposed to a communication interface which is a high-speed port allowing a computer to communicate with, say, a mainframe. Some computers have an inbuilt modem which is also a communications interface.

IEEE-488/GPIB/HPIB

This parallel bus is mainly used for controlling electronic measuring instruments and sometimes printers and other peripherals. Hewlett-Packard developed the bus and hence call it the HPIB. Others call it the general-purpose interface bus, GPIB, or the IEEE-488 interface after the standard which defines it. To add to the confusion, Ellefsen tells us in his article describing IEEE-488 in the June/July 1980 issue of *WW* that two other names are also used – IEC bus and ASCII bus. As with RS232, data coding and interpretation are not defined in the IEEE-488 standard; however, cable and connectors are.

Twenty-four lines are [illegible]sed, eight for grounding and shiel[illegible] [illegible]d 16 carrying t.t.l.-level signals. Ea[illegible] up to 15 devices connected to the bus recognizes its own address (or addresses). Seven of eight bidirectional data lines usually carry data in the form of ASCII words and the eighth may be used as a parity bit (binary or other codes may be used). All variable information, including addresses and control signals, is carried on the asynchronous data bus. Five of these lines carry addresses. In addition to the data bus there are three hand-shaking lines and five interface-management lines.

Statuses of connected devices vary; they may be 'talkers,' 'listeners' or controllers, or any combination of these three. A computer would normally be classed as a controller, talker and listener whereas a signal generator would paradoxically be a listener and a meter a talker since it would normally only talk to controlling devices. Cable length is up to twice the number of devices connected in metres or 20m, whichever is less, and the maximum data transfer rate is 1M-byte/s, although this speed is rarely approached in practice. Adding an IEEE bus to a computer is not easy. Special-purpose i.cs such as the TMS 9914 are available for IEEE-488 control.

S100 bus

This is a large bus – the 100 of S100 represents the number of lines used – and having been designed for an 8080-based system it has been around for some time. It has recently been revised for use with 16-bit processors and defined as IEEE-696. Until now, no recognized standard existed for S100 with the result that slight variations have appeared, especially from manufacturers producing boards and systems based on processors other than the 8080. Widely used in industry, this bus is well established and there are many S100 boards available with functions ranging from memory expansion to speech recognition.

The original S100 bus has separate eight-bit data input and output lines, which means that eight-bit processors have to have their bidirectional data-bus divided into input and output to make them S100 compatible. In the IEEE standard, these assignments are retained for eight-bit processors but when 16-bit devices are used, these 16 lines become bidirectional. Eight address lines have been added, bringing the total to 24 which represents an addressing capability of 16M-bytes. Although certain control lines have been added and others removed, the control bus is still well suited to 8080/A80-based systems. Sixteen-bit processors such as the Z8000 have multiplexed address/data lines which have to be separated externally. After separation, these buses connect directly to the S100 system.

The IEEE standard specifies a maximum data rate of 6MHz, bus length of 635mm and a maximum of 22 boards connected to the bus. Three spares lines are left for user options and four for future use. Some processors lend themselves to S100 busing. If you are thinking of adding an S100 bus to your computer after buying, it pays to look carefully at how the control signals of the computer processor compare with those required for S100.

Floppy-disc interface

There are interface standards for both 8 and 5¼in floppy disc-drives. As few computer manufacturers also make disc drives, their disc interfaces invariably conform to these standards to allow their product to accept any make of drive. The computer operating system usually determines whether 8 or 5in drives or both may be connected. There is no such standard in the '3in' microdrive world yet – even the sizes of the discs vary – and there is little 'off the shelf' software on microdiscs. However, most microdrives can store as much if not more information than a 5¼in drive and they are faster and rapidly becoming cheaper.

SASI/SCSI interface

Usually associated with hard-disc drives, the SCSI i/o bus started life as the Shugart Associates System Interface (SASI) but became the Shugart Corporation System Interface (SCSI) when the company responsible for it changed its name. Now the standard has been adopted by ANSI which has given it a new title – Small Computer Systems Interface. Perhaps by coincidence, the initials SCSI still stand. Flexibility is the main claim for the SCSI interface. Housekeeping, error correction/detection, formatting, etc., are carried out by the interface. To suit changes in storage media, designers and buyers only have to modify the interface; hardware and software in the computer remain the same. Connections between the interface and processor never change either. Because of this flexibility, SCSI is already widely used on microcomputers for hard-disc and floppy, rigid and streaming tape interfacing. It will probably survive since it is equally suitable for use with optical-disc storage media. The port uses a 50-pin connector. Even-numbered pins 2-18 carry data and odd-parity signals and pins 32-50 carry control signals.

Centronics

Specifically a parallel-printer interface designed by a printer manufacturer but widely adopted. Connectors vary, although a 36-way Delta socket is often found on the printer, but signals used are consistent. There are seven t.t.l. level data lines representing an ASCII word and data-strobe, acknowledge, busy, select, fault and demand signals for control and hand-shaking. Centronics supply a printer cable of just over three metres, which seems quite long for t.t.l.-level signals. Converters for changing RS232 serial data to Centronics parallel are freely available but often quite expensive. Although this interface was designed to drive a printer, the port is a convenient means of transmitting data to any device since driving software is invariably included in the computer.

Processor bus

If you intend designing your own interfaces you should look for a computer that allows you easy access to all the pins on the processor. As an experimenter you will find that this feature becomes more and more important as time goes on. Inputs for isolating address, data and control buses from the processor should be available.

D.m.a. channel

A direct memory-access channel allows peripheral devices to gain direct access to memory without involving the processor. In this way, data can be transferred between peripherals and memory at very high speeds. Coordination of the channel requires use of a high-speed device called a d.m.a. controller, although some modern processors have the facility built in. d.m.a. may sound simple but in practice it is not.

Other buses

Buses described below are common, but are mainly encountered by designers and experimenters since they are used for connections inside a computer rather than outside. There is a manufacturer's 'in-house' bus standard for every microprocessor family and if you intend experimenting it might be worth finding out how the computer you intend buying is assembled internally. Circuit diagrams of the inside of a computer are notoriously difficult to get hold of, but without them modifications are tricky to say the least.

Multibus is an 86-line bus developed by Intel for its SBC range of boards but now used by a number of manufacturers, especially in the US. It is an extensive bus and can accommodate connection of multi-function boards.

STD is a bus developed by Pro-Log and Mostek for smaller single-function boards, allowing a system with a specific function to be developed, as opposed to Multibus which allows a more general system to be assembled. Again, a number of manufacturers now produce boards using the STD bus.

Further reading

E. G. Brooner and P. Wells, Computer communication techniques, Sams. (Discussions of computer networks from the smallest to Viewdata and Ethernet).

E. C. Poe and J. C. Goodwin, The S100 and other micro buses, Sams. (Descriptions and pinouts for S100, STD, IEEE-488, STD, Versabus and other buses peculiar to microcomputer popular in America such as TRS80, Apple I & II, Pet, TI99/4, Atari and LSI 11).

P. T. H Roberts, A microcomputer bus standard at last, *Wireless World*, December 1983 (S100).

Table guide

The table (see over) includes details of a selection of computer boards, which the reader may like to compare with the ready-packaged computers we described last month. These computer boards are usually supplied without keyboard, display or power supply.

As with the 'complete' computers, many manufacturers offer a series of models and in these cases we have selected basic versions to represent the range. We have indicated important upgrades and features of alternative models separately. Options mentioned (open circle or brackets) are only those available from the manufacturer of the computer.

Processor. This column lists the main processor or processors, and optional co-processors are indicated in parentheses.

Languages. These are a little more difficult to tabulate. In some cases, operating system and Basic (or other language) are combined and how much rom or ram each section takes is not always clear – or even important. What is important in most 8-bit microcomputers is the total amount of rom in the system because it often limits the amount of memory-address space left for user programs. Basic is the most popular language for the smaller microcomputers, hence the number of B's under the heading language, but there is one computer which uses the more efficient language Forth (F). Many computers designed for use with disc-operating systems only use rom during the initialisation so the rom size is not significant.

Operating system. More expensive computers use disc operating systems and provided that the operating system is a common one, very many languages will be available. Again, the amount of rom that any operating system uses reduces the amount of directly addressable program space.

Storage. Ram is often called main memory. Eight-bit processors can directly address 64K-bytes of memory so the maximum amount of directly addressable ram is 64K less however much rom is used. Memory can be arranged in pages, but paged memory takes longer to access so processing is slowed down. Sixteen-bit processors have varying numbers of address lines but nearly always more than 16.

Under the heading Disc, a computer with an open-circle entry can use a disc interface supplied by the manufacturer but disc drives are not fitted as standard on the model concerned. Where a filled circle appears, the computer is fitted with one or more disc drives. The same applies to cassette recorder entries.

Interfaces. The most popular interfaces are included in the table shown which of the popular interfaces each computer offers; again a filled circle indicates that the feature is included as standard and an open one that an option is available from the manufacturer.

Computer boards

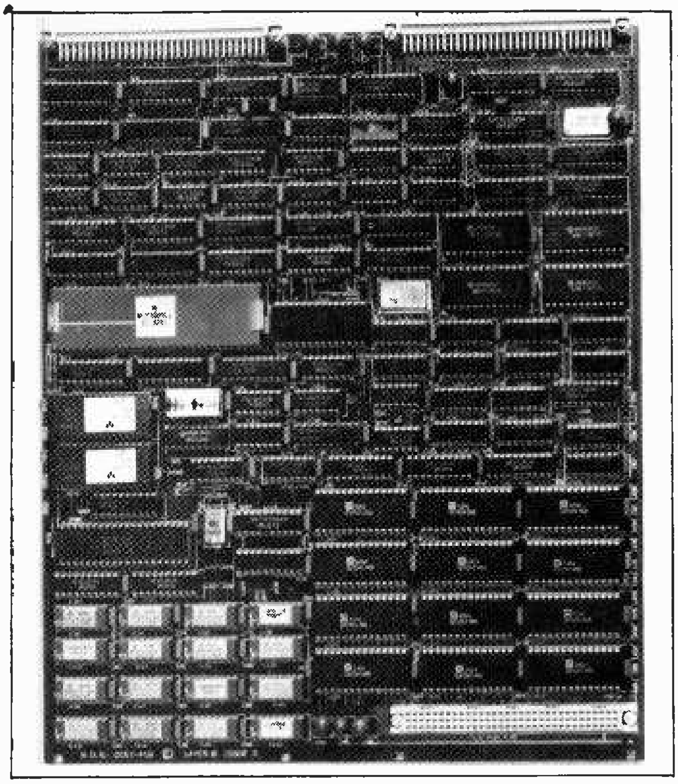
For those who want a microcomputer tailored to suit an application or to build into their own equipment, we have included this section on computer boards. These boards are outside the scope of the survey, but this list of some of those available will give you an idea of how specifications, interfacing capabilities and prices compare with those of 'complete' computers. They do not usually have a power supply, keyboard or display facilities.

Arcom *ARC:* range of Eurocard single-board microcomputers includes ARC40, a small Basic computer for developing Z8 programs (includes eprom programming facility) for use with the Arc42 Z8 prototyping board. Arc8000 is a Z8001 VME-bus c.p.u. board with CP/M Z8000 cross-assembler option. Analogue and digital i/o, IEEE-488 and eprom-programmer/cassette-interface boards are available for use with both boards. The 4 or 8MHz Arc8000 has two RS232 interfaces. **WW 501**

Control Universal *Cube series:* main c.p.u. Eurocards are identical except for the processor, which may be either 6502 or 6809. Memory boards, i/o interfaces, floppy-disc controllers, eprom programmers and software supplement the range. These c.p.u. boards include two serial i/o channels, 20 digital i/o channels four 32K-byte memory sockets for rom, ram or eprom and a battery back-up circuit for non-volatile rams. The company also manufactures a range of boards allowing a modular BBC-computer compatible system to be built. Further boards include expansion for the BBC computer. **WW 502**

Fulcrum Computer Products *S100* boards: this company distributes a large number of S100-compatible boards for processing, interfacing and data storage, such as an 8MHz 68000-based unit for which software includes CP/M-68K and Forth. Other S100-compatible c.p.u. boards use Z80, or 8085/6/7/8/9 processors. Among the many memory, i/o and disc-controller boards is a 512-by-640 pixel colour-graphics interface providing 16 out of 4096 colours, shaded black/white, light-

Continued after addresses



Addresses

For more information on the computers described this month and last, contact the manufacturers and agents listed here.

ABS Computers
North Street
Portslade
Brighton BN4 1ER
Tel. 0273 413211

Orb

Acorn Computers Ltd
Fulbourn Road
Cherry Hinton
Cambridge CB1 4JN
Tel. 0223 245 200

Electron, BBC computer

Act International Ltd
111 Hagley Road
Birmingham B16 8LB
Tel. 021 454 8585

Apricot, Sirius

Action Instruments Europe Inc.
St James Works
St Pancras
Chichester
West Sussex PO19 4NH
Tel. 0243 774022

PAC

Advance Computers
8a Hornsey Street
London N7 8HR
Tel. 01-609 0061

Advance 86a, 86b

Alpha Microsystems (GB) Ltd
Berkshire House
56 Herschel House
Slough
Berkshire
Tel. 0753 2821922

AM1000 series

Apple Computers
Eastman Way
Hemel Hempstead
Hertfordshire
Tel. 0442 48151

IIE, III, Lisa

Aston Technology Ltd
Aston Science Park
Love Lane
Birmingham B7 4BJ
Tel. 021 359 4861

Crystal 68000 systems

Atari International
Railway Terrace
Slough
Berkshire
Tel. 0753 33344

Atari 400, 600, 800

Bleasdale Computer Systems
Francis House
Francis Street
London SW1P 1DE
Tel. 01-828 6661

BDC 680A

BMC International
Encotel Systems Ltd
7 Imperial Way
Croydon Airport Indust Est
Croydon
Surrey CR0 4RR
Tel. 01-686 9687 & 01-680 6040 (six lines)

BMC if800
Televideo TS1603H/TS1603

British Micro
Penfold Works
Imperial Way
Watford
Hertfordshire WD2 4YY
Tel. 0923 43956

Mimi

Bromcom
Bromley Computer Consultancy
417-421 Bromley Road
Bromley
Kent BR1 4PJ
Tel. 01-697 8933

Superstar

Campúters
33A Bridge Street
Cambridge CB2 1UW
Tel. 0223 315063

Lynx 48K/96K/128K

Ceedata Ltd
Glebe House
Armfield Close
West Molesey Trading Estate
East Molesey
Surrey
Tel. 01-941 4889

8200 series

CGL (Computer Games Ltd)
CGL House
Goldings Hill
Loughton
Essex IG10 2RR
Tel. 01-508 5600

CGL M5

Comart Ltd
Little End Road
Eaton Socon
St Neots
Huntingdon
Cambridgeshire PE19 3JG
Tel. 0480 215005

Comart CP100/1000 series
Communicator

Commodore Bus. Machines
675 Ajax Avenue
Slough SL1 4BG
Tel. 0753 74111

Commodore 64PC, 700 & VIC20

C/WP Computers
108 Rochester Row
London SW1P 1JP
Tel. 01-828 9000

C/WP Cortex

Datac
Tudor Road
Altrincham
Cheshire
Tel. 061-941 2361

MC series

Digital Equipment Corp. (DEC)
PO Box 110
Reading RG2 0TR
Tel. 0734 868711

Professional 300 series
DECmate II
Rainbow 100

Dragon Data Ltd
Kenfig Industrial Estate
Margam
Port Talbot
West Glamorgan SA13 2PE
Tel. 0656 744700

Dragon 32

DVW Microelectronics Ltd
PO Box 135
345 Foleshill Road
Coventry CV6 5RW
Tel. 0203 668181

Husky

Eaca
Lowe Electronics Ltd
Bentley Bridge
Chesterfield Road
Matlock
Derbyshire DE4 5LE
Tel. 0629 2817/2430/4057/4995

Colour Genie

Elan Computers Ltd
31-37 Hoxton Street
London N1 6NJ
Tel. 01-739 4282

Elan Enterprise 64/128

Epson
Dorland House
388 Wembley High Road
Wembley
Middlesex HA9 6UH
Tel. 01-900 0455

HX20 portable, QX10

Flight Electronics Ltd
Quayside Road
Southampton
Hampshire S02 4AD
Tel. 0703-34003/27721

Microprocessor MPF1 Plus

Future Computers Ltd
PO Box 306
Purley
Surrey
Tel. 01-689 4341

FX range

Haywood Electronic Associates
Electron House
Leeway Close
Hatch End
Middlesex HA5 4SE
Tel. 01-428 0111

Haywood 9000 series

Hewlett Packard Ltd
Nine Mile Ride
Wokingham
Berkshire RG11 3LL
Tel. 0344 773100

HP-75C portable, 85B, 86B, 150, 200, 16A

HH Microcomputers
Viking Way
Bar Hill
Cambridge CB3 8EL
Tel. 0954 81140

Tiger

Hotel Microsystems
69 Loudoun Road
London NW8 0DQ
Tel. 01-328 3737

Minstrel

Hytec Microsytems Ltd
Sandy Lane West
Oxford OX4 5JX
Tel. 0865 714545

Prelude range

IBM PC Enquiry Centre
Rockware Avenue
Greenford
Middlesex UB6 0DW
Tel. 01-578 4399

IBM PC

ICL
ICL House
Putney

London SW15 1SW
Tel. 01-788 7272

ICL PC

Immediate Business Systems
3 Clarendon Drive
Wymbush
Milton Keynes MK8 8DA
Tel. 0908 568192

Fieldwork 50

Integrated Microproducts Ltd
Number One Industrial Estate
Medomsley Road
Consett
Co Durham DH8 6SY
Tel. 0207 583481

IMP-68

ITCS
2 Kingston Road
Staines
Middlesex TW18 4LP
Tel. 0784 63211-3

Andromeda range

Iotec Ltd
Bowling Back Lane
Bradford BD4 8TF
Tel. 0274 731509

Iotec 64CD

Jarogate Ltd
197-213 Lyham Road
London SW2 5PY
Tel. 01-671 6321

Jarogate MP5 series (and JPU processor board)

Jupiter Cantab
Cheshunt Building
Bateman Street
Cambridge CB2 1LZ
Tel. 0223 313479

Jupiter Ace

Kemitron Industrial and
Scientific Computers
21-23 Charles Street
Hoole
Chester CH2 3AY
Tel. 0224 21817

K2000E

LSI Computers Ltd
Copse Road
St Johns
Woking
Surrey GU21 1SX
Tel. 04862 23411

Octopus

Leenshire Ltd
Moorside Road
Winnall
Winchester
Hampshire SO23 7RX
Tel. 0962 64175

VCT 6900 series

Logica VTS Ltd
64 Newman Street
London W1A 4SE
Tel. 01-637 5171

VTS Vitesse

Mattel Electronics Ltd
Mattel House
North End Road
Wembley
Middlesex HA9 0AB
Tel. 01-900 0311

Aquarius, see Radofin

Memotech Ltd
Station Lane
Witney
Oxfordshire OX8 6BX
Tel. 0993 2977

MTX series

Micronix Computers Ltd
Suite 2
26 Charing Cross Road
London WC2
Tel. 01-240 0213/0271

MX400/800/1600/2400

Modcomp
Sun Computing Services Ltd
Concorde House
St Anthony's Way
Feltham
Middlesex TW14 0NH
Tel. 01-890 1440

Zorba

Modus Systems Ltd
Park Drive
Baldock
Herts SG7 6EW
Tel. 0462 894848 (4 lines)

Tensor range
MD3A

Motorola
Crellon Microsystems
380 Bath Road
Slough
Berks SL1 6JE
Tel. 06286 4300

Motorola Exorcet 100 & VME/10
Syntel MC 02, MP 09 & 68K8

NEC Business Systems Europe
Computer Division
164/166 Drummond Street
London NW1 1YP
Tel. 01-388 6100

Advanced PC, PC 8000/8800 series

Newbrain
Brainwave Software Ltd
Tilbury-juxta-Clare
Great Yeldham
Halstead, Essex
Tel. 0787-237831

Newbrain

Oric Products International Ltd
Coworth Park
London Road
Ascot
Berks SL5 7SE
Tel. 0990 27641

Oric

Osborne Computer Corp. (UK)
38 Tanners Drive
Blakelands North
Milton Keynes MK14 5LL
Buckinghamshire
Tel. 0908 615274

Osborne Executive (future of company uncertain at time of writing but stock still available)

Philips Business Systems
Electra House
2 Bergholt Road
Colchester CO4 5BE
Tel. 0206 575115

P3000/3500

Phoenix Systems
2nd Floor
Buckingham House
42 Princess Street
Manchester 1
Tel. 061 236 1172
Stratos

Plessey Microsystems Ltd
Water Lane
Towcester
Northants NN12 7JN
Tel. 0327 50312

PMM68K Multibus board
System 68
Miproc

Portico Technology
South Bank House
Black Prince Road
London SE1
Tel. 01-735 8171

Miracle

Positron Computers Ltd
Unit 16
Deacon Trading Estate
Newton-le-Willows
Lancashire WA12 9XQ
Tel. 09252 28828

Sage
Positron 900 series

Powertran
Portway Industrial Estate
Andover
Hampshire SP10 3NN
Tel. 0264 64455

Powertran Cortex kit

Radofin Electronics
4th Floor
Hyde House
The Hyde
London NW9 6LG
Tel. 01-205 044

Aquarius

Rediffusion Computers Ltd
Kelvin Way
Crawley
Sussex
RH10 2LY
Tel. 0293 31211

Teleputer 3

Research Machines Ltd
PO Box 75
Mill Street
Oxford
Tel. 0865 249791

RML 380Z
Link 4802

Rockwell International
Electronic Devices Division
Heathrow House
Bath Road
Hounslow TW5 9QW
Tel. 01-759 2366

Aim series

Seed
Strumech Eng. Electronic
Developments Ltd
Portland House
Coppice Side
Brownhills
Walsall
West Midlands WS8 7EX
Tel. 05433 78151/4321

Seed System 19 series

SBC
Lambart Micro Computers Ltd
52 Moorbridge Road
Maidenhead
Berkshire SL6 8BN
Tel. 0628 72037

Duet 16

SemiTech Microelectronics
145-147 Ewell Road
Surbiton

Surrey KT6 6AW
Tel. 01-390 6177

Pied Piper

Sharp Electronics (UK) Ltd
Thorp Road
Newton Heath
Manchester M10 9BE
Tel. 061 205 2333

MZ80

Sinclair Research Ltd
25 Willis Road
Cambridge CB1 2AQ
Tel. 0223 353204

ZX81
ZX Spectrum

Sirton Computer Systems Ltd
Unit 14
29 Willow Lane
Mitcham
Surrey CR4 4NA
Tel. 01-640 6931

Midas MPS

Sord Computer Systems Inc
Samuel House
St Albans Street
Haymarket
London SW1Y 4SQ
Tel. 01-930 4214

Sord M23/203/223/243/416

Southwest Tech Prods (SWTP)
12 Tresham Road
Orton Southgate
Peterborough PE2 0SG
Tel. 0773 234433

SWTP FO9/S09/S+

Stirling Microsystems
241 Baker Street
London NW1 6XE
Tel. 01-486 7671

Dennis 6809 kit

Tandy Corporation
Tameway Tower
Bridge Street
Walsall WS1 1LA
Tel. 0922 648181

TRS80 models 1, 4 & 100
PC2
PC4
Portable

Tashkl Computer Systems
24 Logan Road
Wembley
Middlesex HA9 8PX
Tel. 01-904 4467

OM8064

Televideo
Encotel Systems Ltd
7 Imperial Way
Croydon Industrial Estate
Croydon
Surrey CR0 4RR
Tel. 01-686 9687 & 01-680 6040 (6 Lines)

Televideo TS1603H/TS1603
BMC if800

Texas Instruments
Data Systems Division
Manton Lane
Bedford MK41 7PA
Tel. 0234 67466

TI99/4A

Addresses continued

Torch Computers
Abberley House
Great Shefford
Cambridge CB2 5LQ
Tel. 0223-841000

Triumph Adler (UK) Ltd
27 Goswell Road
London EC1M 7AJ
Tel. 01-250 1717

Alphatronic
PC/P2/P3/P4/P30/P40

Transam
51 Theobalds Road
London WC1X 8SF
Tel. 01-405 5240

Tuscan

Tycom Corporation
Burdett House
40 New Bridge Street
London EC4V 6BE
Tel. 01-248 4800

Microframe

Videcom Ltd
Newtown Estate
Henley-on-Thames
Oxfordshire RG9 1HG
Tel. 04912 78427

Apollo

Wessex Microcomputers
Northdown
Corton Deham
Sherborne
Dorset DT9 4LT
Tel. 0963 22402

Wessex Wyvern

Windrush Microsystems Ltd
Worstead Laboratories
North Walsham
Norfolk NR28 9SA
Tel. 0692 405189

6800/6809 systems

Zenith Data Systems
EuroMicro Ltd
EuroMicro House
Coleridge Lane
London N8 8ED
Tel. 01-341 2447

Z100 series

Computer Board addresses

Arcom Control Systems Ltd
Unit 8
Clifton Road
Cambridge CB1 4BW
Tel. 0223 242224

ARC8000, 40 and 80 series

Control Universal Ltd
Unit 2
Andersons Court
Newnham Road
Cambridge CB2 9EZ
Tel. 0223 358757

Cube range

Fulcrum (Computer Products) Europe
Valley House
Purleigh
Essex CM3 6QH
Tel. 01621 828763

S100 boards

Measurement Systems Ltd
Mill Reef House
9-14 Cheap Street
Newbury
Berkshire RG14 5DD
Tel. 0635 45420

Trojan
System 96

Micronix Computers Ltd
Suite 2
26 Charing Cross Road
London WC2
Tel. 01-240 0213/0217

Plessey Microsystems Ltd
Water Lane
Towcester
Northants NN12 7JN
Tel. 0327 50312

PSM range

Pronto Electronic Systems Ltd
466-478 Cranbrook Road
Gants Hill
Ilford
Essex IG2 6LE
Tel. 01-554 6222

VME systems
Pronto Z80 Eurocard system
STD-bus compatible s.b.c.

Protel Computer Systems Ltd
Waterford House
Erftstadt Court
Denmark Street
Wokingham
Berkshire RG11 2YF
Tel. 0734 785440

Model 2000

Rade Systems Ltd
290A High Road
Willesden
London NW10 2EU
Tel. 01-451 4414/5/6

Rader 150

Syntel Microsystems
Queens Mill Road
Huddersfield HD1 3PG
Tel. 0484 35101/2
68-series boards

Systime Computers Ltd
Millshaw Park
Leeds LS11 0LT
Tel. 0532 702277

Systime 8300 series

Triangle Digital Services Ltd
23 Campus Road
London E17 8PG
Tel. 01-520 0442/1468

Forth computer board

Maker	Model	Interface: Video output	Real-time clock	Analogue	Other parallel	S100	IEEE-488	Serial	Processor access	Communications	Storage: Cassette	Disc(s)	Ram (K)
Arcom	ARC 8000		○	○	●		○	●	●				<8M
	ARC 42		○	○	●		○	○	●				16K
Control Universal	Cube	○	●		●			●	●		○	○	16K
Fulcrum	S100 Super Quad	○			●	○		●	●			○	64
Measurement Systems	System 96	○	●	○	●			●	●	●		●	64
Micronix	80HD	●	●					●	●			○	64
Plessey	PMM68K				●			●	●			●	(4M)
Pronto	VME-SYS/1				●			●	●			●	256K
Protel	2000				●			●	●			○	512K
Rade	Rader 150	●	○	○	●		○	○	●			○	64K
Syntel	MP19	○	○	○			○	○	●			○	<64K
Triangle	TDS 900		●	○	●		○	●	●				12
	TDS 902		●		●		○	●	●		○		48

Maker	Model	Printer: Other interface	Centronics	O.S.: Rom/disc	Type/size	Languages: Others	Rom size	Included	Processor: Speed	Bits	Type	No. of boards	Basic price (£) excluding v.a.t.
Arcom	ARC 8000			r/d	4K	○		(F)	4	16	Z8001	1	580
	ARC 42			r	with Basic		<16K	B		8	Z8	1	85
Control Universal	Cube		○		Flex (6809)		16K		2		6502/6809	1	139
Fulcrum	S100 Super Quad								4	8	Z80	1	580
Measurement Systems	System 96		●	r/d	OS9			(B-09/C)	2	8/16	6809	4	2450
Micronix	80HD			d	CP/M				4	8	Z80A	1	445
Plessey	PMM68K	●		d	UNIX III	○	16K		8	16	MC68000L	3	~3400
Pronto	VME-SYS/1	●		d	CP/M 68K	●			8	16	68000	3	9200
Protel	2000	●	●	d	Versados				8	16	68000	3	~2100
Rade	Rader 150		○	d	CP/M	●			4	8	Z80A	2	370
Syntel	MP19	●		r/d	OS9			(B)	4.9	8	6809	1	250
Triangle	TDS 900			r	Assembler & Forth extensions		8k <16K	F	4.9	8/16	6301	1	180
	TDS 902			r	Assembler & Forth extensions		16K	F	4.9	8/16	6301	1	~450

pen interface and RGB or composite-video outputs (£3400). The company also has S100 to IEEE-488 interface and eprom programming boards. **WW 503**

Measurement Systems Ltd *System 96:* modular approach intended for 'research, educational, industrial and commercial applications'. Memory may be up to 1M-byte and the system organized for ten users simultaneously or for one user with up to 256 independent tasks in order of priority. Virtual memory, floppy and Winchester-disc options are available and up to 12 serial ports may be added for multiple users or external communications. The c.p.u. board has four direct memory-access channels, one of which is normally allocated to the disc controller to allow data-transfer rates of up to 2M-bytes/s. Languages running under the 'Unix-like' operating system, OS9, include Basic09, i.e. Basic with Pascal features, Pascal, CIS Cobol and a C-language compiler. **WW 504**

Micronix *80HD:* Single-board microcomputer includes Z80 counter-timer, serial and parallel i/o peripheral i.cs with Western Digital floppy-disc controller and Texas c.r.t. controller. Has SASI-bus for hard-disc or cartridge storage, two serial and parallel ports and Z80 i/o bus. CP/M is current language but CP/M+ and MP/M2 are planned. Maximum ram size is 128K (2K video ram separate) and sockets are included to add 8K-bytes of rom, excluding 4K system monitor eprom. Keyboard port is ASCII parallel. **WW 505**

Plessey *PSM range:* 68000-based boards using IEEE-796 bus (Multibus). Range includes c.p.u. board with Intel 8232 floating-point processor, two 512K-byte dynamic ram boards (one with parity checking, the other with error detection and correction) a 64K non-volatile memory board with battery and a 64K dynamic ram board. The processor board has three programmable 16-bit timers, two uarts, seven interrupt levels and built in fault diagnosis which is monitored through a separate port. One RS232 port is for console and the other includes modem-control lines. **WW 506**

Pronto *VME systems:* this company provides 68000-based VME boards from two companies – Mostek and Thomson CSF. Mostek boards include c.p.u., 256K-byte dynamic ram, serial communications and floppy-disc and SASI interface units: these are intended for products designed from the ground up. Pronto expect that a multi-user system using Unix system 3 will be available before the end of this year. One of the Thomson VME c.p.u. boards includes a port adapted for use with the G64 interface which allows over 50 existing interface memory and control boards to be used with a VME-based system. As opposed to the Mostek boards, these products allow VME boards to be used with systems already in use. Pronto also have a set of Z80 Eurocards intended for use in equipment to be manufactured on a small or medium scale. **WW 507**

Protel *Model 2000:* described as being 'particularly suited to process control, industrial, educational and certain computer functions' these 68000-based units use the VME bus and are built on extended double-Eurocard boards. The c.p.u. board has RS422/RS232 serial ports, seven interrupt levels and 32K-bytes of static ram or 64K-bytes of eprom. Dynamic ram boards for up to 512K-bytes with parity checking and serial i/o boards with eight RS232 or RS422 ports and dynamic-memory access are included in the range. Also available are Comspeed local-area network boards based on the Cambridge ring principle for data transfer at up to 10Mbit/s. **WW 508**

Rade Systems *Rader 150:* this unit is described as a single-board computer with options and is mainly intended for manufacturers who want to put someone else's computer in their own equipment. The single board computer includes 64K-bytes of ram, floppy-disc interface, direct memory-access controller i.c., timer/counter i.c. and eight expansion connectors. An eight-bit keyboard port is standard, as are t.t.l. video outputs for a c.r.t. and a light-pen input; a serial keyboard interface is available. Optional boards that plug into this main unit provide dual parallel ports, dual serial ports, cassette interface, ram/rom expansion, hard-disc interface, hardware real-time clock and analogue conversion. **WW 509**

Syntel *68-series boards:* some 20 Eurocard-form boards based on 6802, 6809 and 6800 processors are offered by this company. They include IEEE-488, analogue and graphics interface boards. One of the boards has two 6821 parallel-interface adapters and a 6840 counter/timer i.c. to provide 32 general-purpose i/o lines, eight interrupt/handshake lines, nine timer i/o lines and three counter/timer channels. All of the boards are compatible with the G64 bus used by Thomson CSF (see Pronto VME systems). Some development software is available from Syntel. **WW 510**

Systime *S300 series:* these boards are cased and with power supply and either floppy-discs or a combination of Winchester and floppy disc drives. An 8087 64-bit numeric-data processor may be used as co-processor for the 8080. Five RS232 serial lines provided by four uarts allow up to five users. Other peripheral i.cs on the processor boards include an interrupt controller, 8203 dynamic-ram controller and three counter timers, one of which is spare. Initialization and diagnostic software are contained in 16K-bytes of eprom and the c.p.u. board has room for 512K-bytes of ram. IEEE-796 bus (Multibus) allows use of up to 1M-byte of ram. **WW 511**

Triangle Digital Services *TDS900:* described as a 'Forth computer to build into products', this board is intended to act both as development tool and as an element of the finished product. Programs developed using Forth are held in eproms in the final design. These boards are suitable for use in battery-powered equipment since they consume about 28mA. An application note describes a sound switch for the severely handicapped which allows mains appliances to be controlled using whistles. **WW 512**

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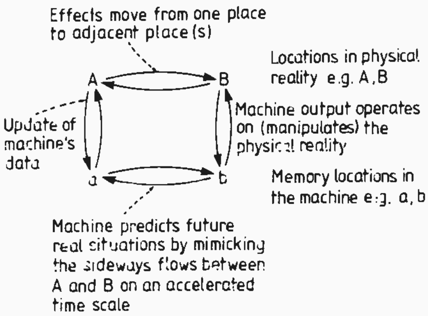
continued from page 60

points which are physically distant in reality may not be necessary *at all* in our machine, although this is pushing the point rather far.

A further requirement of our machine is that updating, or interaction, capability between points in physical reality and the related points in our machine where the digital analogue for that region of physical reality is stored, should be as efficent as possible.

The task of the machine architect is to exploit the potential of his technologies to meet these requirements. I believe I have done the best compromise in the Property 1 a invention[2], but it is not ideal, considering the above criteria. The above criteria are not merely a *post hoc* rationalization



tending to show that my architectures are the best.

From the point of view of the above analysis, the reigning computer architecture theorists are doomed to failure. They (e.g. Petri nets) concentrate on the mechanism of computation in the machine, the bottom horizontal lines between a and b. However, this has no value if the thinker does not bear in mind the dualism; that the arrows between a and b are a reflection of arrows between A and B; that computation only has value to the extent that it mimics events which occur in the real world. (This relates to my statement in the fourth paragraph above that the 'broad range of application', by which I mean the main field of application for our machine, and therefore the paradigm which should control their architecture, is directed towards practical rather than intellectual applications.

References

1. I. Catt, Dinosaur Among The Data?, *New Scientist*, 6 March, 1969
2. For Property 1 a invention, see "Wafer Scale Integration", *Wireless World*, July, 1981, pages 57-59.

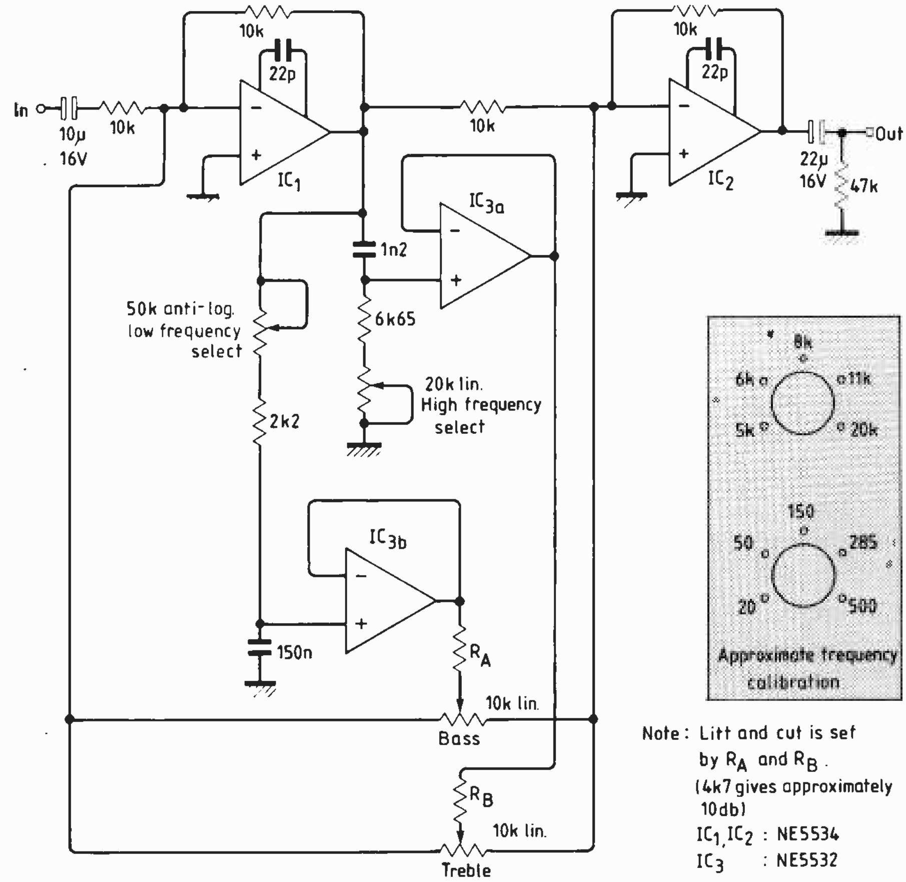
CIRCUIT IDEAS

Tone control

Several advantages over the Baxandall configuration are claimed for this tone control. Interaction does not occur because control potentiometers are terminated by a virtual earth. High and low-frequency turnover points are adjustable and response gives a true shelving characteristic with exact mirror images for lift and cut. Being non-inverting, the stage may easily be by-passed.

NE5534 op-amps give best results, but an HA4605 quad op-amp i.c. saves space with little degradation. The single-pole filters may be replaced by state-variable filters to give full parametric control.

B. E. Porter
Kings Lynn
Norfolk

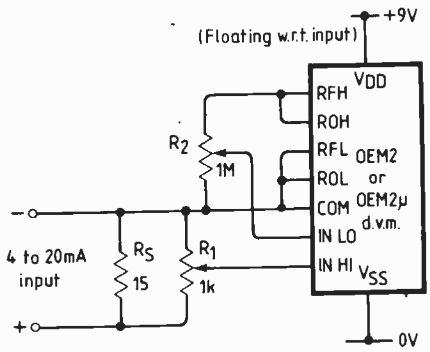


Note: Lift and cut is set by R_A and R_B. (4k7 gives approximately 10db)
IC_1, IC_2 : NE5534
IC_3 : NE5532

Auto-zero with offset

Many a-to-d converters including popular 7106 and 7126 i.cs have an auto-zero facility but this otherwise desirable feature is a limitation when a digital meter is required to display zero for a non-zero input. This circuit solves this problem and can be used for displaying for example 0 to 1600rev/min from a 4-20mA signal.

For clarity, the modified external circuit is illustrated for OEM-2/OEM-2µ digital voltmeters which incorporate 7106/7126 a-to-d converters with 31/2-digit l.c.ds, decimal-point drivers and auxiliary components for a ±199.9mV full-scale d.v.m. As shown in the modified circuit R_s converts the 4-20mA signal into an input voltage of between 60 and 300mV. R_1 provides full-scale calibration control and is adjusted to give a 40 to 200mV input. A 40mV offset derived through R_2 from the stable 100mV reference at ROH is injected between COM and INLO. The differential voltage between INLO and INHI now gives the desired display range of 0rev/min at 4mA/40mV rising to 1600rev/min at 20mA/160mV input.

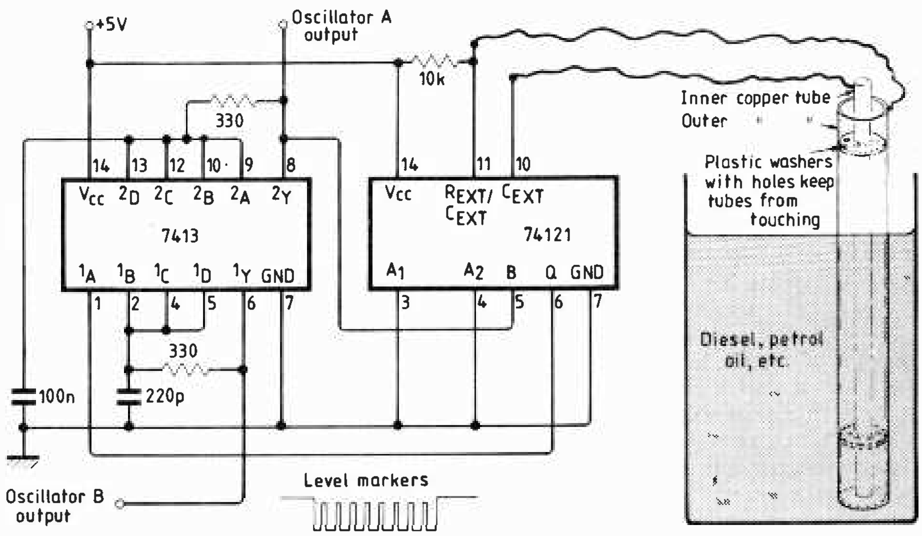


Peter Rummer
Anders Electronics Ltd
London

Fuel-level indicator

When connected to a frequency counter, this circuit using a capacitive transducer made from copper central-heating pipe indicates the level of diesel fuel in a tank. Half of the 7413 is an oscillator (A) used to trigger the 74121 monostable i.c. How long the monostable i.c. is triggered for depends on the capacitance of the level transducer. While the monostable i.c. is triggered, pulses from the gated 7413 oscillator (B) pass to the output and represent the fuel level.

John Allsebrook
Loughborough
Leics

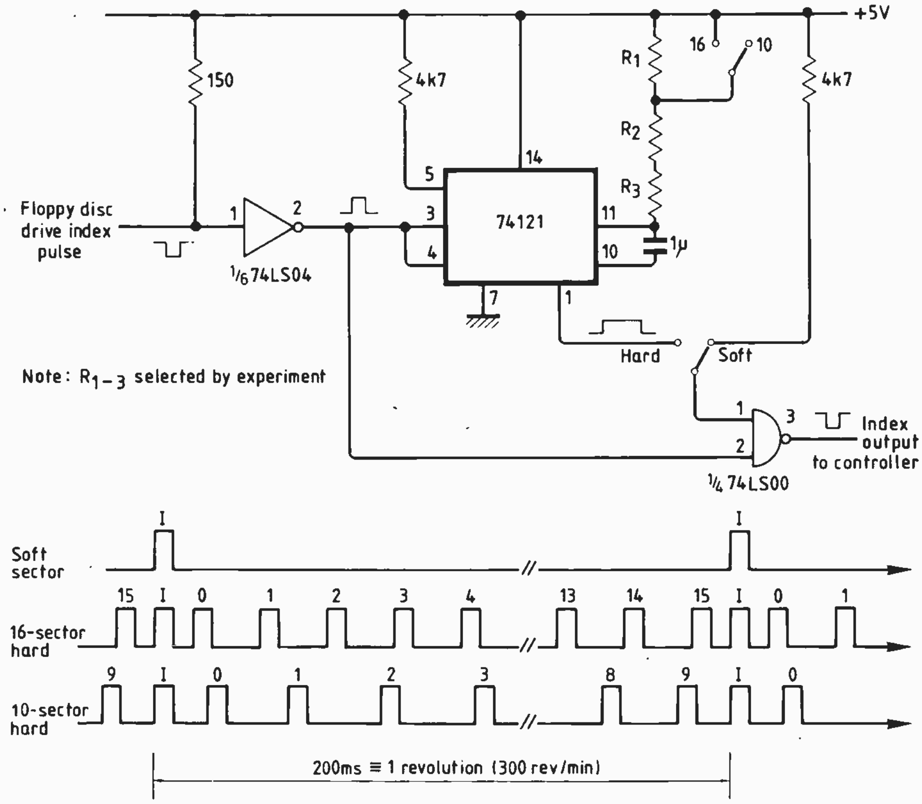


Hard/soft sector selector

Many soft-sectored mini-floppy disc systems do not use the index-hole detector output from the disc drive so hard-sectored discs may be interchanged with soft-sectored types. But in soft-sectored disc systems where the index hole is used, waveforms produced by extra index holes prohibit the use of hard-sectored discs, see timing diagram.

Soft-sectored discs have only one index hole which produces one pulse per revolution (200ms). Either 10 or 16 extra holes are used on hard-sectored discs to indicate the start of each sector to the controller. These extra pulses may be removed by inserting this circuit between the index line of a floppy-disc drive and a system designed for use with soft-sectored discs. The monostable i.c. is triggered by the trailing edge of each sector hole. If another hole is detected during the monostable-triggered period, it must be the true index hole and is signalled as such through the NAND gate to the controller. The two switches for selecting between hard or soft sectored discs and 16 or 10 holes could easily be combined into one three-position switch. In multi-drive systems, it is probably desirable that the selector is only connected to one drive.

D. J. Greaves
St Johns College
Cambridge



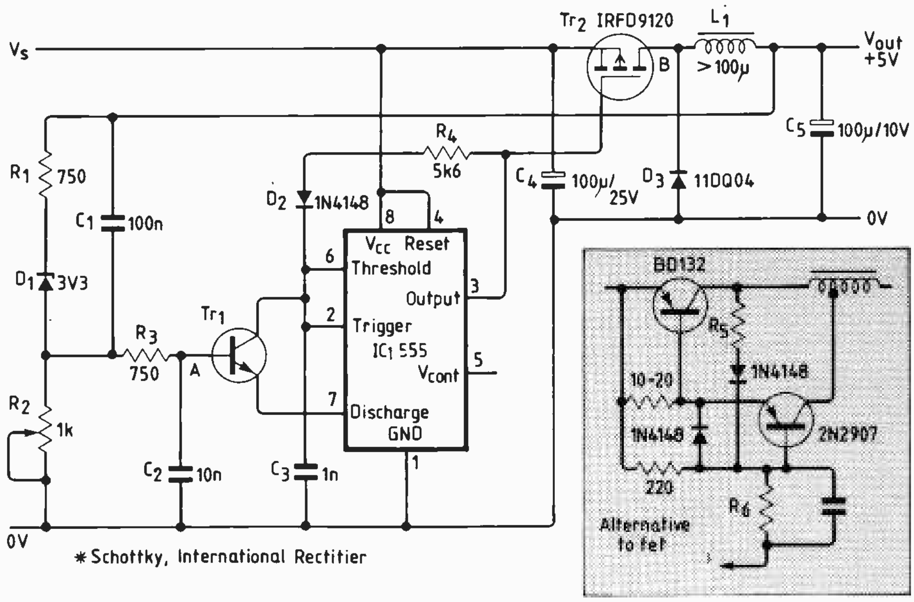
Matchbox switching regulator

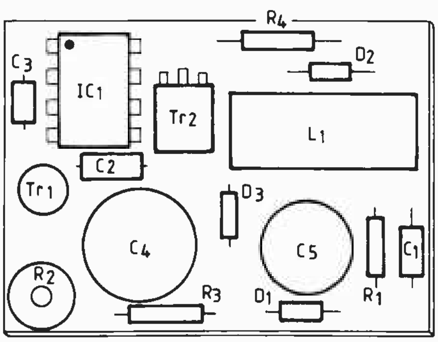
Intended for a plug-mounted power supply, this small switching regulator gives 5V at 1A using an input voltage from 7 to 18V. The prototype uses a dil power mosfet (International Rectifier) as switching element and measures 27 by 36mm.

Control signals provided by the 555 totem-pole output are ideal for driving a fet. Off time of the output device is determined by values of C_3 and R_4 and is fairly constant but on time is governed by the discharge rate of C_3 through the bipolar current-source transistor. This current is switched through the 555 discharge pin, mainly to simplify calculations. Forward-path gain of the unit (A to B) depends heavily on the supply and at 18V is only in the region of 140 (calculated). Line regulation is therefore low but may be improved by inclusion of an op-amp or a feed-forward resistor between the supply and point A on the diagram.

In the feedback network, C_1 improves transient response and C_2 filters high-frequencies from the output. Some 30 turns of 0.5mm wire wound on a Neosid 14mm powdered-iron toroid was used for the prototype output choke. Copper on the top surface of the p.c.b. is soldered to the fet drain terminals to act as a heat sink.

Shown separately, the bipolar alternative to the fet output device uses a tapped choke to keep the output transistor as near to saturation as R_5/D_4 permit. Resistor R_5 is a trade-off between dissipation in the output device and collector current in the driver. The choke tap provides nominally between one and two volts across the driver; $R_{5,6}$ are calculated using worst-case supply voltage and drive requirements of the two transistors. Other component values are determined by experiment.





Richard Aston
Northwich
Cheshire

Non-volatile ram module, September 1983. Polarity of the batteries in this module was indicated incorrectly.

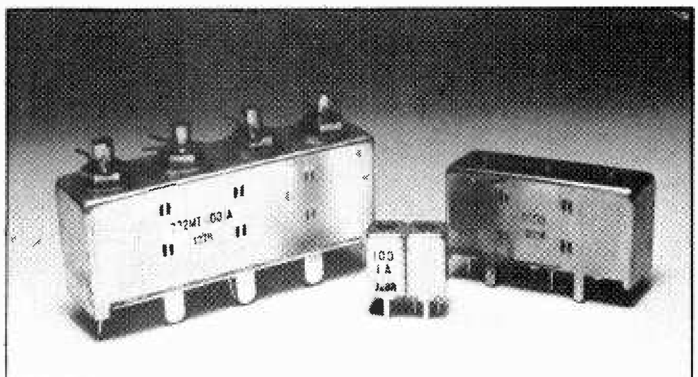
NEW PRODUCTS

Smaller filters cover more frequencies

The range of standard helical r.f. filters from Toko has been revised and extended to include coverage of the 800 to 1000MHz band and to provide smaller low-profile versions of the 7HW types. The 7HW filters are widely used in communications equipment including cellular radio. Over 15 types are available, offering a combination of selectivity, accurate matching and stability covering commercial, public service and amateur band frequencies in v.h.f. and u.h.f. Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG.
WW301

Thin transformers

The latest transformers from Avel-Lindberg are claimed to be the World's thinnest. The 0.8VA version in the OB range is 10.5mm high, which enables it to be mounted in a p.c.b. frame and may be added to equipment within the existing space, if there are extra power requirements. Dual primary windings for 120 or 240V mains a.c. are complemented by centre-tapped secondaries which give 10 to 48V in series or 5 to 24V in parallel. The transformers are tested to 5kV up to a maximum operating temperature of 120°C and conform to Class 2 specifications. The connecting pins may be soldered directly to a p.c.b. and extra mechanical strength can be provided by bolting the transformer down through the holes provided in the moulded plastic casing. Others with 2, 4, 6, 8, 10 and 14VA ratings are available. Avel-Lindberg Ltd, South Ockenden, Essex RM15 5TD.
WW302



WW301

Circuit design on home computer

A linear circuit analysis program, designed to run on the Acorn/BBC micro-computer is available from the designers, who originally wrote it for their own use as electronic design consultants. Circuits of up to 16 nodes and 60 components can be analysed. The program can simulate resistors, capacitors, inductors, transformers, bipolar and fet transistors, and operational amplifiers in any combination and analyse the circuit for input impedance, output impedance, gain and phase. The designers claim that considerable time can be saved in prototype breadboarding which in some cases may be omitted altogether. Versions of the program are being prepared for use with different computers. £35 inclusive from Number One Systems, 9A Crown Street, St Ives, Huntingdon, Cambs PE17 4EB.
WW303

High street disc-drives

Computer peripherals are just beginning to follow computers into the high street shopping centres. An attack is being launched into this market by Cumana with their

WW304

half-eight drives for 5.25" flexible discs for use with the Acorn/BBC and or the Dragon home computer. The drives are available with 40 or 80 tracks and single or double-sided. Each drive comes with a user manual and a formatting disc, as well as the appropriate firmware operating system and interface. Cumana Ltd, Pines Trading Estate, Broad Street, Guildford, Surrey GU3 3BH.
WW304

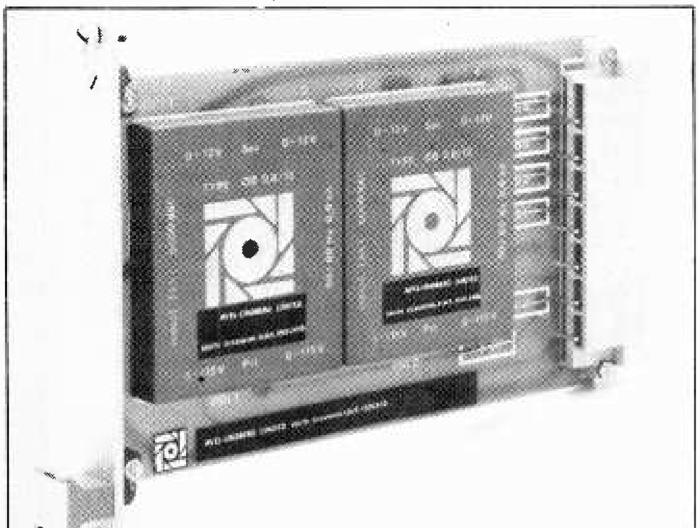
Linear-digital u.l.a.

Many electronics applications require analogue and digital circuitry together. This requirement can be satisfied by the Micronas MAS 7850, a c.mos integrated circuit containing both analogue and digital elements. The digital section of the circuit contains 48 D-type flip-flops which are already wired in to optimize performance and minimize silicon area. There are also 92 uncomitted logic elements, giving the digital section of the chip the equivalent total of 494 two-input gates. Circuitry at the 30 i/o pads can be configured to give various interfaces; c.mos or t.t.l. levels, tri-state, analogue switches, inputs with or without protection diodes etc. There are also 8 npn emitter follower transistors which may be connected in Darlington pairs.

The linear section of the chip contains four op.amps, two comparators, an eight-bit resistor ladder, auto-zeroing circuitry, a +5V to −5V d.c. to d.c. converter and some i/o circuitry. Each of the op.amps can be wired into different modes to optimize performance and power consumption. Unused op.amps are 'switched off' and consume no power. The comparators have high gain with a slew-rate of 10V/μs. They can also be configured as additional op.amps. Applications for the circuit include switched capacitor filters, modulators and demodulators, a-to-d and d-to-a converters, and many other uses in instrumentation and process control, wherever both analogue and digital signal processing is required. Coole Marketing Services Ltd, 26 Pamber Heath Road, Pamber Heath, Basingstoke, Hants RG26 TG.
WW305

Eprom programmer

An enhanced version of the Elan E2 eprom/eeprom programmer has been made available which can directly interface with development systems. Two communications modes may be used: an RS232C link to a computer to provide a memory dump, or remote control. Any of eight serial formats are key selectable as are data transmission rates up to 9600b/s. The remote operation is defined for most development systems and is compatible with Data O 20B routines or most equivalents. This allows the device selection and programming function of the E2 to be controlled from the keyboard of the development system. Once the data has been transmitted, the programmer may be disconnected and used as a stand-alone editing programmer/copier. The E2 is supplied with 16K bytes of ram as standard and this may be expanded to 32K. A wide range of editing functions can be down loaded from the host system so that it can be released to continue other tasks. The editing instructions include: byte string search and automatic amendment, automatic block changing of data, and the splitting or merging or programs. Single bytes may be programmed instantaneously and the contents of smaller eproms may be combined to be transferred to a single larger device. All currently available single-rail devices may be programmed and an optional socket is available for use with microprocessors that have on-chip eproms. Because the E2 is software controlled it may be configured to cope with any new device, or programming algorithm that may be developed in the future. Elan Digital Systems Ltd, 16 Kelvin Way, Crawley, W Sussex RH10 2TS.
WW306

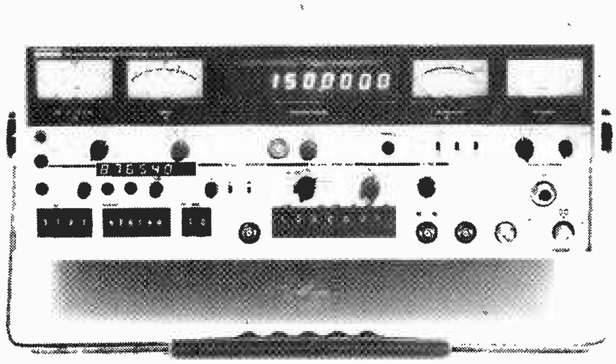


WW302

NEW PRODUCTS

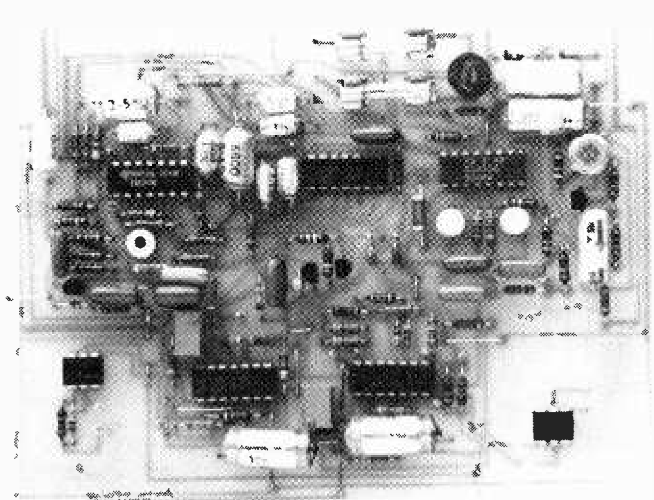
Radio telephone tester

An integrated test system for radio telephones has applications in land mobile, marine and aeronautical services. The RTT system incorporates eleven test modules which, although linked internally, can be operated independently. As only two leads are needed to connect the system to the test tranceiver, testing time is short and fault diagnosis is made simple. The instrument can measure automatically pilot tone transmission and reception and can provide selcall encoding and decoding for individual identification display. The p.l.l. signal generator has low noise, harmonic content and leakage to allow sum-microvolt sensitivity testing. Sinad measurement and a.f. monitoring are included. The r.f. power meter can measure in seven ranges up to 300W, and transmission frequency can be measured to as little as 1Hz, which is useful for quasi-synchronous testing. One feature, amongst others claimed to be unique, is the ability to test receive and transmit at the same time. This enables checks on full duplex receiver desensitivity. The unit is portable and can be operated from a 12V d.c. supply, which makes it suitable for field use. Other options include 1.5GHz testing, adjacent channel power measurement and off-air measurement. RTT, Enterprise House, Central Way, North Feltham Trading Estate, Feltham, Middx TW14 0RX.
WW307



WW307

WW309



WW310

Low cost micro-controller

Designed for use in industry, to add a controller to a product, the Xanar 680 microcontroller is also suitable for hobby and educational use. Typical applications include: printer controllers, games, digital voltmeters, digital weighing scales, a telephone timer, clock, car computer and eprom programmer.

The controller is based on the Motorola 6802 processor with either a 6821 p.i.a. for 18 i/o lines, or a 6522 v.i.a. with the same number of lines and a shift register and two 16-bit timer/counters. The board includes a 5V regulator and a 3.5MHz crystal. The controller holds its program in a 2716 or 2732 eprom (not supplied). The controller needs to be used with some external hardware, such as a keyboard (a 16-key hexadecimal keypad) and a display. It can also be programmed through a host computer with a rom emulator, such as the Softy II. When found to be operating correctly the program is transferred to eprom. Other methods for programming the controller are by using the Greenwich Instruments' 'Instant Rom' or by trial-and-error eprom programming (not really recommended!). In kit form, the Xanar Controller costs £19.95 for the 6821 p.i.a. version or £21.85 for the 6522 v.i.a. version. It is only £3 more to have them ready-built. Xanar, 20 Baldwin Road, King's Lynn, Norfolk PE30 4AN.
WW308

IC tester

An instrument from British designers to test most t.t.l. logic i.cs is offered at a price of £895, about half the price of the nearest competitor in the Far East. It is programmed in rom with test patterns for 14, 16, 20 and 24 pin devices from all t.t.l. families. The z.i.f. socket used for the devices is automatically powered down when released so testing can be very rapid and safe. The tester can differentiate between the various output configurations, such as open collector or tri-state. Iterative test loops can be used to find intermittent or temperature sensitive breakdown. Physically the instrument fits into a sturdy case and is suitable for field service use. A 12-key keypad is used to enter the device number and a push of the 'test' key is all that is required of the operator. A pass or fail result is indicated on a led display. Testing rates have been found to be about 360 devices per hour with mixed components rising to 800 per hour with identical devices. Optional extras include software to test c.mos logic devices, an interface with additional software for ribbon cable testing, and another interface for in-circuit t.t.l. testing ABI Electronics, 2 Nostell Fold, Dodworth, Barnsley, S Yorks S7 3SR.
WW309

Build your own modem

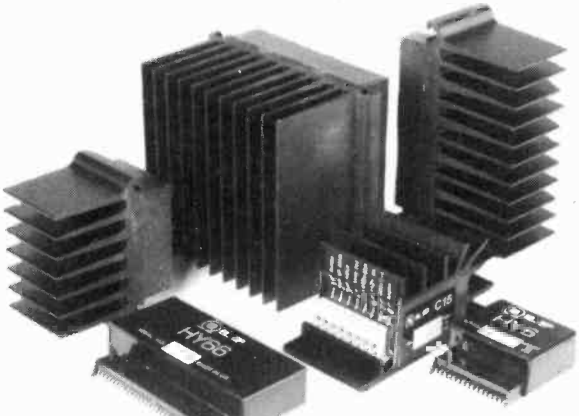
When assembled according to easy-to-follow instructions, the MD1 modem will allow a computer to communicate over a telephone line. The completed modem is CCITT compatible, operates in full duplex over a telephone line, powered from the phone line but optically isolated from it, and may be switched between originate and answer modes. It is directly connected to the telephone line without an acoustic coupler. The kit is available for £39.95 inclusive from Racom Ltd, 81 Cholmely Road, Reading, Berks RG1 3LY.
WW310

Printer buffer

Suitable for Epson dot matrix computer printers, is the range of printer buffers from Electroplan. They offer considerable saving in time as they can store the text of a print-out and direct it to the printer, thus freeing the computer so that it can carry on computing without having to wait for the printer. A buffer will take seconds to load, compared with the minutes taken to print. Models are available with Centronics or RS232 interfaces and with memory capacities of 16K, 32K and 64K bytes. As a gauge, 16K represents 240 lines of solid text, about four pages of A4, or 8 to 12 pages of program listing. Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH.
WW311

AMPLIFIERS

ILP



Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to over twenty different countries – including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I. L.Potts – Chairman

WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.
With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (–3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards
For ease of construction we recommend the B6 for modules HY6–HY13 £1.05 (inc. VAT) and the B66 for modules HY66–HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (–3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms.
Input impedance: 100K Ω. Damping factor: 100Hz > 400.

'NEW to ILP' In Car Entertainments

C15
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.
Very easy to use.
Robust construction. **£9.14 (inc. VAT)**
Mounts anywhere in car.
Automatic switch on.
Output power maximum 22w peak into 4Ω.
Frequency response (–3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω.
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω.
Size 95 x 48 x 50mm. Weight 256 gms.

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Stereo version of C15. **£17.19 (inc. VAT)**
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PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
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PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
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PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

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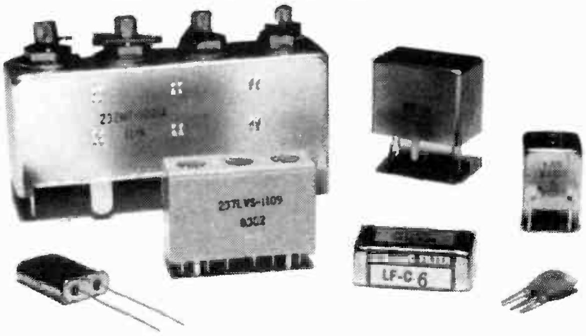

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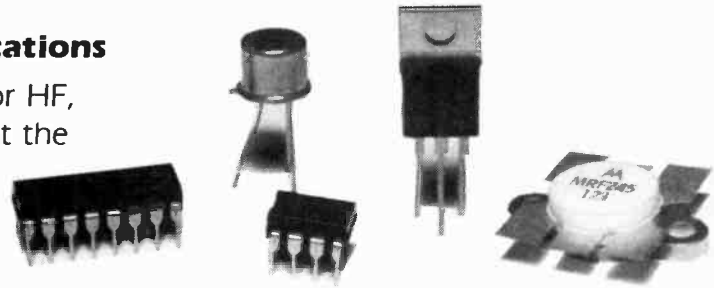

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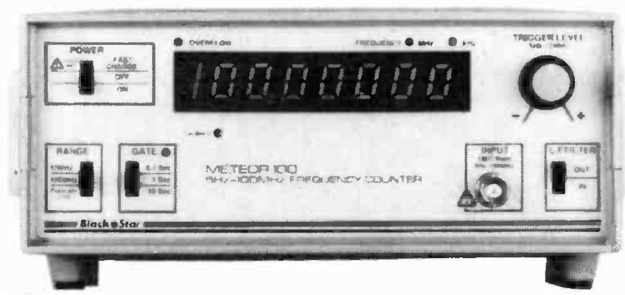

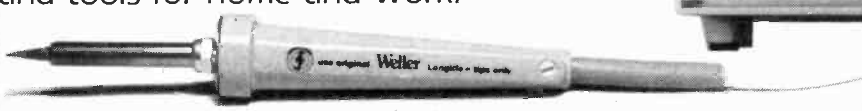

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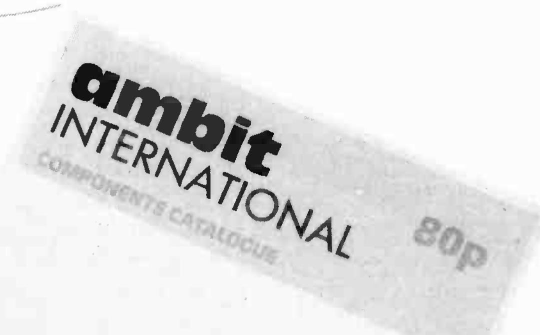

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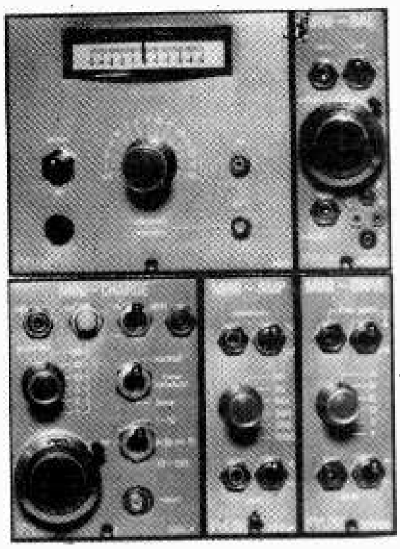

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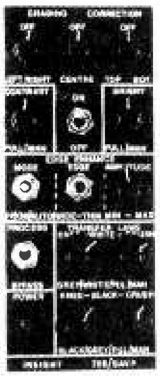

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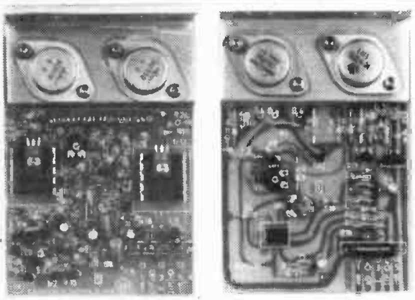

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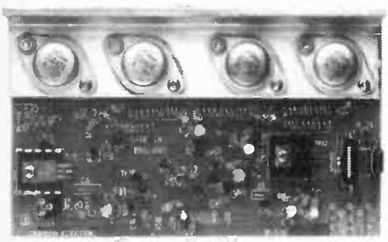

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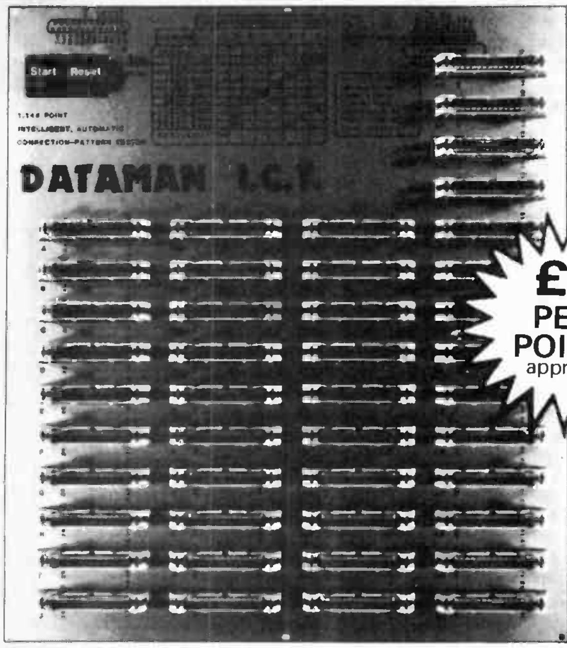

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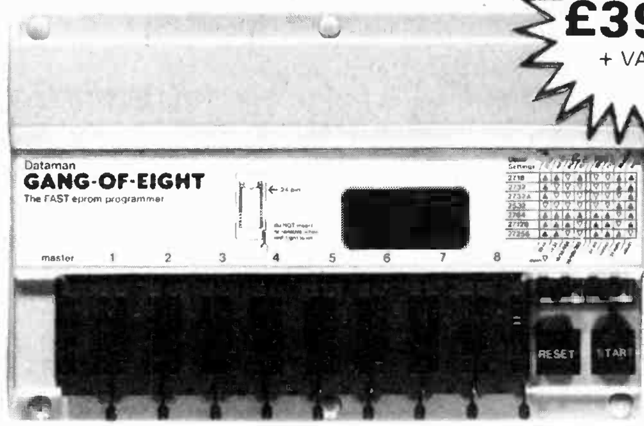

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MENTA GIVES REAL INSIGHT

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Outstanding editing, debugging, single-step, set breakpoint etc. Very useful on-line ASSEMBLER — also DISASSEMBLER to serial output. Cassette interface.
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Plugs into microprocessor socket, reads and writes to system ROM, RAM and I/O.
Prints memory contents in HEX, ASCII or ASSEMBLER MNEMONICS.
Prints MEMORY MAP of addressing space.
Performs CHECKSUMS. TESTS RAM, prints addresses and bits which default.
Tests data lines for SHORTS to rails, other data or address lines.
Tells engineer of address/data faults impossible to find with other tools.
Easy to program: retains sequences for testing up to fifteen different products in permanent memory.
Microdoctor is supplied in Z80, 6500, 6800 and 8085 format with appropriate disassembler (say which you want).

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EPROM PROGRAMMER/EMULATOR

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Will copy any EPROM to any other — same type or different. Uses TV for display of HEX MEMORY MAP with many code inserting, deleting, shifting and editing features. Has standard serial and parallel I/O routines for communication with computers and printers — and cassette interface.
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3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95
3AT2	3.35
3AW2	3.35
3B2	3.00
3B7	4.50
3B24	7.50
3B28	12.00
3C4	1.00
3C45	24.00

3CN3A	2.50
3CX3	2.50
3D21A	29.50
3D22	19.50
3J187E	398.00
3J187G	398.00
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4-250A	65.00
4C27	25.00
4C28	25.00
4CX250B I.T.T.	37.50
4CX250B EIMAC	58.00
4CX250B surplus ex-government	12.50
4CX250B tested ex-equipment	6.00
4CX250R	48.50
4CX350A	71.50
4GS7	2.25
4GV7	2.25
4J52	75.00
4X150A	25.00
5A152M	9.00
5A163K	10.00
5A170K	6.25
5AN8	1.20
5AR4	2.00
5AU4	1.50
5B.110M	10.00
5B-254M	14.50
5B-255M	14.50
5B-257M	9.00
5B-258M	14.50
5C22	40.00
5R4GB	2.80
5R4GY	2.80
5U4G	1.00
5U4GB	2.50
5V4G	1.25
5Y3GT	0.80
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A8G	1.50
6AB7	0.60
6AB8	0.66
6AC7	2.00
6AF4A	2.50
6AG5	1.50
6AG7	1.95
6AH6	1.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.00
6AK6	2.00
6AL5	0.52
6AM4	3.25
6AM5	6.00
6AM6	1.20
6AN5	3.95
6AN8A	2.15
6AQ5	1.20
6AQ8	0.85
6AR5	2.00
6AR8	2.00
6AS5	1.50
6AS6	1.50
6AS7G	7.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU6	0.85
6AV6	0.72
6AW8A	2.95
6B8G	1.50
6BA6	0.69
6BA6W	1.50
6BA7	4.50
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	1.00
6BE6	0.72
6BF5	1.60
6BG6G	1.25
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	2.75
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BL8	0.65
6BR5	0.70
6BR7	4.15
6BR8	2.15
6BR8A	2.15
6BS7	4.50
6BS8	2.50
6BW4	1.50
6BW6	5.35
6BW7	1.50

6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.00
6BZ7	2.95
6BZ8	0.95
6C4	1.10
6C5	1.95
6C6	0.50
6C8G	1.50
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	0.60
6CA7	4.50
6CB6	1.50
6CD6GA	4.50
6CF6	1.50
6CH6	10.35
6CL6	3.50
6CL8A	2.00
6CM5	1.60
6CS6	0.75
6CW4	7.25
6CY5	1.00
6DC6	2.95
6DK6	1.15
6DQ5	3.35
6DQ6B	2.50
6EA8	2.50
6EB8	1.75
6EU8	1.75
6EW6	1.50
6F1	2.00
6F6G	2.00
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F18	1.50
6F19	0.48
6F21	2.50
6F22	0.70
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F33	17.00
6FG5	1.95
6GH8A	0.80
6GK5	1.50
6GK6	2.00
6GV7	2.50
6GW6	2.50
6H3N	1.10
6H6	1.35
6H6GT	1.20
6J4	1.10
6J4WA	3.15
6J5	1.95
6J5GT	1.50
6J6	0.65
6JB6A	3.95
6JE6C	3.95
6JS6C	3.50
6K7G	0.70
6K8Y	3.95
6KD6	5.50
6L1	2.50
6L19	3.95
6L6GC	2.75
6L6GT	1.15
6L7G	0.75
6LD20	0.60
6LF6	4.50
6LQ6	4.50
6N7	2.50
6N7GT	1.50
6P15	1.50
6P25	4.00
6P28	2.00
6Q7	1.20
6Q7GT	1.20
6S4A	1.50
6S7	1.10
6SA7GT	1.00
6SC7	1.50
6SG7	1.20
6SH7	1.20
6SJ7GT	1.20
6SK7	0.80
6SK7GT	1.20
6SL7GT	0.85
6SN7GT	0.69
6SQ7	0.80
6SS7	1.95
6U4GT	1.75
6U5G	1.50
6U8	0.85
6U8A	1.50
6V6GT	0.80
6X2N	1.00
6X4	0.96
6X5GT	0.50
6X5GTY	1.00
6X8A	2.25
7A7	2.00
7AD7	1.75
7B7	2.50
7C5	3.00
7C6	2.50
7H7	2.00
7Q7	2.00
7S7	3.00
7Y4	1.95
8B8	2.50

8FQ7	1.95
10C1	5.50
10C2	0.70
10D2	1.25
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
11E2	16.50
11E3	55.00
12AE6	0.85
12AG8	1.50
12AL5	1.00
12AT6	0.59
12AT7	0.95
12AT7WA	2.50
12AU6	1.50
12AU7	0.55
12AV6	0.80
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AYZ	4.00
12AZ7A	1.95
12B4A	3.50
12BA6	1.50
12BE6	1.05
12BH7A	1.80
12BL6	0.70
12BY7A	2.75
12CX6	1.20
12E1	17.95
12E14	28.00
12GN7	3.95
12HG7A	3.95
12J7GT	0.70
12K5	1.00
12K7GT	0.60
12K8	1.10
12Q7GT	0.50
12SA7GT	1.00
12SH7	1.00
12SK7	1.00
12SJ7	0.60
12SN7GT	1.85
13D3	3.20
13D7	3.20
13DR7	2.95
13E1	115.00
14S7	1.00
17DW4A	1.75
17EW8	0.95
17JZ8	2.75
18D3	1.60
19AQ5	1.15
19G3	17.00
19H4	23.95
19Q6	9.00
20A2	10.50
20D1	0.70
20D4	1.75
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.05
20P5	1.15
21LU8	2.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30	2.85
30C1	0.70
30C15	0.40
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	4.15
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KO6	5.50
47	6.00
50B5	1.50
50C5	0.95
50CD6G	1.15
50JY6	2.95
52KU	2.00
61SPT	4.50
75B1	2.50
75C1	2.95
83A1	7.00
84	3.00
85A1	6.50
85A2	2.00
90AV	10.00
90C1	2.70

90CG	13.50
91AG	9.00
92AG	12.50
92AV	12.50
95A1	6.50
108C1	1.50
150B2	3.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
205F	12.00
257A	6.00
307	5.00
329	5.00
388A	17.50
425A5	8.00
431U	2.00
572B	35.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
725A	275.00
803	14.95
805	39.00
807	1.50
810	55.00
811A	12.95
813	18.50
813 USA	59.50
833A	115.00
866A	3.50
872A	19.00
873	60.00
884	5.50
954	0.50
955	0.90
958A	0.90
1299A	0.60
1625	3.00
2050W	9.50
2050	7.00
3545	4.00
4313C	4.00
5642	8.50
5651	3.20
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5675	23.50
5687	4.50
5692	3.50
5696	3.50
5704	3.50
5718	6.50
5725	2.50
5726	2.50
5727	2.50
5749	2.50
5750	2.00
5751	3.50
5763	4.95
5814A	3.25
5840	3.50
5842	6.50
5879	3.90
5881A	4.60
5894	39.50
5899	4.50
5963	2.00
5965	2.25
5993	8.00
6005	1.95
6012	16.00
6021	3.95
6057	2.50
6059	3.75
6060	2.25
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	5.75
6080WA	8.50
6096	2.85
6132	10.00
6136	2.50
6146B	7.50
6201	6.95
6211	2.50
6267	1.50
6350	2.00
6360	5.50
6386	14.50
6545	8.50
6550A	8.00
6870	11.50
6883B	9.95
6973	3.75
7025	2.50
7027A	4.65
7032	2.00
7059	2.50
7189	2.50
7199	3.95
7247	2.00
7360	8.95
7475	5.00
7551	5.75
7558	11.50
7581A	3.00
7586	11.50
7591A	3.95
7609	47.00
7868	3.95
8012	4.20
8136	1.00
8298A	4.95
8417	5.95
9001	0.90
9006	0.90
18042	10.00
18045	10.00

WIREWOUND RESISTORS

PREFERRED VALUES

4 Watt	4R7-1K8	0.15
	2K2-6K8	0.18
	10K	0.24
7 Watt	R47-4K7	0.18
	5K6-12K	0.19
	15K-22K	0.20
11 Watt	1R-10K	0.20
	15K-22K	0.24
17 Watt	1R-10K	0.26
	15K-22K	0.28

WW-2

BASES ETC.

B7G	0.15
B7G Skirted	0.30
B8G	0.70
B9A	0.20
B9A Skirted	0.30
B10B	0.16
B13B	0.50
8 Pin DIL	0.14
14 Pin DIL	0.15
14 Pin DIL/Q	0.30
16 Pin DIL	0.17
OCTAL	0.35
CANS	0.27
B9A PCB	0.15
B5	0.75
B9G	0.38

ZENER DIODES

BZX61 0.15
6V2 7V5 8V2 9V1 10V 11V 12V 13V
15V 16V 18V 20V 22V 24V 27V 30V
33V 36V 39V 47V 51V 56V 68V 75V

BZY88 0.07
2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1
5V6 6V2 6V8 7V5 8V2 9V1 10V 11V
12V 13V 15V 18V 20V 24V 27V 30V

THERMISTORS

VA1040	0.23
VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

BATTERIES

7V Power Mike batteries
TR175 £1.40 ea
other prices on request

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★ ENTRANCE ON A227
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THE 'ALADDIN'S' CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

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Fully refurbished DIABLO/DRE series 30 2.5 Mb disk drives.
DEC RKO5, NOVA, TEXAS compatible.
Front load. Free stand or rack mount *£550.00*
Exchangeable type (via lid removal) *£295.00*
me3029 PSU unit for 2 drives *£125.00*
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1000's of spares for S30, 4000, 3200, HAWK ex stock.
Plus in house repair, refurbishing service.
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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

COMPUTER 'CAB'

All in one quality computer cabinet with integral switched mode PSU, Mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the PSU is fully screened and will deliver a massive +5v DC at 17 amps, +15v DC at 1 amp and −15v DC at 5 amps. The complete unit is fully enclosed with removable top lid, filtering, trip switch, 'Power' and 'Run' LEDs mounted on Ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. **Give your system that professional finish** for only £49.95 + Carr. Dim. 19" wide 16" deep 10.5" high. Useable area 16"w 10.5"h 11.5"d.
Also available **LESS PSU**, with FANS etc. Internal dim. 19"w. 16"d. 10.5"h. *£19.95*. Carriage & insurance £9.50.

CALCOMP PLOTTERS

936 3 colour digital incremental, 37" drum, parallel interface and accessories *£2,500.00*
7184 colour digital **8 x 5 FEET** flat bed & controller (cost 25,000) 1 only at *£1,950.00*
Viewing by appointment.

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

SCOOP! BRAND NEW CASED WORD PROCESSOR KEYBOARDS

Made by the famous 'KEYSWITCH' corporation, for a well known computer company's top of the range word processor at a price of over £200.00!! Constructed around an internal **INTEL 8048** cpu this superbly styled 106 key keyboard was intended to interface with a main computer via a TTL serial interface. Standard **HALL EFFECT** long life switches are utilised on an XY matrix, buffered by 74 series TTL ic's to the eight bit CPU port enabling simple modification to your own custom decoding logic via an EPROM etc. Many other features for the most exacting user include: **numeric keypad, cursor control pad, ten clear top function keys, LED indicators,** single 5v supply on-off lock switch etc. Supplied **BRAND NEW** and boxed with circuit diagram. ***ONLY £49.95 + £2.00*** P&P

DRE 7100

8" Disk Drives
New **£225** + VAT

VIDEO MONITORS

12" CASED. Made by the British KGM Co. Designed for continuous use as a data display station, unit is totally housed in an attractive brushed aluminium case with ON-OFF, BRIGHTNESS and CONTRAST controls mounted to one side. Much attention was given to construction and reliability of this unit with features such as, internal transformer isolated regulated DC supply, all components mounted on two fibre glass PCB boards – which hinge out for ease of service, many internal controls for linearity etc. The monitor accepts standard 75 ohm composite video signal via SO239 socket on rear panel. Bandwidth of the unit is estimated around 20 Mhz and will display most high def graphics and 132 x 24 lines. Units are secondhand and may have screen burns. However where burns exist they are only apparent when monitor is switched off. Although unguaranteed all monitors are tested prior to despatch. Dimensions approx. 14" high x 14" wide by 11" deep. Supplied complete with circuit. 240 volt AC operation. ***ONLY £45.00 PLUS £9.50 CARR.***
24" CASED. Again made by the KGM Co with a similar spec as the 12" monitor. Originally used for large screen data display. Very compact unit in lightweight alloy case dim. 19" H x 17" D x 22" W. All silicon electronics and composite video input make an ideal unit for schools, clubs, shops etc. Supplied in a used but working condition.
ONLY £55.00 PLUS £9.50 CARR & INS.

SAVE £250 SUPER PRINTER SCOOP

CENTRONICS 739-2

The "Do Everything Printer" at a price that will NEVER be repeated. Standard Centronics interface, full graphics, 4 type fonts with **high definition & proportional spacing for word processor applications.** 80-132 columns, single sheet, roll or sprocket paper handling plus much more. Available only from DISPLAY ELECTRONICS at a ridiculous price of only ***£199.00***
Options: carriage & insurance ***£10.00***
Interface Cable ***£10.00***

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

SOFTY 2

The amazing SOFTY 2. The complete "toolkit" for the open heart software surgeon. Copies, Displays, Emulates ROM, RAM and EPROMS of the 2516, 2532 variety. Many other features include keyboard, UHF modulator, Cassette interface etc. Functions exceed capabilities of units costing 7 times the price! Only ***£169.00*** pp £1.95 *Data sheet on request*

QUALITY INTERFACE CABLES & CONNECTORS

18/3B D25S to 10ft 18 way *£4.90*	22/2C D25S to 16ft 22 way *£6.50*
22/2A D25S to 3ft 22 way *£2.90*	22/3C D25S to D25P 15ft 22 way *£11.50*
22/3B D25S to D25P 9ft 22 way *£8.50*	1014B D15P to 12ft 15 way (BBC) *£2.90*
25/08 25 way cable 5ft long *95p*	12/15 10 way cable 12ft long *£1.00*
D25S ex equip *60p* D25S socket new *£1.25*	D25 split shells *£1.00*

SUPER DEAL? NO — SUPER STEAL!!

The FABULOUS 25CPS TEC Starwriter Daisy wheel printer at a fraction of its original cost.

BRAND NEW AT ONLY £499 + VAT

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.**

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 nnormally cost to buy. Fully guaranteed all I.C.'s full spec. 100+ ***£6.90*** 200+ ***£12.30*** 300+ ***£19.50***

DATA MODEMS

Join the communications revolution with our range of EX TELECOM data modems. Made to most stringent spec and designed to operate for 24 hrs per day. Units are made to the CCITT tone spec. With RS232 i/o levels via a 25 way 'D' skt. Units are sold in a tested and working condition with data. Permission may be required for connection to PO lines.
MODEM 2B "Hackers Special" fully fledged up to 300 baud full duplex, ANSWER or CALL modes. Data i/o via standard RS232 25 way 'D' socket. Just 2 wire connection to comms line. Ideal networks etc. Complete with data, ready to run ***£85.00***
MODEM 20-1 Compact unit for use with **MICRONET, PRESTEL** or **TELECOM GOLD** etc. 2 wire direct connect. 75 baud transmit 1200 baud receive. Data i/o via RS232 'D' socket. Guaranteed working with data ***£49.95***
MODEM 20-2 same as 20-1 but 75 baud receive 1200 baud transmit. ***£130.00***
MODEM 20-3 Made for data rates up to 1200 baud in full duplex mode over 4 wire circuit or half duplex mode over 2 wires. ***£130.00***
MODEM 13A compact, async, same size as telephone base. Up to 300 baud, full duplex over 2 wires, but call mode only ***£75.00***
DATA PUMP MODEM compact unit up to 1200 baud full duplex over 4 wires or half duplex over 2 wires. BELL specification with data i/o via RS232 25 way D socket, remote test etc. 240 v operation. Supplied complete with data ***£65.00*** carr. £4.50.
For more information or details of other types of ex. stock modems contact sales office.

Carriage 13A £4.50. 2B/C & 20 £9.50.

66% DISCOUNT

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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, Cap's, 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.

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ALL types of Computer equipment and spares wanted for prompt **CASH PAYMENT**

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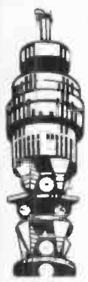
(1926)



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(291)

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£6,000-£8,500

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The successful applicant will be engaged primarily in the repair and calibration of our range of premium voltmeters and calibrators, and will be prepared to undertake site visits in support of our systems activities.

He or she will have practical experience in the repair to component level of precision analogue and embedded microprocessor circuitry. Some understanding of high level programming and IEEE 488 BUS is desirable.

Relocation assistance will be offered where appropriate. Please apply in writing for an application form to:

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(2365)

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Do you have analogue design skills but feel you are missing out on the microprocessor revolution? Wayne Kerr have opportunities for analogue design engineers who want the challenge of interfacing with the microprocessor. The resulting ATE and Bridge products are in the forefront of their fields and you could be part of this exciting environment.

Our company, part of a rapidly expanding international group, offers competitive salaries with associated benefits and pleasant working conditions in the South of England.

If you are interested and would like further details, please write to:
Miss Jo Hall, Personnel Officer, Wayne Kerr Limited, Durban Road, South Bersted, Bognor Regis, West Sussex PO22 9RL. Tel: (0243) 825811

(2393)

ASSISTANT MAINTENANCE ENGINEER

required for our busy film/video company in the West End. Duties involve maintenance of a wide variety of film dubbing equipment (16mm and 35mm) and video equipment (1in and U-Matic standards).

Someone with lots of enthusiasm and some relevant electronics experience will have the opportunity to develop their skills and work without the boss looking over their shoulder all the time.

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(2361)

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(1935)

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Experienced Test Engineers are needed to perform both card and rack testing on these pieces of equipment, faultfinding to component level and conducting acceptance tests prior to despatch. As assistance may be required in the production of test procedures, the ability to develop such procedures and additional test rigs would be an advantage.

Candidates with at least three years' relevant experience together with a full TEC qualification or equivalent, should write or telephone for an application form to:

The Personnel Officer, Micro Consultants Group, 17 West Mills, Newbury, Berkshire. Tel: Newbury (0635) 48222.

(2369)

MICRO CONSULTANTS GROUP

HUNTINGDON HEALTH AUTHORITY
Hinchingbrooke Hospital

Medical Physics Technician I

(Technician in charge of bio-medical equipment support unit)

We require an experienced technician, who will be in charge of the Bio-Medical Equipment Support Unit, which provides the technical service support for Anaesthetics, Electro-Medical and associated equipment within the Health Authority.

The post will be based at the new Hinchingbrooke Hospital, the District General Hospital, although the duties of the post will extend to all hospitals and units within the district.

Salary scale: £8,910 to £10,398 per annum.

Application form and job description from: District Personnel Officer, Huntingdon Health Authority, District Headquarters, Primrose Lane, Huntingdon, Cambs PE18 6SE. Tel: Huntingdon 50571 Ext. 32.

Closing date for applications: 11th January, 1984.

Previous applicants need not re-apply.

(2374)

A.B.Electronic Products Group PLC

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SALES ENGINEER, CABLE TELEVISION & ELECTRONIC COMMUNICATION SYSTEMS

Wolsey Electronics, market leaders in the U.K., is a company within the AB Electronic Products Group PLC

Wolsey is the leading U.K. manufacturer of MATV and Cable Television distribution equipment and digital "Warden Call" alarm systems for the elderly and infirm. Expansion in these and allied fields, including Direct Broadcast Satellite systems and fibre optics, has created a further requirement for an experienced Sales Engineer to operate in London and South East England.

Based at home, the applicant appointed will have the full backup facilities of Wolsey's London Planning Office and Depot.

Salary and conditions of employment will be competitive and commensurate with the applicant's experience, who will probably be aged 25 to 40 years.

A company car will be provided.

Write or telephone for an application form to:

(2357)

The Personnel Manager,
AB Electronic Products Group PLC, Abercynon,
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SENIOR DEVELOPMENT ENGINEER

Location: West London

An appointment exists within a long-established electronic data capture company for a Senior Development Engineer.

The following requirements associated with this appointment are:

★ Knowledge of microprocessor based data capture equipment.
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★ Customer liaison.

The successful applicant would probably be qualified to HNC level, and have at least three years' experience in the electronic industry, preferably in data processor type equipment, and have experience of microprocessors and data communications interfaces.

Normal large company benefits . . . + company car. Salary commensurate with experience.

Please write or telephone in first instance for an application form to Miss Carol Cox, Kimball Systems (A Division of Litton Business Systems), 113/117 Gunnersbury Avenue, Ealing, London W5 4LR. Tel. 01-993 5934.

(2362)

Telecommunications for the future

Maintenance Engineers

London, Birmingham and Manchester

£10,000 – £13,000 plus allowances

Mercury operates a new independent digital communications network for voice/data and T.V. transmission in the U.K. using the latest technology and techniques.

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Suitable applicants will have a sound knowledge of digital and analogue techniques as applied to the telecommunications field. In addition they will have had several years experience on either maintenance and repair or commissioning of customer equipments in at least one of the following areas:–

i) Microwave point to point or point to multipoint systems.

ii) PCM/TDM multiplex systems.

iii) High speed data communications systems.

Salary will be dependent on age and experience and is negotiable in the range £10,000 – £13,000 p.a. The London posts carry an additional weighting of £1,200 p.a. An estate car will be provided and applicants should hold a clean driving licence. Staggered working hours and call out duties will be necessary for which additional payments will be made.

These are outstanding career opportunities offering the chance to make a significant personal contribution to the success of one of the most exciting developments of the 1980's.

Please write or telephone for an application form to: Mercury Communications Ltd., Ninety Long Acre, London WC2E 9NP, Tel. 01-836 2449 stating which location you are interested in.

Mercury
COMMUNICATIONS

(2371)

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We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details.

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We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

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.

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87 St. Leonard's Road, Windsor, Berks.
Windsor (07535) 58022 (5 lines)

(1640)

CLIVEDEN

Electronics Technicians

Petty-Ray Geophysical Division of Geosource is one of the leading companies in the field of oil exploration and require single personnel, in the age range 21-35, who are looking for a varied and interesting career working overseas.

You should be educated to ONC/HNC in Electronics or C & G Radio and TV Technician level, and on appointment you will be assigned to one of our field crews either in AFRICA or the MIDDLE EAST for on-the-job training in the operation and maintenance of digital seismic recording equipment.

Candidates must be in possession of a current driving licence.

We offer a good starting salary which is paid NET, food and accommodation will be provided and rest leaves are generous.

If you would like to have more information about these positions please write giving brief career details to:-

The Personnel Officer, Petty-Ray Geophysical Division of Geosource, 3-5 The Grove, Slough SL1 1QG, Berks.

(2358)

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EMC/EMP assessment on high technology equipment

At Frimley, we have an international reputation for our work on the design and development of sophisticated electronic systems and equipment for both civil and defence applications. Our multi-discipline teams of engineers, both men and women, are engaged in an expanding programme of advanced projects in which extensive use is made of state-of-the-art techniques in the solving of complex problems.

Within our Technology Group, we are looking for experienced RF Engineers, with qualifications to degree/HNC level, to provide specialist support to teams engaged in equipment design. This will involve carrying out theoretical and experimental assessments of system electromagnetic compatibility (EMC) or vulnerability to nuclear electromagnetic pulse effects (EMP).

These positions call for a sound electrical/electronics engineering background and specific experience of at least one of the following: electromagnetic analysis, computer-based mathematical modelling, development of HF equipment including HF/VHF transmitters and receivers, and EMC measurements.

All appointments will provide exceptional opportunities to work in a particularly stimulating technological environment and make a significant personal contribution to our work. If you have the necessary innovative ability and professional expertise, you can look forward to a really challenging future with ample scope for career development.

We offer a competitive salary together with an attractive range of fringe benefits.

Write with details of experience and qualifications to Margaret Perceval, Personnel Department, Marconi Space and Defence Systems, Chobham Road, Frimley, Surrey GU16 5PE. Or telephone Camberley 63311 for an application form.

Marconi
Space & Defence Systems

(2389)

PETERBOROUGH HEALTH AUTHORITY

Are you looking for an interesting and challenging new position? Are you qualified to at least ONC level with practical electronics experience? Then why not come and join an expanding electronics department in Peterborough?

We are looking for a technician to maintain X-ray, radio therapy and ultrasonic scanning equipment

Salary £6,132 to £7,926 per annum by seven annual increments

Ring Allan Edwards on Peterborough (0733) 67451, ext. 250 for details and application forms or write to:

District Works Department
Peterborough District Hospital
"Eastlea", Thorpe Road
Peterborough

Closing date for applications: 28 December, 1983

(2399)

UNIVERSITY OF LONDON
INSTITUTE OF EDUCATION

ELECTRONICS TECHNICIAN

(Grade 5/6)

Required for Child Development and Educational Psychology Department. Duties include maintenance of Audio, Video and Psychological Equipment, and the development of the use of Microcomputers in Education and Research. Good knowledge of Analogue and Digital Electronics and the ability to design, construct and service apparatus essential. Knowledge of Microcomputer programming an advantage.

Applicants should have HNC/HTEC or equivalent and seven to 10 years' experience.

Salary within range £7529-£9852 inclusive.

Please ring Mary Griffin, Personnel Section, University of London Institute of Education, 20 Bedford Way, London WC1H 0AL, 636 1500 ext 254, for further details and application form quoting ref T5-6/CDEP. Closing date 31 January.

(2391)

COMMUNICATIONS POSITIONS

TO MAKE YOU THINK A LITTLE FASTER

Below are a number of positions that will up the pulse and make the grey matter churn round a little faster.

Telephone Paul Hecquet or write to him to discuss these and many other positions we have within our Communications Division.

Systems Engineer/Proposals – on site work — c£12,000 — South East

The job will be to carry out complete systems appraisals/evaluations, generate a proposal for predominantly civil/civilian duty VHF/UHF users. Ref: 2/135.

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Experience in television engineering, VHF/UHF techniques and/or Data Comms would be useful to this Cable TV systems provider. Ref: 3/260.

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For technical and engineer level people to around £17,000 for supervisory staff. You must have experience with a TV Broadcasting organisation though not necessarily UK based. Ref: 1/241.

The Electronics Recruitment Company
Temple House
25/26 High Street, Lewes
East Sussex BN7 2LU
Tel: Lewes (07916) 71271

(2313)

RF ENGINEER

Degree status
Satellite communications experience preferred
Two-year Essex contract
£12 per hour

Telephone
Graham Williams
(0920) 5921
STAFFHIRE LTD.
80-82 High Street
Ware, Herts

(2400)

CINE LINGUAL SOUND STUDIOS LTD.

Due to expansion we require an

EXPERIENCED ELECTRONICS ENGINEER

for the maintenance of our film dubbing theatres

Salary up to £10,000

For further information contact Lynne Robinson on 01-437 0136

(2368)

ELECTRONICS ENGINEER

Auditel Systems Ltd. specialises in the manufacture of conference communication systems and designs equipment for specific applications. The company is small but expanding and an opportunity exists for an Engineer with a degree or H.N.C. in electronics to assume wide ranging technical responsibilities with the chance to become involved with the company's future. The position covers technical liaison between design and production, systems design and documentation, testing and commissioning. Candidates should have a background in audio and digital electronics with some microprocessor experience. Salary negotiable, area £9,000 p.a.

Please apply to J. M. White
AUDITEL SYSTEMS LTD
78 Asheridge Road
Chesham, Bucks HP5 2PY

(2357)

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(2172)

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Lockheed's benefits package gives you free bachelor accommodation; free food, work clothing and laundry; free return flights to the UK on your three paid leave periods a year; medical and life insurance; excellent sports and recreational facilities.

If you've a C&G or its forces equivalent, and at least seven years experience on the equipment areas we've specified, it's well worth your while getting in touch.

Because with us, your skills could really make a big difference.

Talk to Larry Mulhearn on 01-574 5000, or write to him at IAL, Recruitment Consultancy, Aeradio House, Hayes Road, Southall, Middx. UB2 5NJ. Please quote Ref. L229.

Lockheed IAL

(2373)

SCOTTISH OFFICE
DIRECTORATE OF TELECOMMUNICATIONS

WIRELESS TECHNICIAN

(£6,251-£8,450)

Applications are invited for the above post based in East Kilbride near Glasgow

Candidates must have a sound theoretical and practical knowledge of Radio Communications Systems both fixed and mobile, in the frequency range HF to 2GHz. They must also be able to use test equipment and simple machine tools. A sound basic knowledge of digital techniques would be an advantage. They should have a minimum of three years' appropriate experience and should hold an Ordinary National Certificate in Electronic or Electrical Engineering **or** a City and Guilds of London Institute Certificate in an appropriate subject **or** a qualification of higher or equivalent standard. Some assistance may be given with re-location expenses.

A valid UK driving licence is essential.

Application forms and further information are obtainable from Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (quote ref. PM(PTS) 1/4/83). (031-556 8400 Ext. 4317 or 5028.)

Closing date for receipt of completed application forms is 12 December 1983.

(2367)

WEST YORKSHIRE METROPOLITAN COUNTY COUNCIL

An Equal Opportunities Employer

RADIO TECHNICIAN

Post Ref ES 20 206/F28
£7,191-£7,896

Based at Chantry House, Wakefield, duties involve the provision of an effective service of operation, maintenance and repair of the radio telephone system. Network consists of approximately 650 vehicle-mounted radios, 5 VHF transmitter sites and numerous land lines.

A TEC/ONC level qualification in electrical, electronic or radio engineering or a similar discipline is required, and experience in the maintenance and repair of radio communication equipment is essential.

Mr R. Mackey (Wakefield 367111, Ext 3519) will answer queries.

Closing date: 30 December 1983.

Application forms are available from, and should be returned to, the Director of Manpower Services, 8 St John's North, Wakefield WF1 3QA (Tel. 367111, Ext. 2840).

(2379)

Sandra Jeram 637 5200
F. S. Wiffen
L/FS/017/7A7

Are you an inventive electronics person with good, old-fashioned horse-sense?

We are looking for someone to join us in N.E. Surrey in a small but busy and creative team designing electronics for a range of laboratory and industrial measurement equipment.

We use analogue and digital circuitry and 6800/6809, and have recently started to make use of FORTH. There is plenty of opportunity for brain-stretching, and scope for the contribution of ideas from outside the electronics field.

If this sounds as if it might suit you, or that you might adapt to it, then get in touch.

We would expect that the successful candidate will have experience in nitty gritty electronics and probably be HNC/Degree level but qualifications are of much lower importance than actual ability.

Telephone Tania Thompson (Chertsey 62671) or write for an application form to:

KENT INDUSTRIAL MEASUREMENTS LTD.
Hanworth Lane, Chertsey, Surrey KT16 9LF

(2385)

National Heart and Chest Hospitals
Brompton and London Chest Hospitals

Medical Physics Technician

ELECTRONICS

A vacancy exists for a technician with hospital experience to join the team of technicians in the Department of Medical Electronics. The department provides a comprehensive maintenance and development service to two busy Cardiothoracic hospitals. The technician will be based initially at the London Chest Hospital E2, but he/she must be willing to also work at Brompton Hospital SW3.

The post is as MPT4 but prospects for promotion to MPT3 do exist.

For further information contact Mr P. Butler, Chief Technician, 01-980 4433. Ext. 340.

For a job description and application form contact Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP. Tel: 01-352 8121. Ext. 4357. Closing date: 13th January, 1984.

(2390)

R.T.T. SYSTEMS
RADIO TELEPHONY TESTING

R.F. ENGINEERS – DESIGN AND SALES

We are a Division of a highly successful Electronics Group with considerable expertise in Control Systems; this new Division is involved with Radio Telephone Test Systems and has a major technical expansion programme ahead.

To assist in these exciting projects we require additional R.F. specialists to work with our small team designing, producing and selling to all markets.

DESIGNER/PROJECT CONTROLLER

Must have sound theoretical background in circuit design applied to a practical understanding of R.F. Engineering to 1.5 GHz or above. Must have degree level in Electronics and several years' experience in design, development and project control – possibly using outside consultants. Must be highly self-motivated and results orientated. Being a Radio enthusiast would be a bonus.

SALES ENGINEER

Must have considerable experience of customer liaison and selling test equipment preferably associated with R.F. communications.

Sales are direct to end users in private and public industries. The company therefore expects a high degree of professionalism in both planning and application.

Ideally the sales engineer should be qualified with practical training in electronics/R.F. Must be prepared to stay away from home occasionally.

Applications only from people wishing to enjoy the freedom and opportunity to exercise your personal innovativeness with prospects of growing with the company. Benefits include: company car, substantial salary, bonus, plus normal benefits associated with progressive company.

Send your career details or phone for an application form to: **R. J. West (01-844 1811) R.T.T. (Division of Hanworth Enterprises), Gresham House, Twickenham Road, Feltham, Middlesex TW13 6HA.**

(2394)

Marine Electronics Engineer

ECUADOR

Duties: To join a British team working with Ecuadorian counterparts on the assessment and efficient utilisation of Ecuador's fisheries resources. The expert will be required to run and maintain the specialist electronic equipment on a modern fisheries research vessel, particularly echo-sounding and sonar equipment. He/she will also advise other team members on the efficient operation of the equipment and assist in the training of Ecuadorian staff. Considerable sea-time will be involved.

Qualifications: Applicants, who should be British citizens, should possess relevant professional qualifications and experience and be capable of technical improvisation to meet changing needs in the development of the survey programme. A working knowledge of Spanish is preferable.

Appointment: Two years. The salary in the range £9,950-£12,800 will be paid commensurate with experience and qualifications, and subject to United Kingdom Income Tax. In addition, a tax-free variable Foreign Service Allowance in the range £105-£645 per annum and a supplementary allowance in the range £325-£1,580 per annum, both dependent on salary and marital status, are payable.

The post is wholly financed by the British Government under Britain's programme of aid to the developing countries. In addition to basic salary and overseas allowances, other benefits normally include paid leave, free family passages, children's education allowances and holiday visits, free accommodation and medical attention.

For full details and application form please apply, quoting Reference AH 312/L/AJ, stating post concerned, and giving details of age, qualifications and experience to:

Appointments Officer,
Overseas Development Administration,
Room AH 351,
Abercrombie House,
Eaglesham Road,
EAST KILBRIDE,
Glasgow G75 8EA

ODA

OVERSEAS DEVELOPMENT

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(2389)

DESIGN ENGINEER

Earn over £20,000 p.a.

We are looking for an outstanding design engineer to join the team that created the Elan Enterprise home computer.

The successful applicant will have several years' experience of digital design techniques, as well as great creative flair and boundless enthusiasm.

The situation is based in Central London and an extremely attractive salary will be negotiated.

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David Levy
INTELLIGENT SOFTWARE LTD. (DEPT. WW)
21 Store Street, London WC1E 7DH

(2375)

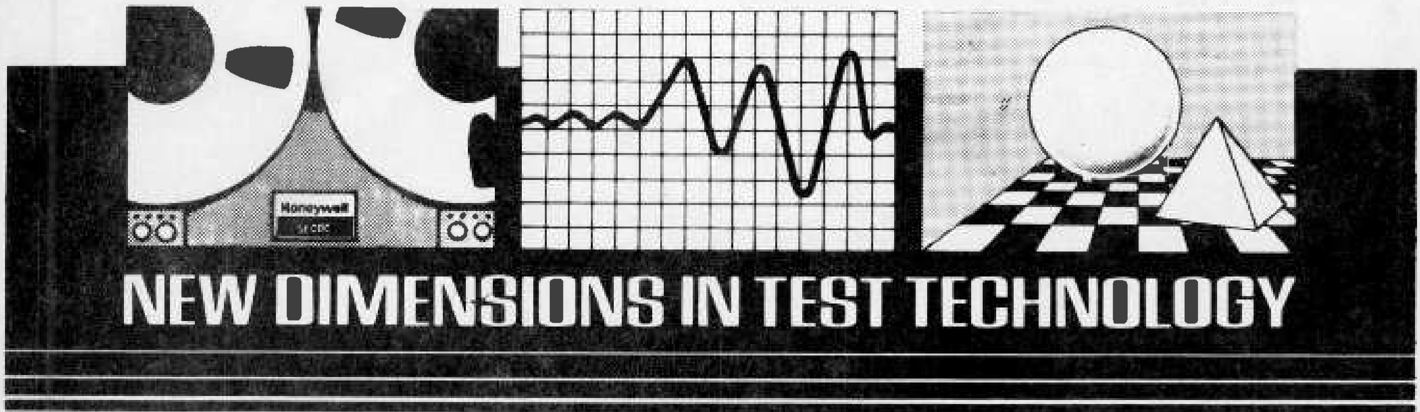
It's more by design than accident that Honeywell is ahead in advanced instrumentation worldwide. The Test Instrument Division based at Bracknell, is responsible for ensuring the effective operation of Industrial Tape Systems, Video Graphic Camera Systems and Oscillographic recorders countrywide in industrial, medical and R & D establishments.

We now need experienced Electronics Engineers, who after a brief product familiarisation period, will be able to work to maximum effectiveness in trouble-shooting hi-technology equipment. Ideally, you will have a minimum of three years experience in fault-finding and maintaining 'state-of-the-art' equipment.

The position also involves a high degree of customer contact and you will be expected to work on your own initiative to assist in expanding our customer base.

By joining us you can expect all the rewards of working for a highly successful International company, and in addition to an excellent salary, company car and worthwhile fringe benefits, there is every opportunity for career advancement.

Write with full career details to Richard Gould, Personnel Department, Honeywell Control Systems Limited, Honeywell House, Charles Square, Bracknell, Berkshire RG12 1EB. Telephone: Bracknell (0344) 24555.
Please quote Ref WW/84/TID.



NEW CHALLENGES FOR ELECTRONICS ENGINEERS

Honeywell

INDUSTRIAL PRODUCTS GROUP – TEST INSTRUMENTS DIVISION

(2343)

TEST ENGINEERS (AUDIO)

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The ideal candidate will be qualified to HTC/HND/Degree level or equivalent and will have experience in one or more of the above fields; but of equal importance will be his/her practical design and manufacturing experience, together with drive and ability to take a project from the drawing board to final commissioning on site. A vacancy may also exist for a Junior Engineer who is able to demonstrate the above potential.

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Applicants should telephone or write to:

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(2526)

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(2344)

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Phone 7019010 or 703 0415 for details

(2347)

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Applications are invited from men and women who are qualified or about to qualify to First Degree level in Electronic/Electrical Engineering or related disciplines.

Consideration will also be given to applicants holding an HND/HNC/HTEC in Electrical or Electronic Engineering or the City and Guilds Telecommunication Technicians Full Technological Certificate, and who have appropriate industrial experience.

Your salary while training will be £6,652 per annum. On the satisfactory completion of training, your salary will be £8,421 and will rise by annual increments to £10,461 per annum; further progression to £12,966 per annum is possible.

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Application forms must be returned by Friday 20th January 1984.

(2377)

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(2372)

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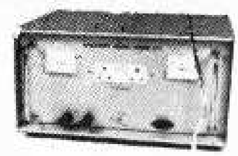

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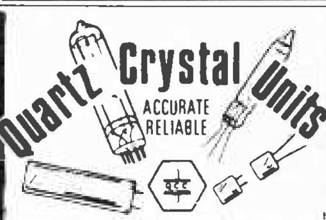

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SITUATIONS VACANT

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The person we appoint will be responsible for maintaining laboratory equipment and preparing practical equipment displays to meet the needs of teaching demonstrations and equipment training tuition.
Applicants should be qualified to HNC level (or equivalent) in electronics and have previous experience involving the use of electronic test equipment. Experience of maintaining television equipment would be an advantage.
Salary will be on the range £8,450 - £10,490 according to qualifications and experience. Relocation expenses will be paid where appropriate.

IBA INDEPENDENT BROADCASTING AUTHORITY

* An Equal Opportunities Employer *

Please write or telephone for an application form quoting Ref: WW/828cc to Glynis Powell, Personnel Officer, IBA, Crawley Court, Winchester, Hampshire SO21 2QA. Telephone 822270.

(2376)

BRITISH ANTARCTIC SURVEY

Electronic Engineer

The British Antarctic Survey requires an Electronic Engineer to join a team using a computer and microprocessor controlled high frequency radar, known as the Advanced Ionospheric Sounder (AIS), to study the high latitude ionosphere. The successful candidate will be required to maintain and operate the equipment at Halley, Antarctica (76°S, 27°W). He will also be encouraged to contribute to the research programme.

The engineer will be responsible for maintenance of the system hardware, encompassing a mini-computer, microprocessors, high power RF transmitter and a variety of instrumentation using both digital and analogue techniques. He will also need to be able to understand and modify the system software. The project team works in close co-operation with university and government groups, both in the UK and abroad, some of whom have their own equipment alongside the AIS (e.g. Fabroy Perot interferometer, all sky camera, riometer array).

As the station is isolated for most of the year, the ability to work without detailed supervision and to solve problems as they arise is paramount. The engineer will be expected to be adaptable and to take his share of the general base work.

The appointment will be for a period of approximately 39 months commencing in April 1984. After an initial period of hardware and software training in Cambridge, the successful candidate will sail for Antarctica in October 1984 to spend two Antarctic winters at Halley station. After completion of the Antarctic tour he may be required to spend a period from May 1987 in the United Kingdom undertaking development work.

Candidates should be graduates in Electronics, Electronic Engineering, Computer Science or Physics preferably with some relevant experience.

Salary: From £6,830 per annum plus annual increments.

Applicants should be physically fit, aged between 21 and 35 years and must be male as the nature and location of the work will require the successful candidate to live in premises provided by the British Antarctic Survey which are only equipped for male accommodation.

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For an application form and further details, please write to:
The Establishment Officer, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET.

Please quote ref: AS 3/84

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NATURAL ENVIRONMENT RESEARCH COUNCIL

(2378)

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